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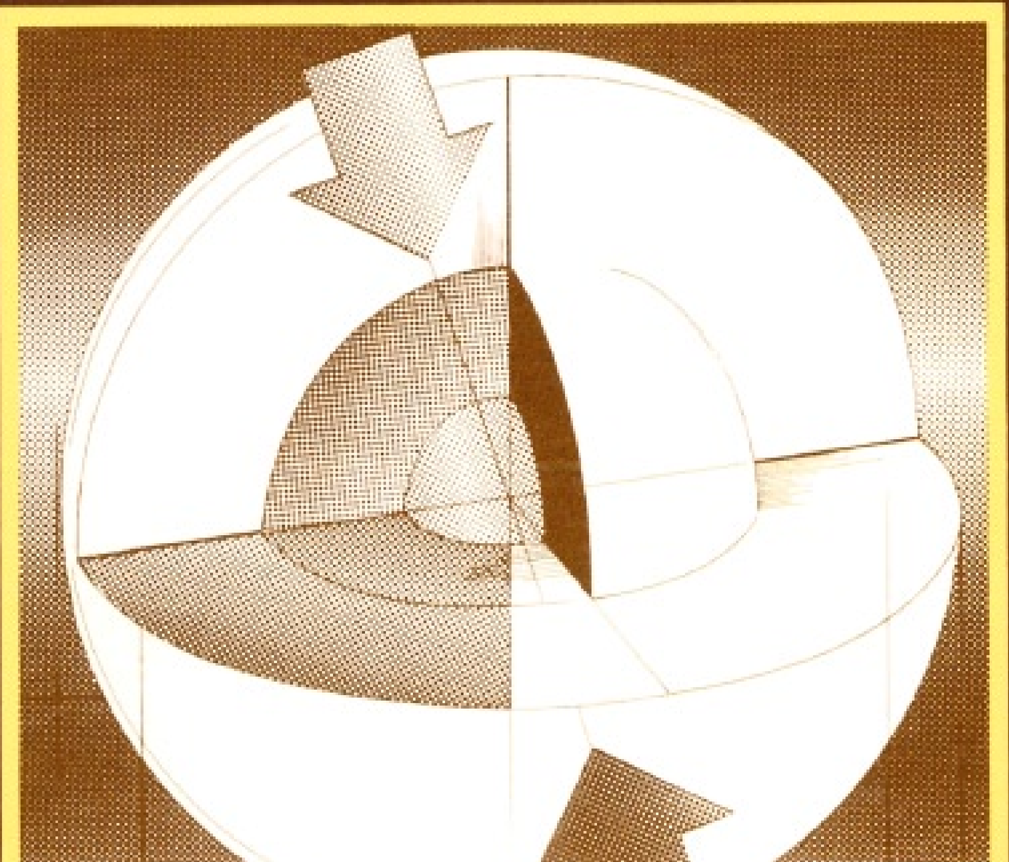
Input-Output Approaches in Global Modeling

Proceedings of the Fifth IIASA Symposium on Global Modeling

Gerhart Bruckmann, Editor



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IIASA PROCEEDINGS SERIES

Volume 9

Input-Output Approaches in Global Modeling

INPUT-OUTPUT APPROACHES IN GLOBAL MODELING

Proceedings of the Fifth IIASA Symposium on Global Modeling, September 26–29, 1977

GERHART BRUCKMANN
Editor

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PREFACE

In the field of global modeling, IIASA has assumed a monitoring role. Each of the first four global modeling conferences held at IIASA was devoted to a major global model that was approaching completion. The model was presented and then thoroughly discussed by an international group of scholars working in the field.

The Fifth Global Modeling Conference deviated from this scheme insofar as it was methodology oriented rather than model oriented; the main purpose of the conference was a critical (yet constructive) survey of the role that input–output techniques have played, and may play, in global modeling work. The two major models discussed in this conference were the Leontief model ("The Future of the World Economy") and FUGI ("Future of Global Interdependence"), a model developed by a Japanese group of scientists. Reports on other input–output models included a survey on global modeling work in the USSR.

The last part of the conference was devoted, as usual, to a presentation and discussion of other ongoing global modeling activities. Permission from the copyright holders to reproduce some of the papers and a number of figures in these proceedings is gratefully acknowledged.

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Chapter 1

WELCOMING ADDRESS

R. E. Levien

I would like to welcome you to our Fifth Conference on Global Modeling. IIASA has sponsored these conferences because it believes that one of its major functions is information exchange among groups working worldwide on problems of common interest. While IIASA is not actively engaged in inter- or multisectoral global modeling, it has an interest in seeing that the state of the art is well described and well disseminated around the world, which is the purpose of these conferences.

The previous four conferences were concerned with the Pestel-Mesarovic Model, the Bariloche Model, the MOIRA Model, and the SARUM and MRI Models. This year we are concentrating on input-output models. Next year it is our intention to hold a summarizing conference at which we shall bring together both the advocates and the critics of the various approaches to global modeling to determine the current appreciation of such efforts. What may happen after next year is not clear; we shall see at that time whether this series warrants continuation. But today and for the next few days, we have a very interesting series of presentations about global models, focused primarily, but not exclusively, on input-output models.

My second function this morning is to convey to you some current information about the Institute. Since many of you are familiar with the history of IIASA, I shall use this opportunity to report only on our current status. Over the past few weeks we have been developing the research plan for 1978 and 1979. The Institute is moving from annual year-by-year research planning to a mode in which we plan two years ahead in some detail and then give an indication of activities for the subsequent three years. Forecasting systems analysis development even over a six-month period is very difficult. Nevertheless, we aim to project our development better than that and use the information to recruit the people we need in time, so that they come here at the point of the development of programs for which they are needed. We are also strengthening our efforts to establish collaborative links and funding arrangements that will support the development of IIASA's work.

The Institute still has much of the structure I have mentioned on previous occasions. It has what we call a two-dimensional matrix organization. The Institute's two major cross-cutting Programs we represent by the horizontal rows of the matrix. The Programs address two kinds of problems. The first we call global: these inherently cut across national boundaries and cannot be resolved by the actions of single nations. The second we call universal: these are problems that reside within national boundaries but that all countries face.

The Energy Systems Program, led by Wolf Haefele, is concerned with the evolution of the global energy system, particularly how it can make the smooth, necessary transition, about 15 to 50 years from now, from being based on oil and gas to being based on virtually inexhaustible energy sources such as nuclear, solar, and coal. The basic research of this five-year project is nearly completed, and in 1978-1979 the Program's findings will be synthesized into a "core" book. This will be supported by a series of "satellite" books on such subjects as energy resources, energy demand, and energy and climate.

The Food and Agriculture Program, led by Ferenc Rabar, is entering its second year. A major emphasis is on the systems aspect of agriculture, meaning the relationship between food and agricultural development and, for example, the environment. Also, we are focusing on the national level of analysis rather than the global one, since we feel that agriculture is inherently a local enterprise that depends on local resources, traditions, and climates. We are developing policy models on a pilot basis for a number of different kinds of countries--developing or developed, market or planned economy, food exporters or importers. We hope these pilot models will give rise to a family of models among perhaps 20 or 25 different countries, which we can then use to explore major policy issues in natural agricultural policy. If we are successful, we will use the international linkage model developed by Michiel Keyzer, who worked on the MOIRA Model, to link these national policy models in order to get some sense of global international dynamics. But it is a very ambitious goal and I cannot promise success: it is simply the direction in which we are working.

The Institute is exploring other possible cross-cutting Programs such as regional development and the man-climate relationship. There is no shortage of potential Programs, and we welcome suggestions from you about those areas where you think IIASA might make a contribution and about possible leadership for such major international Programs over periods of five years or so.

The vertical columns of the matrix are the research Areas; these represent pools of skills needed for systems studies. We believe that to carry out a broad and comprehensive study, one must draw together skilled people with specific talents and put them in an interdisciplinary team with a cross-cutting leadership. So we have four research Areas. Resources and Environment, led by Oleg Vasiliev, is concerned with water resources and environmental issues. During this coming year we will be looking at regional water management and at the linkage between demand and supply both in planning and operating regional river and water management systems. I expect that the relationship between agriculture and the environment, which is of great importance for the production of food, will become a major focus.

The Human Settlements and Services Area, led by Andrei Rogers, studies population, resources, and growth. The focus is on the consequences of population growth and urbanization in developing countries, particularly the demand for resources and the impact on the environment around the world. Attention is also being given to the management of health care systems.

The Management and Technology Area has recently been reconstituted under the leadership of Rolfe Tomlinson. Of particular concern is the management of new technologies, and the impact of technological innovation on technology and society, on the management of programs, and on the environment. A possible new topic being explored is environmental management in which we would focus on the kinds of ecological disasters that could occur and how the international community could best plan to manage them when they occur.

The fourth Area, System and Decision Sciences, is concerned primarily with economic planning and resource allocation, econometric modeling, optimization, and informatics. Experts from the Area work individually and in consultation with scientists from other Areas and Programs to develop the necessary computer software for dealing with methodological subjects. In the optimization field, for example, we are focusing on structured linear programming, and in particular on dynamic linear programming. National economic planning is also a subject we are turning our attention to this year.

Beneath the matrix, in a residual category that we call General Research, we put topics that do not fit neatly into the other Areas and Programs; some of them are quite important to IIASA's work. They include a series of books, published by John Wiley, on aspects of the state of the art of systems analysis, and a handbook of systems analysis. Also included in this category are cross-cutting themes that are candidates for future programs, as for example regional development. Finally, and I think most important for this meeting, are the global modeling reviews.

This brief review will give you an idea of the current state of the Institute's multidimensional program and our plans for the immediate future. We welcome any comments you may wish to make about improving our activities and strengthening our collaborative efforts. What we really seek is your assistance in identifying both topics of importance to our National Member Organizations and people and institutions that might be interested in contributing to the activities of the Institute. So while we very much value comments on the weaknesses of our research plans, we value even more suggestions on how we can strengthen them through linkages with ongoing work in your countries.

Again welcome to IIASA. I hope this meeting will be a fruitful one for you. Thank you.

Chapter 2
INTRODUCTION TO THE CONFERENCE

Gerhart Bruckmann

As Dr. Levien mentioned in his welcoming address, the first four global modeling conferences held at IIASA were each devoted to some major global model that by that time had approached a state of completion. The First Global Modeling Conference focused on the Pestel-Mesarovic model which was published as a book (*Mankind at the Turning Point*) half a year later. The presentation and discussion of the model developed by the Fundacion Bariloche preceded the publication of the model by more than two years; this was also true for the MOIRA model, which was the focus of our third conference.

The fourth conference deviated slightly insofar as it was devoted to a comparison of two models, the SARU model developed by the Department of the Environment of the United Kingdom, and the MRI model developed by a group of scientists at the Polish Academy of Sciences. It proved particularly fruitful to investigate methodological correspondences between two models that had been developed from two entirely different paradigms.

The fifth conference which we are holding now is, again, slightly different in format. The main purpose of the conference is to investigate to what extent input-output techniques can be used and are being used in the service of global modeling. The first part of the conference, therefore, is devoted to the main model in this field, "The Future of the World Economy," developed in the United States by several groups of scientists under the guidance of Prof. Wassily Leontief. After a presentation and discussion of this model, we are fortunate to announce a presentation of the Japanese model FUGI which, although it is not entirely based on input-output techniques, does use them to a substantial extent.

The third day of the conference will be devoted to other input-output approaches. We are particularly grateful for the participation of a group of Soviet scientists who will not only speak on input-output, but will also give us a presentation of global modeling work in the Soviet Union in general.

The last part of the conference, beginning Wednesday afternoon, will, as usual, be devoted to a presentation and discussion of new modeling work going on elsewhere. In all of our earlier conferences, this fourth and last part of the conference has always proved to be of particular interest insofar as it has given the most recent information on any modeling work carried out by institutions of high reputation.

Let me, in this spirit, welcome all old friends among you who have already participated in earlier IIASA global modeling conferences, and those of you who are here for the first time.

Part One

THE FUTURE OF THE WORLD ECONOMY

Chapter 3

AN INTRODUCTION TO THE STRUCTURE AND APPLICATION OF THE UNITED NATIONS WORLD MODEL (Abstract)*

P.A. Petri
Brandeis University

The paper offers an introduction to a model of the world economy developed under the auspices of the United Nations. The model consists of fifteen regional subsystems linked by flows of goods, services, capital and aid; it can project detailed and consistent paths of global development to the year 2000 under alternative sets of assumptions about crucial factors like population growth, lending and development assistance, resource availability, and so on. The variables of the system range from familiar macroeconomic concepts such as GDP, consumption, and capital stocks to detailed production, import, and export levels of sectors such as textiles, electrical machinery, and motor vehicles, and of fourteen specific metals, fuels, and agricultural commodities. Satisfying the equations of the system implies that supplies of specific products are sufficient to meet demands in each region, that global imports and exports are consistent, and that production in each year is sufficient to cover the requirements of capital formation as well as current account needs.

To illustrate the application of the system, the paper compares the quantitative implications of two strategies designed to increase the exports of the world's poorest regions: one focuses on the exports of products that are produced by relatively pollution-intensive processes, and the other focuses on traditional labor-intensive products. The pollution-intensive product strategy is found to require more capital and supporting imports and greater shifts in the development patterns of the economies involved. Thus, it appears to be costlier not only in terms of environmental quality but also in terms of some critically scarce economic inputs.

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*This paper appeared in *Applied Mathematical Modelling* 1(5): 261-268, June 1977.

DISCUSSION

Kile asked whether the effect of the formation of cartels can be accounted for by the model. Petri replied that the formation of cartels cannot be predicted, but may be very well accounted for by the model, by shifting from determining the prices on the basis of cost to an exogenous treatment.

Bottomley wondered to what extent growth might not be export-generated, as was the case in several Asiatic countries. Petri replied that there is a great deal of variability as to how growth is financed.

Fritsch asked according to what criteria the list of resources was established. Petri replied that sometimes the inclusion was determined not by absolute importance, but by data availability.

Granberg asked whether the model reflects the dependence of the efficiency of capital investment upon technological progress. Petri replied that the model contains subsidiary trend equations which show how the capital requirement coefficients change over time and with the level of development.

Reichardt asked how the model reflects the speed with which technological knowledge and know-how spread over regions. Petri replied that, to the best of data availability, they had tried to quantify the development in individual economic sectors. Each year's coefficients reflect not only changes in the product mix, but also technological progress.

Randers wondered what happens in the model if some resource is being artificially withheld by producer countries. In reply, Petri pointed out that a new project was just started to allow the system to be run not only with the balance of payments or investment constraints but also with resource constraints. Richardson asked how Petri sees the main problam of earlier models, in the light of his own findings. Petri replied that there was much to be learnt from every earlier model; one should always be aware that every future model will also be far from perfection. Fleissner asked what exogenous factors are driving the model. Petri stated that, in the present form, GDP trends are exogenous (e.g., according to UN targets) but the model can also be made to run endogenously, e.g., by restricting the amount of investment to a particular level of savings; it is not always the investment equation but often the balance of payments equation which does the ultimate governing of the growth for various individual regions.

Deutsch raised the problem of calibration - if the model had been set up in 1910, would it have yielded the correct values for 1940 and 1970? In reply, Petri pointed out that, due to lack of data, calibration has been impossible, but updating the model to 1975 and comparing it to the true data will be useful.

Reichardt asked whether a sensitivity analysis was carried out, to determine which variables or parameters have the strongest impact. Petri replied that different assumptions concerning the development of prices result in dramatic changes in the balance of payments positions of various regions.

In reply to a question by Chant whether the group was yet under pressure to extend their forecasts farther into the future, Petri said that the contrary was the case; various international agencies wanted useable forecasts for 1980 and for 1985. Should a model not become obsolete too soon, it must continually be updated.

Randers said that the model should ideally be suited to investigate the effect of various aid policies, e.g., a 2-percent transfer of GDP from industrialized to less developed countries. Petri agreed but added that this analysis does not suffice; for instance, the role of the Middle East is crucial in this process because that is where the bulk of trade surplus has accumulated. Furthermore, one must be aware of a multiplier: relaxing a foreign exchange constraint by a dollar may generate 2.5 dollars worth of growth.

In reply to a question by Hrabovsky, Petri stressed that moving the model to 1975 will be done along different lines: projecting it from 1970 and investigating the differences, and analyzing the changes that occurred during that period and building these changes into the model.

Chapter 4
USING THE GLOBAL INPUT-OUTPUT MODEL FOR LONG-TERM PROJECTIONS*

Stanislav M. Menshikov**

1. INTRODUCTION

The intent of this paper is twofold: (a) to give a brief description of long-term projections performed with the help of the Global Input-Output Model; and (b) to discuss the potential use of the model for the study of future long-term trends in economic growth and development.

The Global Input-Output Model referred to in this paper was built in 1973-75 for the United Nations Centre for Development Planning, Projections and Policies (CDPPP) by a team of scholars headed by Wassily Leontief (formerly of Harvard, currently of New York University), Anne Carter and Peter Petri (both of Brandeis University). The model was built specifically in order to provide a tool of analysis of the impact of prospective economic issues and policies on the International Development Strategy. It was to provide a framework for global projections, which would also include sufficient disaggregation and detail on the principal regions of the world; the sectoral breakdown of their economies; some basic aspects of agriculture, food and nutrition; availability of mineral resources with special reference to energy and metals; some environmental aspects, such as pollution

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*Parts of this paper have been published in *The Future of the World Economy. A United Nations Study.* Oxford University Press 1977 (copyright © United Nations 1977).

**The author is currently Assistant Director, Centre for Development Planning, Projections and Policies, United Nations, New York. He is on leave from the Institute of Economics and Industrial Engineering, Novosibirsk, USSR.

and pollution abatement; some detail on international trade, aid, capital flows, etc.

After the model was built it was used, in 1975-76, for a series of long-term projections. The CDPPP, in consultation with the model-builders, provided the basic exogenous inputs, and also participated in the analysis of the results of the computations. The actual computations were made in Brandeis University by A. Carter and P. Petri.

Detailed discussions of the structure of the Model and of the projections made have been published in Leontief, Carter and Petri, 1977 (1) and also in Petri, 1977 (2).

The Global Model has now also been transferred to the computer at the United Nations in New York and is being used for additional projections in connexion with the preparation of a new United Nations development strategy.

Work is also under way on the verification and updating of the model using newly available statistical information centered around 1975, rather than 1970.

2. THE STRUCTURE OF THE MODEL AND THE TYPES OF SCENARIOS

The model is basically an open Leontief system with a set of interchangeable variables for each of the 15 regions to be used either exogenously or endogenously (such as total GDP, total employment, total investment, balance of payments, etc.). Structural parameters (technological coefficients, coefficients of the structure of final use vectors, capital-output and labour-output ratios, export shares, import dependence coefficients, etc), though changeable in time, have been estimated independently and are fed into the model as outside data. Some variables, (i.e. demographic) are always treated exogenously.

The use of lagged relationships is limited to equations determining investment requirements (as a function of the difference between desired fixed capital in the current period and actual fixed capital in the base period), inventory change and income from foreign investment. Behavioural equations with or without lagged variables are not used in the model proper,though cross-country regressions have been used to estimate some of the structural parameters.

The model is solved for individual benchmark years (1970, 1980, 1990, 2000). With some modification, the model could be solved for any one of the intermediate years. However, at present a solution for any given year is practically independent of the solutions for any previous year, with the exception of the base year (1970). A small change from "historic" (1970) capital to capital in the previous period (t-T) would be sufficient to make the model partially dynamic in some of the scenarios.

The structure of the model dictates the type of scenarios for future projections.

It is obviously not fruitful to use the model for projections of short- or medium-term growth paths since it is not based on behavioural equations estimated from time series. Nor is it possible, at present, to use the model to forecast possible future trends based on an optimization procedure with a set of interchangeable objective functions.

However, because of its inherent stability and fairly detailed structure, the model may be useful for analytical studies of possible future long-term trends, for testing different assumptions about policy, structural change in technology and consumption patterns, resource availability, change in international economic relationships, etc. For each set of assumptions the model will provide a global outcome, which can be analysed from the point of view of feasibility and consistency.

Two types of scenarios have been used up to now for long-term projections with the Global Model:

1. Scenarios in which overall growth paths for all the regions were exogenously determined on the basis of certain assumptions. In this case the model was used as a global accounting framework, showing the feasibility, as well as sectoral, trade and balance-of-payments implications of various assumed or desirable growth paths.

2. Scenarios in which a set of constraints were devised with respect to labour force, savings, and balance of payments. In this case the model was used to project global, regional, sectoral, trade and other growth paths consistent with such constraints. The emerging picture would be consistent, as the model goes, however, there would still remain questions of feasibility and of various political and economic implications.

3. SCENARIO X AND SCENARIO A

In the CDPPP we were, naturally, interested first and foremost in scenarios which would be directly associated with targets and objectives set or discussed by the various legislative bodies within the United Nations system. It has to be said that in recent years a number of different targets and objectives have been put forward, which are not necessarily mutually consistent within the envisaged time horizon. These are:

- Satisfying the basic needs of the people (in food, clothing, housing, education, medical care);
- The creation of 1 billion new jobs in the developing countries by the year 2000;
- Achieving a minimal 4 percent growth rate of food and agricultural production in the developing countries;

-- Increasing the share of the developing market economies in world manufacturing production to 25 percent by the year 2000;
-- Substantially reducing the average income gap between the developing and developed countries;
-- Improving internal income distribution so as to accelerate the eradiction of mass poverty;
-- Achieving a new international economic order and its different components (including commodity trade stabilization, increase in financial and technological transfers, reduction of barriers to trade in manufactured goods, a code of conduct for transnational enterprises).

For a discussion of these targets see UN.E/5937, 1977 (3); UN.IDS, 1970 (4); GA, 1974 (5); GA, 1975 (6); ILO, 1976 (7); UNIDO, 1975 (8).

In choosing a set of scenarios we decided to concentrate on a limited area of investigation, namely, the target of substantially reducing the income gap between developing and developed countries. The aim was also to test the consistency of this target with the objectives and plan of action for the establishment of a new international economic order.

This does not mean any implied or unintentional criticism of other targets or objectives. We have been watching with interest the various attempts at model quantification of these targets and objectives by Bariloche, 1976 (9), UNIDO, 1977 (10), Hopkins, 1976 (11) and others. See also, Cole, 1976 (12) for a fairly comprehensive survey of recent experiments in global modelling. Some of our own plans for further projections with the Global Input-Output Model are discussed in the concluding section of this chapter.

In the course of our work two basically different scenarios were devised, which we call Scenario X* and Scenario A.

Scenario X is based on the proposition that the average income gap between the developed and developing countries should be drastically reduced before the end of this century.

According to data accumulated for the model base year (1970) the average gross product per capita in the developed countries was 12 times as large as in the developing countries**. A simple extrapolation of previous long-term growth rates for the developed countries (4.5 percent) and an assumption of an average annual growth rate in developing countries of 6 percent (as specified in(4)) does not lead to even a start in diminishing the gap because of the difference in respective population growth rates

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*Scenario X is accompanied by a number of modifications, which are rather close to it. These are Scenarios C, D, G, H, R and M, discussed in Leontief, Carter and Petri, 1977 (1).

**Other estimates, based on computed international purchasing power parities, are much smaller. See Kravis, 1975 (13).

(1.0 percent in the developed, 2.5 percent in the developing countries). Thus different growth paths have to be constructed to achieve a substantial reduction in the income gap.

For purposes of Scenario X "medium" projections of population growth were chosen from data provided by the Population Division of the United Nations. These projections give the averages of 0.7 percent for the period 1970-2000 for the developed countries and 2.3 percent for the developing. It has to be stressed that in these projections which are based on a detailed analysis of fertility, mortality, age structure, urbanization and other basic factors underlying and determining population dynamics, growth of population is not looked upon as an exponential process, in which a constant growth rate is maintained. Rather these projections show that population growth rates first tend to increase, then to decline, after certain levels of income and degrees of urbanization are reached. It follows from these projections that population growth rates in the developed regions will be falling in the remaining quarter of this century and that a stable state of population will be reached after 2025. The coming quarter of the century will, however, evidence a continuation of a very high rate of population expansion experienced in the developing regions between 1950 and 1975, but population growth rates will start declining here in the first quarter of the next century with a stable state to be probably reached after 2075. This outcome would be achieved not through mass starvation, but through demographic change occurring at relatively high levels of economic development (see UN. Population, 1974 (14)).

Scenario X also assumed a certain set of growth rates in gross product per capita. These were constructed in such a way that, starting from current rates they would either increase or decrease, depending on the average per capita income achieved in the region. Thus, developing regions with per capita incomes below $2,000 were permitted to gradually increase their per capita growth rates up to 6 or more percent per annum, while developed countries would have to reduce their per capita growth rates to 4 percent at incomes $3,000 to $4,000; to 3 percent at $4,000 to $5,000; to 2.5 percent at $5,000 to $6,000; and so forth.

These assumptions had the effect of bringing the respective average growth rates of total gross product of the developed countries down to 4 percent and of increasing those for the developing countries to 7.2 percent, i.e., substantially higher than the current target of 6 percent. If these paths were followed, the average income gap would be reduced from 12:1 in 1970 to 7.7:1 in 2000.

The effect of these changes on living standards in the poorest regions of the world should not be overestimated. Thus, per capita income in most developing regions of Asia and Africa (excluding the oil-exporting countries) would increase to only about $400 in 1970 prices. In fact, the absolute income gap, as opposed to the relative gap, would in fact, become larger for these regions. This also shows the inadequacy of Scenario X with respect to the satisfaction of basic needs in the poorest countries. However, even the growth envisaged by Scenario X would be a substantial step forward, if accompanied by progress in improving internal income distribution.

Scenario A is an example of a scenario in which most growth rates are not pre-determined, but estimated endogenously. The basic assumptions of this scenario were suggested by the model-builders, rather than by the CDPPP. The following are the main constraints used in this scenario:

-- For all developed regions, excluding Western Europe (medium income) and Africa (medium income): total employment is exogenously determined as being equal to estimated labour force.
-- For resource-rich developing regions, (excluding Middle East and African oil exporting countries), namely Latin America (low income) and Africa (tropical), as well as for centrally-planned Asia: total investment is exogenously determined as equal to total internal savings and possible external borrowing.
-- For resource-poor developing regions, namely: Africa (arid), Asia (low income), Latin America (medium income), as well as for two medium income regions in Western Europe and Africa the balance-of-payments deficits (or surpluses) were exogenously set equal to zero.
-- For Middle East and African oil exporters the growth path was exogenously determined, as in Scenario X.

A comparison of the principal features of Scenarios X and A is made in Table 1. It is obvious that growth under the assumptions of Scenario A is unfavourable for most of the developing

Table 1. Growth Rates and Income Gap in Scenarios X and A.

	Scenario	Developed Countries	Developing Countries
GROWTH RATE (PERCENTAGE)			
Gross product	X	4.0	7.2
	A	3.9	5.4
Population (percentage)	X and A	0.7	2.3
Gross product per capita	X	3.3	4.9
	A	3.2	3.1
INCOME GAP IN THE YEAR 2000			
Gross product per capita (index, developing countries = 100)	X	769	100
	A	1,120	100

regions. While gross product in the developed countries expands at practically the same rate as in scenario X, growth rates in the developing countries are much lower and even lower than the minimum targets set by the International Development Strategy. In fact, they are somewhat lower than the 5.7 percent long-term growth rate experienced by the developing countries as a group in 1961-74, and also in 1971-76 (see (3) and UN. World, 1977 (15)). As a result, the income gap between the developed and the developing areas is barely reduced at all in Scenario A.

It does not follow that any scenario of the same type as A would lead to the same results. For example, if provision was made for substantial change in relative world prices in favour of the goods exported by developing countries; if their export shares would have been increased to account for better access to developed countries' markets and for more economic co-operation between developing countries; if provision was made for larger aid flows to the developing countries, then growth rates of the latter would have been substantially higher than in Scenario A, even under the same constraints.

Thus Scenario A is providing an answer to what will happen with growth and development, if current conditions continue to prevail. The answer is not surprising: growth rates in the developing regions will remain where they are now. For this reason Scenario A has been conveniently nicknamed by its authors as the "no-change" or "old economic order" scenario.

4. IMPLICATIONS OF SCENARIO X

The question immediately arises as to the feasibility of Scenario X, which is a scenario of accelerated growth and development. Let us point to some of the major problems involved.

4.1 Potential for food production

Accelerated growth leads to a substantial increase in per capita requirements for food, which, together with a large increase in population, amounts to the demand for fast growth in agricultural output. According to Scenario X, average annual growth rates of agricultural output in resource-poor developing regions should be about 5 percent, and in resource-rich regions more than 6 percent, which subsumes per capita growth rates of respectively 1.5 and 2.5 percent.

These estimates imply relatively high food-to-income elasticities, as compared with some other projections. Per capita consumption of nutrients (in thousands of kilocalories per day), estimated by the model for 2000 is higher than the basic needs dietary energy targets, determined by FAO, 1969 (16), in every developing region (by 0.1 to 0.6 points). However, our investigation does not go into food consumption by different income group inside countries, and does not specifically address itself to the question of whether the basic needs are in fact satisfied. It has been pointed out that, perhaps, under more equal income distribution in the developing regions, total requirements for food could increase at a somewhat slower rate than indicated in Scenario X.

The most important question was whether the substantial increase in demand for food could be accommodated by a proportional rise in food production. (It was clear from the very large quantities involved, that the developing countries would have to be largely self-sufficient in food, at least on a wide regional basis.) To answer this question, total required agricultural output was converted into a so-called land/yield index, which shows the increase in land necessary to produce the required output at 1970 rates of land productivity. When corrected for possible increases in arable land under cultivation, these figures showed the necessary increases in over-all land productivity. The results of the calculations are shown in Table 2.

As shown in the study, all developing regions have fairly large reserves of arable land which can be brought into cultivation, given adequate investment and institutional arrangements. It is physically possible to increase the land area under cultivation in the developing market regions by some 229 million hectares by the year 2000, or by 30 percent as compared to the actual arable land total of 1970. Presumably many substantial measures of public policy in the areas of land reclamation and irrigation, public and private investment, credit facilities, supply of necessary machinery and equipment, resettlement of agricultural labour, etc., would have to be taken in order to turn this physical possibility into a reality.

Even after mobilizing available excess arable land resources, land productivity (including crop yields and cattle productivity)

Table 2. Land Requirements and Land Productivity in 2000 (Scenario X). (Index: 1970 = 100 percent.)

Region	Agricultural output	Land/ Yield Index	Arable Land	Land Productivity
DEVELOPING REGIONS:				
Latin America (medium-income)	495	517	166	311
Latin America (low-income)	532	460	140	328
Asia (low-income)	506	376	113	331
Africa (arid)	409	371	131	282
Africa (tropical)	438	492	152	324
Asia (centrally-planned)	488	333	120	278

would have to be increased at least threefold in the developing regions, according to Scenario X. Even if the more modest current target of 4 percent annual growth in agricultural output is retained, land productivity would still have to increase about 2-2.5 times. With a continuing marginal growth of output of 2.5 percent per annum, and assuming full utilization of additional land, the necessary increase in land productivity is estimated at 60 percent.

The study goes into recent experiences in various countries and concludes that the doubling and even trebling of land productivity within a 25-30 year timespan is a realistic technical and organizational possibility. This task involves substantial investment into land improvement, irrigation, fertilizer production and distribution, research and development. Given the large excess labour potential in these regions a lot can be achieved by intensifying labour inputs into soil improvement and plant cultivation. The success of the new technological revolution in agriculture of the developing regions depends to a large extent on land reform and other social and institutional changes, which are necessary to overcome non-technological barriers to increased land use and productivity.

4.2 Adequacy of mineral resources

Accelerated growth, embodied in Scenario X, leads to substantial increases in requirements for mineral resource production and consumption. Total world demand for copper is expected to increase 4.8 times between 1970 and 2000, the demand for bauxite and zinc 4.2 times, nickel 4.3 times, lead 5.3 times, iron ore 4.7 times, petroleum 5.2 times, natural gas 4.5 times and coal 5.0 times. These estimates were adjusted, wherever possible, to take into account the influence of future technologies on resource development and consumption, as well as potential savings of primary resources through increased recycling. In spite of the new, more rational and economic ways of using mineral resources, the world is expected to consume during the last 30 years of the current century from 3 to 4 times the volume of minerals that has been consumed throughout the whole previous history of civilization.

To find out whether the finite reserves of minerals in the earth's crust are adequate to sustain this demand, the model provides the possibility of comparing cumulative resource outputs in 1980, 1990, and 2000 with total resource endowments. In view of the uncertainties of estimating future stocks of mineral resources, a very cautious and conservative approach was followed - namely, only the available current estimates of reserves of minerals known to exist at present were used as a basic benchmark without any provision for new discoveries of major new potential sources, such as undersea nodules. (A somewhat more optimistic estimate, augmented by currently known reserves, classified as "hypothethical" and "speculative", was also used for separate calculations under Scenario A.)

When measured against this extremely conservative benchmark it was found that only two of the metallic minerals considered in the study, lead and zinc, are expected to "run out" by the turn of the century, provided that proven reserves do not increase from their current estimates. Of the energy resources, coal was found to be plentiful, natural gas adequate, and in the case of petroleum, available estimates of world reserves were found to be roughly 1.3 times the estimates of cumulative world demand through 2000.

However, the overall adequacy of the world endowment in mineral resources does not necessarily ensure against regional shortages and high prices, nor does it guarantee smooth economic transitions to dependence on shale oil, gasified coal and other "new" energy sources.

As far as regional distribution is concerned, it was found that in the absence of major new discoveries "medium-income" Latin America, arid Africa, and non-oil Asia will remain net importers of most basic minerals in the foreseeable future. Because of balance-of-payments difficulties these regions may have to consider mineral reserve exploration among their top priorities for economic growth.

The study also looked into the problem of costs of mineral extraction. Changes in relative prices of mineral resources were calculated by solving the input-output dual equations for North America for 1970, 1980, 1990 and 2000, taking into account expected changes in input-output coefficients and value-added proportions in terms of expected changes in labour productivity. It was assumed that in view of the relative importance of this region in the world economy, its prices would be largely reflected in the price movements of world trade. For the more optimistic set of mineral reserve projections (Scenario X), these computations led to expected increases in relative prices (corrected for general inflation) between 1970 and 2000 of 2.2-2.6 times for lead, zinc, nickel and copper, 3.3 times for petroleum, and 7.6 times for natural gas. The expected relative increase in the price of bauxite was only 17 percent, the relative price of iron ore would remain constant and the price of coal was expected to fall by some 14 percent.

Thus, even in some cases in which mineral resources were found to be relatively abundant in physical terms they would become more costly to extract in the future. As the more accessible reserves of particular minerals become exhausted, the next layer involving higher extraction costs begins to be exploited. To some extent this can be modified by increasing the efficiency of mineral extraction and by new discoveries of highly productive reserves.

It is estimated that the share of total capital stock used in resources extraction will increase between 1970 and 2000 from 1 to 2.9 percent in the developed market regions, from 2.5 to 6.6 percent in the centrally planned regions, and from 3.7 to 8.4 percent in the developing regions.

Thus, mineral resource endowment is found to be generally adequate to support world economic development at relatively high rates but these resources will most probably become more expensive to extract as the century moves to its conclusion.

4.3 Industrialization

Accelerated development raises significant problems of resource allocation. A major requirement of Scenario X is for the substantial increase of the share of investment in gross product and the share of producer goods in total output. The ratio of gross fixed investment to total final internal use (sum of investment, private and public consumption) would need to increase from 15-20 percent on the average in 1970 to 25-35 or more percent in 2000.

It appears from the calculations with this model that an average investment ratio of 20 percent or less in the developing regions is adequate to sustain annual growth rates of gross product of 4 to 6 percent. However, growth rates of 7 to 8 percent require investment ratios of about 30 percent, while sustained growth rates of 9 to 10 percent or more cannot be accomplished unless the investment ratio goes up to 35-40 percent.

The study shows that currently prevailing private and public savings in the developing countries would be clearly inadequate to finance the necessary levels of investment. These can be augmented at least to some extent by reallocating to investment channels part of current non-civilian public consumption (e.g., military consumption), especially where its share is too high. However, because of high demand for public expenditure for education, health services, social security and other civilian purposes, a large part of the reallocation for investment will have to come out of private consumption. The relative decline in the share of personal consumption would lead to an initial slowdown in the increase of per capita consumption, but to much higher levels later through faster growth of total output.

Special measures would have to be taken to facilitate a more equal distribution of income, so that the benefits of faster growth of average per capita income are shared fully, and on a priority basis, by the poorest groups in these countries. Government action may be needed to see to it that high private earnings derived from accelerated development are directed more into equitable and productive uses.

Substantial relevant measures of taxation and credit and monetary and fiscal stimulation of savings will have to be taken, facilitating an accumulation of resources for investment and directing them into those sectors which are essential for accelerated development. Active investment policy is necessary, including the public setting of investment priorities and an increase in the role of public investment and of the public sector in production and in the infrastructure of the economy.

Scenario X, but also other computations, based on different assumptions, also show the necessity of faster growth in (a) manufacturing, as a whole, as compared to agriculture and extractive industries; and (b) in heavy industry (including machinery, equipment and industrial materials, i.e. steel, rubber, chemicals etc.), as compared to light industry. These tendencies were found to be well pronounced in all developing regions. These findings assume a continuing relatively large dependence on imports of machinery and equipment. A much larger share of domestic machinery and equipment production would be necessary if the developing regions were to drastically reduce their current dependence on this category of imports.

Two caveats should be offered. (1) An accent on heavy industry is essential for industrialization and economic development on the broad regional, though not necessarily on the small country, basis. This would involve a much higher degree of co-operation and specialization between the developing countries, especially in the priority sectors of machinery, equipment and basic industrial materials. (2) Because of its substantial current share in total industrial production, light industry in many cases will remain a leading part of manufacturing output in the period before 2000, in most developing regions.

4.4 Changes in international trade

Under Scenario X the share of developing market regions in world gross product would increase from 11 percent in 1970 to 22 percent in 2000, while their share in world output of manufacturing industries would increase from 6 to 17.5 percent. This may be compared with a target of 25 percent for the year 2000, as set by UNIDO, 1975 (8).

Continued world economic growth would lead to a brisk expansion of international trade. According to Scenario X, the total physical volume of world trade, measured in 1970 prices would increase in 1970 - 2000 at an annual rate of 6 percent, i.e., faster than the average over-all growth rate of world growth product, 4.8 percent. It is projected that in the year 2000, 14.5 percent of world gross product would cross national borders as compared to 10.6 percent in 1970.

An accelerated rate of development would easily increase the share of developing countries in world imports. Assuming relatively small decreases in import dependence, their share in total imports of goods would expand from 16 percent in 1970 to about 31 percent in 2000. However, assuming again relatively modest "trend" increases in their share in world exports, a large potential trade deficit would emerge, especially in regions which are not at present large net exporters of agricultural products or mineral resources. In view of the accompanying large increase in additional foreign debt, the potential balance of payments deficit of these regions would become an insurmountable barrier to accelerated development.

With this basic deterrent in mind the study proceeded to estimate the magnitudes involved in various proposals for significant changes in the character of economic relations between the developed and the developing countries, and see whether these changes would help close the potential balance-of-payments gap of the developing regions.

A change in relative prices of primary commodities vis-à-vis manufactured goods was first explored. This change is in the spirit of the proposals for commodity price stabilization and indexing, included in the over-all programme for the establishment of a new international economic order.

It was assumed that the relative prices, as computed for 2000 (see 4.2 above), would already be paid in international trade in 1980 and 1990. This has the effect of making prices of mineral resources 2.9 times higher, in relation to manufactured goods, than they were in 1970, and agricultural commodities 1.2 times as expensive.

Though some of the developed regions are large net exporters of primary commodities, the over-all effect of the change in relative prices is a substantial addition to the total export earnings of the developing regions. The Middle East, African and Latin American oil regions, and also the metallic mineral exporting regions of tropical Africa, are the main beneficiaries, achieving in some cases substantial export surpluses in their trade balances. However, most of Latin America, Africa and Asia would not benefit from these changes and would have to pay the higher price for minerals of which they are large net exporters.

One way of alleviating this additional burden would be a scheme of financial compensation for higher mineral resource prices. Another way would be to attempt mineral resource exploration in presently resource-poor countries on a priority basis. It was also found that foreign-income increases to the developing countries stemming from the implementation of international commodity schemes for some agricultural goods, of which the developing countries are substantial net exporters, and of mineral resources, other than oil, would be more smoothly distributed between various developing regions, and would amount to \$20 - \$30 billion in 1980, 1990 and 2000.

Special computations were made to estimate the effects of changes in import dependence and larger export shares of those developing regions which are not at present endowed with mineral resources. This is a variant of Scenario X, called Scenario M, in which rates of import dependence for a variety of manufactured goods - namely textiles and apparel, furniture, paper, wood, chemicals, cement, glass and all categories of machinery and equipment were reduced by 10 percent in 1980, by 18 percent in 1990 and by 26 percent in 2000 in Latin America (medium-income), Asia (low-income) and Africa (arid). The underlying assumption is that under accelerated development and industrialization the tendency would be strong for import substitution, especially in products of the manufacturing industries.

In Scenario M shares of the same regions in total world exports of products of light industry were increased by 10 percent in 1980, by 22 percent in 1990 and by 35 percent in 2000. The underlying assumption was that the developing regions would be able to increase their competitive power in the world market, starting with products of light industry. This does not necessarily subsume higher exports to developed regions, but may result from more trade between the developing countries, both inter- and intraregional. In any case, the shares of other regions in world exports of these commodities had to be proportionally reduced. It was also assumed that Latin America (medium-income) would be able to substantially increase its share of exports of agricultural commodities.

The total savings and additional income to the balances of trade of the three developing regions in question, as a result of the assumptions of Scenario M, were estimated at $8 billion in 1980, $34 billion in 1990 and $73 billion in 2000.

It was found that the combined effect of changes both in relative prices and in foreign trade policies, resulting in smaller import dependence and higher exports shares, would be to practically close the potential balance-of-payment gap of the developing regions which do not currently have large exportable surpluses of oil and metallic minerals.

The model was also used to estimate the possible magnitudes involved in larger foreign-aid flows. It was assumed that gross-aid flows from the developed countries in relation to their gross product would increase step by step from their current levels. This increase would not be uniform but would reflect the different starting levels and per capita incomes of various developed regions. It was found that these measures would have the effect of increasing net aid flows to the developing countries by $3 billion in 1980, $15 billion in 1990 and $47 billion in 2000. The overall effect of the increases in aid would be substantially lower than the total effect of relative price changes and better trade policies.

Finally, the model was used to estimate some hypothetical changes in the movement of capital. It was assumed that gross capital outflows from the developed market regions would increase by some 20 percent in both 1990 and 2000, while the average rate of return on such investment to the developed regions would be reduced by 2 percentage points so as to lessen the burden of debt service and foreign income outflows from the developing countries. The net effect of these changes in favour of the developing regions would be about $7 billion in 1990 and $18 billion in 2000. These increments are relatively small financially when compared to other measures discussed previously.

The total effect of the various measures discussed is roughly to achieve the balance-of-payments equilibrium in the developing countries even under conditions of accelerated growth. It should be stressed that these measures are dependent on a significant restructuring of the current economic relations between the developed and the developing countries.

5. GENERAL CONCLUSIONS AND PLANS FOR FUTURE WORK

The over-all conclusions reached as a result of the analysis of Scenario X and its modifications, were that:

(1) The average growth rates, both actual and targeted by the current International Development Strategy, are inadequate, if the goals laid down in various United Nations resolutions are to be reached.

(2) The principal limits to sustained economic growth and accelerated development are political, social and institutional in character rather than physical. No insurmountable physical or technological barriers exist within this century to the accelerated development of the developing regions.

(3) A review of such basic problems as food, mineral reserves, pollution and pollution abatement,* investment and industrialization, world trade, the balance-of-payments gap, etc. shows that a satisfactory solution of these problems is feasible under two general conditions: first, far-reaching internal changes of a social, political and institutional character in the developing countries, and second, significant changes in the world economic order. Each of them taken separately is insufficient, but when developed hand in hand, they will be able to produce the desired outcome.

It has been argued that these conclusions are based on Scenario X which is pre-determined by exogenously set regional growth paths.

The answer is that similar results could have been obtained by pursuing scenarios of the A-type and adding, step by step, the various assumptions explored with respect to the changing internal and external conditions of development. This approach would lead to endogenously determined growth paths which would be very close to those exogenously set in Scenario X.

It has also been argued that the global input-output model does not take into consideration various physical constraints and bottlenecks which accompany accelerated growth (e.g., transportation facilities for handling enormous increases in world trade, some limits involved in the physical placement of plant and equipment, various problems involved in moving large masses of people, costs of research and development, etc.).

The answer to this argument is that more effort should be made to incorporate these and other constraints within the framework of the model. However, even at its present level of disaggregation and sophistication the model presents a realistic overall accounting global framework, in which various scenarios and

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*The subject of pollution and pollution abatement has been approached in the computations with the model, but is not discussed in this paper due to space limitations.

policy options can be fruitfully tested. It is felt that the very cautious and conservative approach to some aspects of development (e.g., mineral reserves) more than outweighs the underestimation of other constraints and bottlenecks.

The global input-output model addresses itself to a rational, and more or less "ideal" world, in which favorable political, social, institutional, and international changes are subsumed. In reality, such changes, which involve confrontation of social groups and nations, are extremely difficult to come by. The model shows what is physically and technologically possible, but it would be too much to expect that it would be able to tackle the political and social problems involved.

As mentioned above, the model was built at Brandeis. At present it is also being transferred to the United Nations computer in New York. Plans for future work with the model involve the following:

(a) Running a series of new scenarios (of both types) with the aim of exploring the conditions of achieving the various goals set by United Nations bodies, as well as testing their mutual compatibility and consistency. This involves, among others, investigating in more depth the internal and external conditions of accelerated growth with a special accent on conditions and perspectives for a new international development strategy in the 1980's;

(b) Using the model for separate studies of some basic features of global development, such as restructuring international economic relations, economic cooperation between the developing countries, the effects of arms limitation and reduction on economic growth and development;

(c) Verification and updating of the statistical base of the model, including a change to 1975 as the base year;

(d) Co-operation with United Nations regional and sectoral organizations on new projections with, and extensions of, the model;

(e) Experiments in global optimization. Perhaps, more co-operation with IIASA in this particular field would be desirable.

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DISCUSSION

Kile suggested the replacement of figures like "1% transfer of GDP" by "x% transfer of gross hard product", of tangible production only, excluding services. Menshikov replied that this suggestion is new to him but could be easily implemented.

Krishnayya wondered why a rise in the relative prices of tropical agricultural products affects the balance of payments position of the respective country, but - according to the model - has little impact on the overall system. Menshikov and Petri replied that this is due to the shape of the equations but seems justified: if, e.g., the price of coffee were raised, it would have a substantial impact upon the balance of payments of Brazil but little impact on Western European economies.

Richardson wondered according to which criteria confidence in the model was determined. Menshikov said that he applied "intuitive" criteria - whether or not particular outcomes seem plausible. Petri added that the results can be checked against the outcomes of other models, as was done for energy where the agreement was quite good. Menshikov added that differences of, say, 30% in energy projections should still be considered as "agreement".

Chapter 5

MODIFICATION OF THE WORLD ECONOMY MODEL: OPTIMIZATION AND EQUILIBRIUM

A.G. Granberg and A.G. Rubinstein

For some years, research on world economic development up to the year 2000 has been carried out under the aegis of the United Nations with an input-output model. Research on the project is performed by a group of scientists headed by Professor W. Leontief for the United Nations Centre for Development Planning, Projections and Policies (CDPPP) [1].

In 1976, the CDPPP invited the Institute of Economics and Industrial Engineering of the Siberian Branch of the Academy of Sciences of the USSR to take part in these investigations. The present paper discusses major ideas of the work and the first experimental results. It gives some modifications of Leontief's world economy model that make it possible to use principles of optimization and economic equilibrium for studying world economic development. Preliminary results are given of calculations up to the year 2000 on the basis of aggregated versions of the models.

The authors would like to thank the assistant director of CDPPP, Professor S.M. Menshikov, for information and active participation in the discussion of problem formulation and the results obtained.

POSSIBILITIES OF TRANSFORMATION OF THE WORLD ECONOMY INPUT-OUTPUT MODEL

The world economy model elaborated by the group headed by W. Leontief is an advanced dynamic input-output scheme that embraces processes of production, produce, and resource distribution; the interaction of economy and environment in the world's large regions; and the principal international (interregional) economic relations.

From the standpoint of a mathematician, the model is a system of algebraic equations that, given the initial information, are satisfied by only one solution. This single solution is attained by introducing a number of exogenous variables (parameters) into the model, thereby eliminating freedom of choice. For example, the freedom of choice of various foreign trade relations is eliminated by introducing coefficients that unequivocally determine the import of each group of goods by region depending on the output of this group of goods in the region. Export is also determined by region depending on the world import for each group of goods, etc. The model does not imply any mechanism for comparing preferred versions of economic development. The development alternatives are selected outside the model; the choice is essentially dependent on the researcher.

During early stages of work on the world economy model when the initial information was being collected and processed to make it possible to obtain realistic results, the application of the input-output type model was certainly expedient. But at later stages, when a great deal of attention had to be paid to an analysis of the efficiency of various development alternatives for separate regions and the world system as a whole, it seemed more fruitful to use optimization models.

Leontief's input-output model can be considered a basis for elaborating models of global optimization (when regional development levels converge) and models of international economic equilibrium (with regional optimization criteria). Transformation of the input-output model consists of:

- Elimination of some artificial relations between variables in the initial model and transference of some fixed parameters into endogenous variables, resulting in the appearance of degrees of freedom (the possibility of choice of alternatives)

- Introduction of regional optimal development criteria
- Introduction of conditions that restrict the set of possible solutions (e.g., restrictions on nonreproducible resources)
- Formalization of principles of effective distribution among regions and of principles of international economic relations

The optimization approach enables more precise study of the world's economic development and increases the strength of the economic magnitudes quantitatively defined in the model itself. Optimal prices (shadow prices) of all kinds of products and resources of different regions are calculated, as are the prices that balance demand and supply in the world market. The ability of the model to simulate different policies of level convergence in world regional development is well developed.

In optimization models, more detailed information is needed, e.g., data on available labor resources, critical development capacities of primary sectors, transportation expenditures, etc., and new problems of modeling arise. For instance, exports and imports are free variables, which widens the range of solution choice. However, this sets up a difficult problem of reflecting interregional production counterflows. In the solutions of models of global optimization and economic interaction, such flows may have no place, but in reality they make up a substantial part of interregional flows (exchange between sets of goods). Models with optimization elements are more sensitive to information on production technologies.

The calculations with the modified world economy models are carried out with aggregated information. The world is divided into 4 regions: (I) North America, (II) the rest of the developed countries (Europe, the USSR, Japan, Oceania, and South Africa), (III) Latin America, and (IV) Africa and Asia (except the developed countries). In each region, 5 production sectors are distinguished: agriculture, extraction industry (resources), light industry, engineering (heavy industry), and services. The emission of 2 types of pollutants is taken into account: nonabatables (pesticides) and abatables (a group of 7 pollutants). Control of the generation of nonabatables is incorporated into the model; a special abatement activity is inserted for abatables (a sixth production sector).

The production of the first 4 sectors is traded and can be used in foreign exchange. The classification of regions and sectors that we use in our computations and the principal information array correspond to the second step of the research on the world economy model performed by W. Leontief's team. At the third stage, calculations imply 15 world regions and in each region there are 45 sectors and 8 types of pollutants [1]. The production and expenditures are measured in billions of dollars (US, 1970).

In addition to the information used in the calculations of the main model, information on consumption, labor coefficients, maximum employment levels, maximum production capacity of primary industries (agriculture and extraction industries) in separate regions, and interregional transport expenditures was used. The information on maximum production output is given in 2 versions: "lower" (version I) and "upper" (version II).

MAJOR PRINCIPLES

The world economy is a multiobjective system that brings together countries (regions) with different interests. Let us assume that the development objective of country S can be expressed in the form of $f_s(x_s)$. (Such hypotheses are widely used in econometric theories.) Each country strives to maximize this objective function in a set of feasible development trajectories. The set is determined by its own resource-technological capacity, foreign economic relations, and global resources. The composition of objective functions $f_s(x_s)$ and feasible trajectories x_s yields the objective vector function of world development $F(x) = f_s(x_s)$.

By bringing together the resource-technological abilities of all countries and the world as a whole with the global ecological conditions, a set of feasible trajectories of world economic development X is obtained. The efficiency of international economic cooperation is determined by the fact that the cooperation of different countries results in their approaching higher levels of their own goals (and consequently, a greater value of function $f_s(x_s)$) than with autarkic development.

The model of the world's economic optimization in its simplest form can be represented as the following problem of vector optimization: $\max_{x \in X} F(x)$.

The simplification of this model consists mainly in its not taking into account the political, social, and economic organizational factors that restrict mobility of national (regional) and world resources. The model assumes that maximum use is made of world resources under current and expected technological conditions; to what extent this will be realized depends on the organization of national economies and international economic relations.

Analysis of the model enables the singling out of a set of alternatives for world economic development called the Pareto set $X^* \subset X$. Each version inserted in this set, $x \in X^*$, is effective in the sense that it cannot be improved for one country (or a group of countries--a region) without making the position of at least one other country worse. All versions not inserted into set X^* can be improved for at least one country.

Thus, the problem of choosing policies for world economic development is restricted to the choice of a set of alternatives that are effective in this sense. But for some countries it is a far from indifferent matter which of the effective alternatives will be realized. A deliberate choice of a particular strategy of world economic development necessitates finding a compromise among the interests of different countries. In accordance with the goals of world economic development proclaimed by the United Nations, compromise among national interests should provide for faster convergence of levels of satisfaction of material and spiritual demands for people of developed and developing countries.

The modifications of the models that will now be considered can be interpreted as specific (but interrelated) tools for searching for and comparing alternatives of world economic development in a set of effective alternatives.

The Global Optimization Model

Both general optimization criteria of the world economy, which are generalizations of regional criteria, and correlation of regional criterion magnitudes are included in the Global Optimization Model. One can simulate the feasibility and consequences of several convergence alternatives on regional development (regional population welfare). Then (beyond the model) one should answer the question whether a particular development alternative is feasible under current international economic relations and if not how it should be changed to make it feasible.

The World Economic Interaction Model

Here the choice of a set of effective alternatives is different. This model is a combination of a vector optimization problem (with regional criteria of optimality) with the conditions of the world economic mechanism (the latter including principles of balance of payments control, price formation policy in the world market, etc.). This model allows the best alternatives of development for each country to be found, given established world economic mechanisms.

Both types of model have a similar block structure. Blocks simulating development of separate regions are connected by conditions for economic development convergence and levels (welfare) of regions, by international exchange balances, by conditions of world economic relations, and by global resource-environment restrictions. Figure 1 shows the structure of the two-region model. Because of the similarity in structure, one can easily use the same information in both types of model.

MODIFICATIONS OF THE WORLD ECONOMY MODEL

We used some models for calculating experimental prospects of world economic development up to 2000. First let us consider simplified models in which interregional transportation expenditures are not accounted for.

The world economic system consists of four regions that exchange four sorts of goods. The major parameters for each region are:

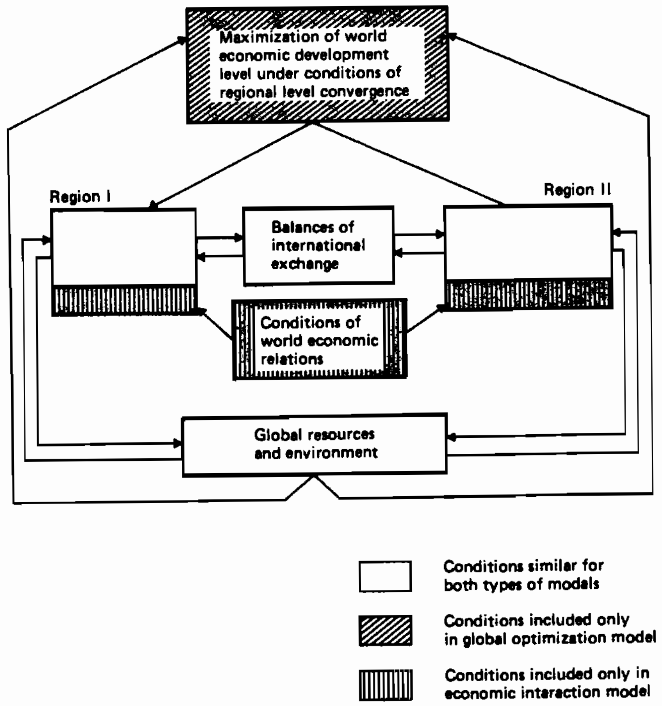

Figure 1. Structure of global optimization and economic interaction models.

a_{ij}^s (i = 1,...,5; j = 1,...,5), material expenditures of sector per unit output of sector j

a_{i6}^s (i = 1,...,5) material expenditures of a sector necessary for reducing the amount of abatables per unit output of sector j

a_{6j}^s and a_{7j}^s (j = 1,...,5), generation of abatables and non-abatables per unit output of sector j

K_j^s and l_j^s (j = 1,...,6), capital and labor expenditures per unit output of sector j

f_i^s (i = 1,...,5), expenditures of sectors per unit investment (for primary sectors these coefficients are assumed to be zero)

r^s, proportion of total capital stock that should be invested in 2000

L^s, maximum employment

For some industries ($j \in \bar{J}^s$) there are fixed lower limits for their output volumes $\underline{d}_j^s$, and for primary sectors ($j = 1,2$) the upper limits $\bar{d}_j^s$ are fixed.

For each region S there are given "development programs" which are housing and government vectors. The degree of program realization is measured by λ_s. Each region tries to maximize the value of λ_s.

Initially, housing consumption by groups of goods is determined as linear approximations of nonlinear functions of the total housing consumption. Aggregated members of these approximation functions make up a constant (nonmaximized) part of the consumption vector $B = B_1,\ldots,B_5$ inserted in the right-hand term of output balances ($\sum_{i=1}^{5} B_i = 0$). The main part of the "development program" is a vector of numbers $(C_1^s,\ldots,C_5^s)$ that includes government consumption and the variable part of housing consumption of the production sector output that depends on the degree of program realization.

Values C_6^s and C_7^s characterize emission of abatables. In realizing the given consumption program, C_i^s, C_j^s, C_k^s are necessary for the labor resources, investments, and capital.

Besides λ_s, the following quantities are unknown for each region S:

x_i^s ($i = 1,\ldots,6$), sector output
E_i^s ($i = 1,\ldots,4$), export production
J_i^s ($i = 1,\ldots,4$), import production
Q^s, abatables ($Q^1 = Q^2 = 0$)
F^s, total pollutants
I^s, investments
K^s, capital value

The model of world regional economic interaction is stated as follows: With fixed exchange prices p_i ($i = 1,\ldots,4$) and fixed trade balance w^s ($\sum_{s=1}^{4} w^s = 0$) for each region, nonnegative values X_i^s, E_i^s, J_i^s, Q^s, F^s, I^s, K^s are determined which maximize λ^s. The main conditions for each region S are:

Restrictions on sector output

$$\underline{d}_j^s \leq x_j^s \quad , \quad j \in \bar{J}^s \quad , \quad x_j^s \leq \bar{d}_j^s \quad , \quad j = 1,2 \tag{1}$$

Balances of production and distribution of traded produce

$$x_i^s - \sum_{j=1}^{6} a_{ij}^s x_j^s - E_i^s + J_i^s - f_i^s I^s - \lambda^s C_i^s \geq B_i^s \quad , \qquad i = 1,\ldots,4 \tag{2}$$

The service balance

$$x_5^s - \sum_{j=1}^{6} a_{5j}^s x_j^s - f_5^s I^s - \lambda^s C_5^s \geq B_5^s \tag{3}$$

Balances of abatement activity and pollution emissions

$$x_6 - \sum_{j=1}^{6} a_{6j}^s x_j^s - \lambda^s C_6^s = 0 \quad , \quad s = 1,2 \quad ;$$

$$- \sum_{j=1}^{s} a_{6j}^s x_j^s - \lambda^s C_6^s + Q^s = 0 \quad , \quad s = 3,4 \quad ; \tag{4}$$

$$- \sum_{j=1}^{6} a_{7j}^s a_j^s - \lambda^s C_7^s - Q^s + F^s = 0 \tag{5}$$

Labor restrictions

$$\sum_{j=1}^{6} l_j^s x_j^s + \lambda^s C_l^s \leq L^s \tag{6}$$

Investments and capital balances

$$\sum_{j=1}^{6} K_j^s x_j^s + \lambda^s C_k^s - K^s \leq 0 \tag{7}$$

$$- \lambda^s C_I^s - r^s K^s + I^s \geq 0 \tag{8}$$

The trade balance

$$\sum_{i=1}^{4} P_i (E_i^s - J_i^s) \geq w^s \tag{9}$$

The objective function

$$\lambda^s \rightarrow \max \tag{10}$$

The regional block of the model is shown in Figure 2.

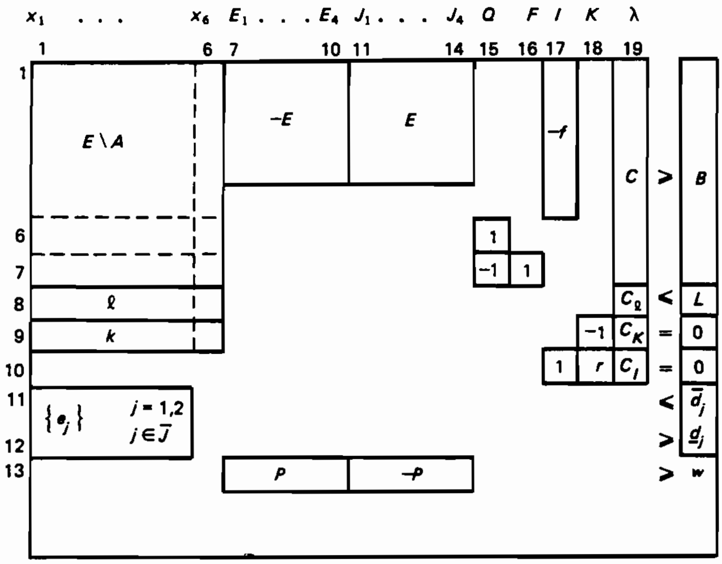

Figure 2. The regional block of the model of world economic interaction.

For the world economy to function properly, it is necessary to provide for balanced export and import of each traded commodity. Such a balance can be achieved only with certain exchange prices. It is necessary to find that system of price exchange $p = (p_i)_{i=1}^4$ for which, among the regional conditions (1) to (10), there are solutions balanced at a global scale, i.e., they satisfy the following conditions:

$$\sum_{s=1}^{4} E_i^s = \sum_{s=1}^{4} J_i^s \quad , \qquad i = 1,\ldots,4 \qquad (11)$$

When the trade balance of each region is zero (all $w^s = 0$) it has been proved (with some assumptions) that there are such prices [3, pp.35-46]. Prices bringing about balances (11) are usually called balance prices, and a corresponding plan is called a balance plan. This plan is effective (Pareto optimal), i.e., no region can improve its state without worsening the state of at least one other region. Moreover, it is not beneficial for individual countries to separate from the system of world trade to form coalitions, i.e., no group (coalition) of regions can provide a more efficient plan for itself after separating. In this case, the model is homogeneous by price p, i.e., a proportional change of all the prices of exchanged production does not change the solution of the problem.

Formulating a problem with a nonzero fixed trade balance is more general (for some regions at least, $w^s \neq 0$ but $\sum_{s=1}^{4} w^s = 0$). For such a formulation it is also possible to prove that there exist solutions and that they belong to the Pareto set. However, this more general model is not homogeneous by price; some additional price normalizing is connected with fixed values of trade balances.

The model considered here is a rather special case of a large class of models of subsystems of economic interaction in which principles of mechanistic economic functioning are not necessarily connected with finding balance prices, demand and supply balance, and so on.

The global optimization model involves most of conditions (1) through (11). It is characterized by the degree of implementation of the "program of world development" λ under additional conditions $\lambda^s \geq \lambda (s = 1,\ldots,4)$; the trade balance condition (9) is excluded.

Thus, nonnegative values x_i^s, E_i^s, J_i^s, Q^s, F^s, I^s, K^s, λ^s, λ under conditions (1) to (8) must be determined, and

$$\lambda^s \geq \lambda \quad , \qquad s = 1,\ldots,4 \tag{12}$$

$$\lambda \rightarrow \max \tag{13}$$

Under conditions (1) to (8), (12) and (13) transform into equations in the optimal solution, i.e., the degree of implementation of regional programs coincides.

As mentioned, the global optimization model can be used for the simulation of feasibility and consequences of change in correlations of regional development levels (welfare). To illustrate this, let us change the parameters of the criterion part of the model. Let Z^s be the physical volume of the variable part of the "development program" of region s (in billions of dollars); Z the physical volume of the world program ($Z = \sum_{s=1}^{4} Z^s$); γ^s the share of region s in the world program ($\sum_{s=1}^{4} \gamma^s = 1$); and α_i^s the share of sector i output in the variable part of the regional program ($\sum_{i=1}^{5} \alpha_i = 1$). Then $c_i^s \lambda^s = \alpha_i^s Z^s$. It is necessary to maximize Z under the conditions $Z^s \geq \gamma^s Z (s = 1,\ldots,4)$.

At least one global plan corresponds to each fixed vector $\gamma = (\gamma^s)$. Changing the coefficients γ^s(still with $\sum_{s=1}^{4} \gamma^s = 1$) we obtain versions of world economic development with various correlations of regional development levels. All the versions that are optimal with appropriate vectors γ belong to a Pareto set. There is a relation between solutions of economic interaction and global models.

Let us solve both versions, models (I) and (II), with the given regional program-vectors c^s and with arbitrary values for variables w^s (but with $\sum_{s=1}^{4} w^s = 0$). The values $\bar{\lambda}^s$ and $\bar{p} = (\bar{p}_i)$

are calculated along with other variables. Then under the conditions of the global optimization problem let us take vectors $\bar{Z}^s$ equal to $\bar{\lambda}^s\bar{Z}$. The following statement is proved. With the above conditions a plan exists (the components of which are designated by symbol ^) in the solutions of global optimization problems. The plan is the same as solving the economic interaction model. Here $\hat{\lambda} = \hat{\lambda}^s = 1$ for all $s = 1,\ldots,4$, and optimal values of dual variables $\hat{\xi} = (\hat{\xi}_i)$, corresponding to restraints of version (II) will coincide with prices $\bar{p} = (p_i)$.

Let us now consider reverse connections between the two models. Let us solve the global optimization model (I)-(8), (II)-(13). Let the optimal values of dual variables be prices for the economic interaction model; then trade balances will be calculated using the formula

$$w^s = (\hat{\xi},\hat{E}^s) - (\hat{\xi},\hat{J}^s) \qquad (14)$$

where $\hat{E}^s$, $\hat{J}^s$ are vectors of optimal values of exports and imports. We must prove that one solution of the elaborated economic interaction model is the same as the global optimization model.

Thus, these two modifications of the world economy model supplement one another. The first model's solution (the economic interaction model) allows the setting of correlations among regional programs under the conditions of the second model. And in solving the second model, dual estimates and values of trade balances are calculated that can be made use of in elaborating the first model.

Taking account of interregional transportation expenditures (service sector expenditures for export and import) makes the model more complicated but does not significantly affect the procedure discussed above. At the present stage of work on the models, no interregional payment and capital flows (those not directly connected with the output exchange of the first four sectors) are taken into account.

In constructing modifications of the world economy model and in analyzing their properties, the authors have made use of studies on the USSR interregional intersectoral models [2,3].

EXPERIMENTAL CALCULATIONS OF THE WORLD
ECONOMY MODEL FOR THE YEAR 2000

Most of the initial information used in calculations of the modified models corresponds to the information used in World model II [4], a six-industry, four-region model prepared for the United Nations development programs of regions; the population size is taken from the "lower" alternative of the 4 × 6 model. The limit volumes for agriculture of developing countries are given at the "central solution" level of model 4 × 6. Other upper limits correspond to optimistic estimates of the development potential of primary sectors.

The global optimization and economic interaction models were run to calculate 6 primary alternatives of world economic development up to the year 2000:

I-The global optimization problem with the given distribution of revenue among regions without account taken of interregional transportation expenditures

II-The economic interaction model with zero trade balances but without account taken of interregional transportation expenditures

III-The global optimization problem with the given distribution of revenue among regions with account taken of interregional transportation expenditures

IV-The economic interaction model with zero trade balances and with account taken of interregional transportation expenditures

V-The economic interaction model with trade balances and a 1-percent growth in GNP of developed countries and account taken of interregional transportation expenditures

VI-The economic interaction model with trade balances and a 2-percent growth of GNP of developed nations, and account taken of interregional transportation expenditures

We now compare the above alternatives with the basic solution of the United Nations world model (see Table 1).

Table 1. Major indicators of the base development level (1970) and the central solution (2000).

	1970					2000				
	NAm[a]	ODe	LAm	AaA	TWo	NAm	ODe	LAm	AaA	TWo
Population (× 10^6)	229	879	281	2,231	3,620	290	1,106	586	4,151	6,133
GNP[b]:										
Percentage of the world total	32.9	51.6	4.8	10.7	100.0	21.4	42.9	10.1	25.6	100.0
Per capita (10^3 US $)	4.62	1.89	0.54	0.155	0.89	9.55	5.02	2.22	0.8	2.11
Annual growth rate per capita (%)						3.3	4.1	7.4	7.8	4.7
Personal and government consumption:										
Percentage of the world total	33.6	50.1	5.1	11.2	100.0	22.0	41.5	10.1	26.4	100.0
Per capita (10^3 US $)	3.87	1.51	0.47	0.113	0.729	8.09	4.01	1.84	0.68	1.74
Annual growth rate per capita (%)						2.5	3.3	4.7	5.6	2.95

[a] NAm, North America; ODe, other developed countries; LAm, Latin America; AaA, Asia and Africa; TWo, total world.
[b] The GNP is determined for the year 2000 as the solutions in the form of the total private and government consumption, investment, abatement volumes, and trade balances.

In our comments, we shall mainly discuss those findings that differ from the central solution.

With respect to the aggregate world economic development indicators, alternatives I to VI differ from the central solution for the year 2000 at most by 3-4 percent, and the more realistic versions III-VI, which take into account interregional transportation costs, exceed the central solution by only 1.5 to 2 percent (see Tables 2 and 3). Such minor differences from the central solution in terms of the efficiency indicators are due to the "narrowness" of the given range of permissible solutions that is determined by the initial information available.

However, as far as regional structure is concerned, the alternatives differ considerably from the central solution, and this allows some conclusions to be drawn about the effect of various factors on world economic development trends, and, especially, about the opportunities for equalization of regional economic development levels.

Total private and public consumption increases as the balance of trade increases, whereas the gap between per capita consumption volumes of developed and developing nations decreases with increasing balance of trade (see Table 4). The largest gap in the per capita consumption volume (by a factor of 6.55) is found for the alternative with zero trade balances (IV), the narrowest gap coinciding with the central solution (a factor of 5.9), the global optimization model, is in alternatives I and III.

As can be seen from Tables 2 and 4, taking account of the interregional shipment costs results in a decrease of the total private and public consumption, and then the interregional shipment amounts decrease substantially. It should also be noted that in global optimization problems based on a given composition of private and public consumption by regions, one obtains substantial but unrealistic trade balances: solutions provided by economic interaction models based on given trade balances are more acceptable.

The given limits on output of primary industries allow acute shortages of their products to be avoided through 2000. The

Table 2. Aggregate world economic development indicators.

Alternatives	GNP	Consumption
I	104.0	104.2
II	103.4	103.4
III	102.5	102.1
IV	101.6	101.5
V	101.9	101.8
VI	102.1	102.0

Table 3. Aggregated regional world economic development indicators up to the year 2000 according to alternatives III-VI.

	NAm	ODe	LAm	AaA
GNP in 2000:				
Percentage of world total	21-21.1	43.5-44.4	9.9-10.3	24.3-25.5
Per capita (10^3 US $)	9.53-9.6	5.19-5.31	2.21-2.32	0.774-0.88
Annual growth rate 1971 to 2000	3.2-3.3	4.2-4.3	7.4-7.5	7.7-7.9
Private and public consumption in 2000:				
Percentage of world total	21.1-22.0	41.5-44.5	9.4-10.1	24.5-26.4
Per capita (10^3 US $)	7.94-8.26	4.09-4.36	1.73-1.88	0.64-0.695
Annual growth rate 1971 to 2000	2.4-2.6	3.4-3.6	4.4-4.7	5.4-5.7

Table 4. GNP and per capita consumption in 2000 for model versions I-VI.

	I				II				III			
	a	b	c	d	a	b	c	d	a	b	c	d
NAm	9.77	12.00	8.43	11.89	9.78	12.18	8.26	12.37	9.55	12.34	8.26	11.88
ODe	5.30	5.51	4.17	5.88	5.26	6.55	4.37	6.54	5.31	6.86	4.09	5.88
LAm	2.37	2.91	1.91	2.69	2.88	2.96	1.77	2.65	2.32	3.00	1.88	2.71
AaA	0.814	1	0.709	1	0.80	1	0.668	1	0.774	1	0.695	1
Developed	6.23	6.19	5.06	5.90	6.20	6.21	5.17	6.42	6.19	6.41	4.96	5.90
Developing	1.01	1	0.858	1	0.998	1	0.805	1	0.965	1	0.841	1

	IV				V				VI			
	a	b	c	d	a	b	c	d	a	b	c	d
NAm	9.53	11.79	8.09	12.64	9.59	11.90	8.02	12.24	9.60	12.02	7.94	11.83
ODe	5.19	6.42	4.36	6.81	5.20	6.45	4.31	6.58	5.20	6.51	4.27	6.36
LAm	2.21	2.74	1.73	2.70	2.24	2.78	1.79	2.73	2.32	2.90	1.84	2.74
AaA	0.808	1	0.648	1	0.806	1	0.655	1	0.799	1	0.671	1
Developed	6.09	6.20	5.13	6.55	6.11	6.22	5.08	6.39	6.11	6.19	5.03	6.17
Developing	0.988	1	0.775	1	0.983	1	0.795	1	0.987	1	0.816	1

NOTE: a--per capita GNP (10^3 1970 US $); b--the ratio of per capita GNP to that of the region that has the lowest GNP; c--per capita private and government consumption (10^3 1970 US $); d--the ratio of private and government consumption to that of the region that has the lowest GNP. Developed countries are those in regions I and II; developing countries are in regions III and IV.

specialization of the regions is affected mainly by differences in performance of individual sectors. For example, Asia and Africa are becoming large net importers of agricultural output, while their own opportunities to produce it remain unexploited. The rest of the developing countries, while overlooking their potential in the extraction sector, are becoming essential net importers of the output of this sector.

The results of the models permit a conclusion to be drawn concerning the effect of trade balances on private and public consumption in individual regions (see Figure 3, which was drawn on the basis of points obtained both from the direct solution of global optimization problems and from iterations of the solution of different versions of the economic interaction model). The

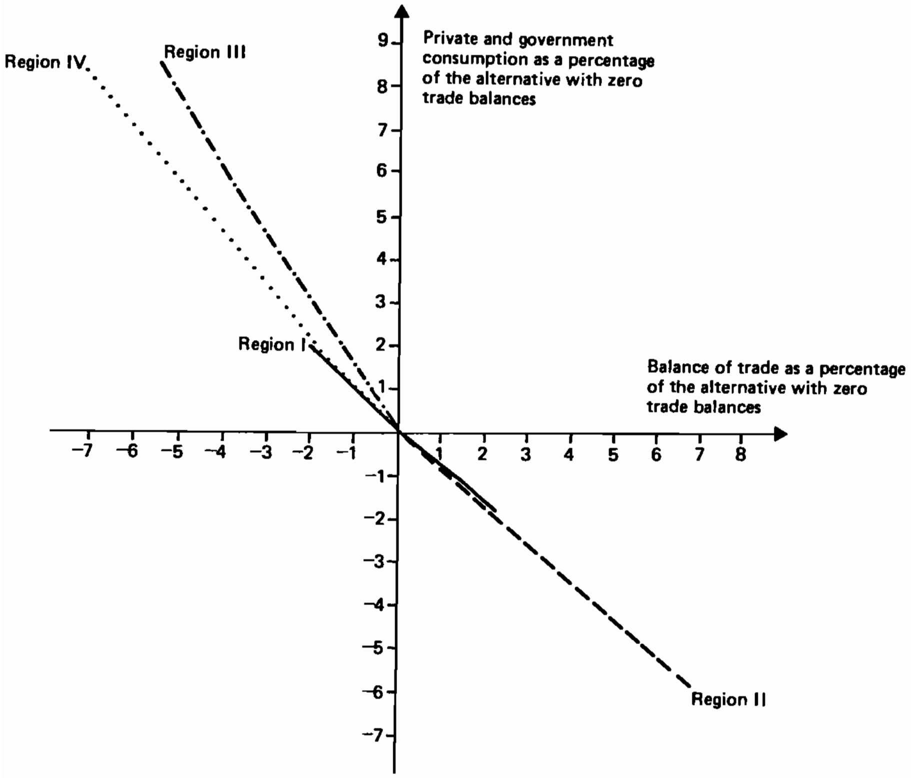

Figure 3. Private and government consumption versus balance of trade for each region.

trade balance values are plotted on the x axis, and the private and public consumption (as a percentage of the level achieved when trade balances are zero) on the y axis. As seen in Figure 3, the trade balance values are similar and proportional to the private and public consumption in all regions. While a change in the trade balance value of 1 percent entails an increase or decrease in private and public consumption by about 0.9 percent in regions I and II, the increase or decrease in region III amounts to 1.5 percent and for region IV 1.2 percent.

As the calculation shows, a change in the trade balance value of 1 percent in developed countries results in its change in developing countries by about 1.7 percent. Taking into account the absolute values of 1 percent of revenue in different regions, one may conclude that a decrease in revenue of $1 in developed countries will result in an increase in revenue of about $1.40 in developing countries. As an analysis of alternatives III to VI (i.e., those with interregional transportation costs taken into consideration) shows, the volume of output produced in different regions differs only insignificantly in most cases from the central solution. Let us enumerate the major differences:

Agricultural production is redistributed between two regions (in all versions): the output increases in North America and decreases in Asia and Africa

The output of the extraction sectors fluctuates largely from version to version for the other developed countries and for Asia and Africa; the other developed countries gain in version III and Asia and Africa gain in the other versions

The output of light industries differs significantly from that of the central solution in versions III and VI due to the redistribution of production between Latin America (an increase) and Asia and Africa (a decrease)

The territorial distribution of the heavy industries varies from version to version, especially for Latin America where the output varies almost twofold

The greatest deviation from the central solution is found for international trade (see Table 5). For example, North America becomes a large exporter of agricultural output and a net importer

Table 5. Output volumes of the sectors in versions III to VI as a percentage of the central solution.

	NAm	ODe	LAm	AaA
Agriculture	118.2-135.9	107.6-111.5	100.0	80.6-86.7
Extraction industry	97.5-98.6	66.3-122.3	113.1	81.0-145.3
Light industry	100.0	100.0	100.9-146.4	90.3-101.7
Heavy industry	76.3-90.3	93.7-107.0	57.4-109.3	148.3-156.8
Services	101.0-103.4	97.6-100.0	99.2-109.4	103.5-107.1
Abatement	100.4-100.9	98.9-105.9		

of the output of heavy industry. In their turn, other developed nations cease to be net importers of agricultural output and continue to increase imports of the extraction sector and to decrease exports of the heavy industries (with the exception of version III). Asia and Africa become net importers of agricultural output but increasingly net exporters of the output of the extraction sector. They stop importing the output of heavy industry. Latin America's specialization changes to a smaller extent as compared with the central solution.

The change in regional specialization as outlined by the above alternatives seems to be quite realistic. For example, North America and other developed countries have the technological prerequisites for a quicker increase in production of agricultural output than was assumed by the central solution. A switch from agricultural output partly to extraction output and a new trend in the structure of international exchange balance turns out to be very favorable for Asia and Africa (see Table 6). Version III seems hardly realizable, since it predicts that only other developed countries will have a positive balance of trade (about $\$320 \times 10^9$, or 5.4 percent of GNP) while all the other regions will have a deficit amounting for Asia and Africa alone to $\$210 \times 10^9$ (6.5 percent of GNP).

Dual prices (shadow prices) are an important technique for analyzing the optimization alternatives of the model. The prices of labor and of ceilings on output to be produced by primary sectors indicate the change in the amount of private and government consumption, given a minor change (within the stability interval)

Table 6. Export-import balance by versions ($\$10^9$).

	Central Solution	III	IV	V	VI
Agriculture					
NAm	9.3	128.4	71.7	133.9	135.7
ODe	-55.4				
LAm	37.1	19.0	50.7	41.2	23.2
AaA	9.1	-147.4	-122.4	-175.1	-158.9
Extraction industries					
NAm	2.5				
ODe	-98.8	-39.7	-207.0	-204.3	-206.3
LAm	13.0	23.5	25.8	25.2	23.8
AaA	83.2	16.2	181.2	179.1	182.5
Light industries					
NAm	-40.9	-44.8	-41.0	-42.2	-41.3
ODe	82.2	67.2	54.1	56.1	58.0
LAm	-8.9	115.6		15.2	121.9
AaA	-32.5	-138.1	-13.1	-29.1	-138.6
Heavy industries					
NAm	35.7	-136.5	-32.9	-60.2	-35.6
ODe	226.4	312.7	92.1	147.0	204.6
LAm	-77.7	-176.3	59.2	-86.9	-169.0
AaA	-184.4				
Balance of trade (percent of GNP)					
NAm	13.7	-50.8	0	27.0	52.6
	(0.5)	(-1.8)	(0)	(1.0)	(1.9)
ODe	27.9	319.7	0	57.0	112.3
	(0.5)	(5.4)	(0)	(1.0)	(2.0)
LAm	-5.1	-59.7	0	-23.1	-46.1
	(0.4)	(-4.4)	(0)	(-1.8)	(3.4)
AaA	-36.5	-209.2	0	-60.9	-118.8
	(1.1)	(-6.5)	(0)	(-1.8)	(3.6)

in the limits on manpower resources or in the maximum possible output volume to be produced by primary sectors. The prices of output show by what amount the private and government consumption increases (decreases) when an additional unit of final produce of a corresponding kind appears (disappears) due, for example, to import or export. The prices of the transportable outputs of sectors are equal to each other for different regions in those versions that do not take into consideration interregional transportation costs and differ in those that do take these costs into account in the prices.

Note that there is some stability in the shadow prices for labor, capital, and investment from version to version (see Table 7); the prices of labor vary from region to region and the prices of capital are almost equal.

On the basis of the calculations of the main versions, a parametric analysis of the problems was carried out for particular regions. Such an analysis is of special importance to developing countries, which are assumed by the main problem versions to have prerequisites for very high growth rates of primary industries. The analysis makes it possible to reveal the effects of a decrease in these rates and to determine, in a sense, the lower limits to growth of primary industries necessary to ensure satisfactory trajectories of the economic development of developing countries. Moreover, such an analysis allows the consequences of different variants of international divisions of labor to be simulated for the economies of individual regions.

The fulfillment level of the given household and government consumption programs that results from the isolated solution of the optimization problems are as follows: for North America 0.997, for the rest of the developed countries 1.021, for Latin America 0.925, and for Asia and Africa 0.938. A comparison with the corresponding fulfillment levels of the program in version IV shows the effect on individual regions of the international division of labor provided that the trade is balanced. From the model

Table 7. Dual values (shadow prices) of labor, capital, and investment (versions II to VI).

	Labor	Capital	Investment
NAm	21.0-21.2	0.06-0.07	0.92-1.02
ODe	11.4-12.4	0.07-0.08	1.00-1.08
LAm	2.0-2.7	0.07-0.08	0.65-0.73
AaA	1.16-1.36	0.07-0.08	0.69-0.75

solution it follows that the values of the objective functions to be maximized cannot exceed the corresponding values in version IV when the problems are solved for individual regions separately. This difference amounts for North America to 0.3 percent of the objective function value in the isolated version, for the rest of the developed countries to 6.6 percent, for Latin America to 1.8 percent, and for Asia and Africa to 0.3 percent. Thus, the effect of the international division of labor is distributed extremely unevenly in this version. The biggest gainer is the rest of the developed countries, whereas North America and Asia and Africa are the biggest losers. If we take account of the GNP/household and the government consumption ratio as well as the dependence of household and government consumption on the trade balance value (see Figure 1) for developed countries, we can conclude that in order that household and government consumption in developed countries not be less than that in the isolated version, the trade balance value for North America should not exceed 0.3 percent of GNP and for the rest of the developed countries 6 percent of GNP.

Let us now consider the development analyses of individual regions (first of all of developing countries) briefly from the point of view of solving the optimization problems.

In Latin America, the highest possible agricultural growth rates were assumed to be 6.8 percent and those of extraction 8 percent. The limits on the output of primary industries were significant in all versions. As already noted, in the isolated solution the objective function value decreases as compared with version IV by 1.8 percent, the growth rates for agriculture being 6.3 percent and for extraction 7 percent. A further decrease in the growth rates for agriculture results in a substantial decrease in the objective function value. For example, with an agricultural growth rate of 6.0 percent (i.e., only 0.3 percent smaller), the household and government consumption amount decreases by 10 percent as compared with the isolated version, and an acute shortage in output of this sector occurs. The shadow price of this amount is 40 times as high as that of the output of the extraction sector.

The parametric analysis shows that net agricultural output export is profitable for Latin America, provided that the annual growth rate of this sector is at least 6.3 percent. To maintain per capita consumption at the level of 1970, it is necessary to achieve about 3.3 percent of the annual agricultural output growth rate, and in order that the gap in consumption compared to developed countries be at the most no bigger in 2000 than in 1970, agriculture should grow annually by over 5 percent. The same growth rate will be necessary for the extraction sector.

If the agricultural growth rate is less than 3.3 percent, it is reasonable that Latin America would become a net importer. For example, if the growth rate is 5 percent, than every $\$10^9$ of net imports of agricultural output (up to a limit of $\$113 \times 10^9$) increases household and government consumption by almost $\$4 \times 10^9$. It seems also to be profitable to import agricultural output in exchange for output of the extraction sector. For example, $\$50 \times 10^9$ of such exchange increases the objective function value by 30 percent. However, such an import quantity seems to be unrealistic for Latin America. An increase in the growth rate of agricultural output yields a significantly greater effect than an increase in imports. For example, an increase in the annual agricultural output growth rate from 5 percent to 6.3 percent is effectively equal to free agricultural import amounting to almost $\$100 \times 10^9$.

Let us now dwell on the analysis of the isolated version of the development of Asia and Africa. In the model runs for Asia and Africa, the prerequisites of high annual growth rates of agriculture and extraction were assumed: 7.6 and 9.0 percent, respectively. However, the limits for agriculture were not used in any version. At the same time, Asia and Africa were considered as significant net importers of agricultural produce, which, as already noted, is due to technological differences.

Provided that development is isolated, the growth rate for agriculture is 7.4 percent and for the extraction sector 6.6 percent. The objective function value differs in this case from that in version IV only insignificantly. However, if we assume the limit for agriculture to be at the level of the second variant of the limits (5 percent growth rate), then an acute shortage in agricultural output occurs. The shadow price of agricultural output is 30 times as high as that of extraction output, whereas the objective function value decreases by half. In order not to increase the gap separating Asia and Africa from the developed world in terms of per capita consumption by 2000, agriculture has to have an annual growth rate of at least 5.2 percent and the extraction sector 4.1 percent. In order that per capita consumption be maintained at the 1970 level, agriculture has to grow annually by at least 2.4 percent. An increase of the growth rate for agriculture from 5 to 6 percent will increase household and government consumption by 35 percent, an increase from 6.5 to 7 percent by 16 percent, and an increase from 6 to 6.5 percent by 16 percent. The growth rate for the extraction sector increases in this case by about 1 percent less than for agriculture.

With an agricultural growth rate of 5 percent and a growth rate in the extraction sector of 3.8 percent, every $\$10^9$ of free agricultural imports (up to a limit of $\$50 \times 10^9$) increases household and government consumption by $\$2.7 \times 10^9$. An increase of the agriculture growth rate from 5 to 6 percent is equal to the free import of this output of $\$168 \times 10^9$. Even with the most optimistic assumptions that imports will be able to prevent the difference in per capita consumption between developed and developing countries from being increased by the year 2000, the growth rate of agriculture should be equal to at least 4 percent. Then, to ensure the compensation of agricultural import by "extraction" exports, the growth rate of the extraction sector should be about 5 percent.

We shall only give here the most essential results of analyses of isolated optimization problems for developed countries from the point of view of the international division of labor. The export resources of the agricultural output of North America are very limited. For example, with an annual growth rate of 3 percent, the resources will virtually be used up in versions V and VI. A further increase in exports is only feasible if the growth rate of agricultural output increases in this region. The growth rate of agriculture is 2 percent, so the export potential of this sector will not exceed $\$10 \times 10^9$.

As for the remaining developed countries, they will be able to refuse to import agricultural output, provided the growth rate of their agricultural sectors is about 3.5 percent. This region has to import the output of the mining industries.

As the experimental calculation shows, the growth rates of output of primary sectors are very important to the future of the world economy. This problem is of special importance to those developing countries that want to develop these sectors at high rates. The most difficult problem for developing countries seems to be the expansion of agriculture and food supply. Agricultural imports can only moderate the shortage in agricultural products to a limited degree; they cannot get rid of it. Moreover, a sharp increase in imports would harm the trade balance; and the harmful effects can be reversed only by a rapid increase in the output of the mining industry, which is then exported.

The studies carried out and their results are preliminary. By no means have all the opportunities of the optimization approach been used in these studies on interregional input-output models of the world economy.

Studies should continue in the following directions:

A detailed classification of sectors and regions should be made

Opportunities to select technological methods of producing output should be taken into account

A more detailed representation of regional development dynamics should be made

Other optimization criteria should be used

Opportunities to select the consumption mixes and to modify them depending on the existing consumption level should be taken into account

The employment problem, especially in developing countries, should be examined

Case studies of prices set at a level differing from the equilibrium price and of output having several prices should be made

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DISCUSSION

In reply to a question by Keyzer, Granberg stressed that every step of the iterative algorithm of his model is the solution of an optimization model; thus, the two versions of the model are directly connected to each other. The shadow prices obtained in the global optimization model are considered to be the prices of global equilibrium.

Rademaker, Fritsch, and Peschel asked for more information concerning the objective function. Granberg replied that, up to now, they formalized only those objective functions that were considered in the original Leontief model. Kaya asked whether the present static optimization model is intended to be expanded into a dynamic one. Granberg, in reply, saw no technical difficulty in changing the static optimization into a dynamic one on three consecutive decades if data are available. Chant wondered whether, given the constraints in the model, it would be possible to narrow the gap between the income level of developed and less developed countries from (presently) 12 to 1 to something around 6 to 1. In reply, Menshikov pointed out that the model simply yields the information that this narrowing is difficult to obtain; moreover, the model shows under what severe conditions it is possible to close the balance of payments gap. The answer of the model, therefore, is not pessimistic but realistic. The implementation of the goals of the New Economic Order is not only a matter for the industrialized countries but depends largely on the conditions within the less developed countries themselves.

Chapter 6

THE INFORUM INTERNATIONAL SYSTEM OF INPUT-OUTPUT MODELS AND BILATERAL TRADE FLOWS*

Douglas Nyhus and Clopper Almon

The INFORUM International system of input-output models links comprehensive input-output models of major industrial countries through an international trade model which shows, for 119 commodity groups, the exports of each of the countries to each of the others and to the rest of the world. The system is intended for forecasting these trade flows and industry outputs, prices, consumption, investment and employment in each of the countries, year-by-year, out ten to fifteen years into the future. The forecasts can, of course, be made under a variety of assumptions about technology, government policy, and international conditions. The trade model was built to accommodate individual country models for the United States, Japan, France, Belgium, Germany, Canada, the United Kingdom, the Netherlands, and Italy. At present, country models have been completed for the first five of these countries and the sixth, the Canadian model, is under construction.

The order of the construction of the models has been dictated by the order in which we have found colleagues in other countries who wished to join the project. We are presently looking for partners in Britain, the Netherlands, and Italy.

Section I of this paper sets out some of the principles we have followed in the construction of this system of models. Section II then explains in detail one of the country models, that for Belgium. Section III, to give some idea of the richness and variety in the models, points out some of the features by which other country models differ from the Belgium model. Section IV explains the international trade model, and Section V discusses directions of research.

This modeling effort, we should like to make clear, while it has pioneered in international cooperation and in many aspects of theory and

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the application of theory to model construction, has grown out of the needs of practical, business forecasting. For over a decade the INFORUM group at the University of Maryland has developed and applied a large-scale input-output model of the United States. This model presently has nearly 190 sectors and produces year-by-year forecasts over the next ten to twenty years. Besides the outputs for the 190 sectors, it forecasts, by econometrically estimated equations, personal consumption expenditures, exports, imports, inventory change, prices, and input-output coefficients for these 190 sectors. At more aggregate levels, it forecasts investment (90 sectors), employment (90 sectors), absolute wages (4 sectors), relative wages (100 sectors), income components such as wages, wage supplements, proprietor income, depreciation, indirect taxes, and property income — profits and interest payments — (56 sectors). The prices influence some input-output coefficients, consumer demands, exports, and imports.

This model has found a number of applications. Several dozen American firms which feel the need to plan further ahead than the next year or two make regular use of its forecasts in their investment planning. Government agencies and others have used it, for example, to study the effects of changes in oil import prices, of improvements in highways, of stockpiles of strategic materials, of control of toxic substances, of pollution abatement, of changes in tariffs, and of the Carter energy plan. New applications arise constantly.

As researchers in other countries learned about this work it was natural to ask, Can such models be built for other industrial economies such as those of Japan and Western Europe? Immediately the problem of the openness of these countries became apparent. Forecasting of exports is <u>a</u> problem in the U.S. model, but for, say, Belgium, it is <u>the</u> problem. Consequently, it became clear that such a model was possible for one country only if similar models could be built for its principal trading partners and the models tied together as they were built.

Since we did not wish to accumulate a collection of separate models in the hope that someday we would be able to connect them, we built the connecting mechanism first, the international trade model described in Section IV of this paper. It was completed in July of 1975. Since that time, we have been working on models of individual countries. Each time a country model is completed, it is connected with the others with data developed for the trade model. Full use of the trade model, however, is still ahead.

I. PRINCIPLES OF CONSTRUCTION

A) Standardization in Housekeeping Programming

As we have emphasized, we are interested in a <u>system</u> of models in which developments in one country affect other countries, not just a <u>collection</u> of models. It is, therefore, necessary that all models operate on the same computer and that their operating manuals should be as similar as possible, given the adaptations necessary to make each country's model fit the data and institutions of that country. A large part of the programming for a modern input-output model is concerned with what may be called housekeeping: reading in and properly storing the input-output coefficients or the parameters of the consumption functions or of other functions; imposing exogenous "fixes" on final demands for some commodity by adding to, multiplying, or overriding the results of the equations; preparing neat tables and graphs of the results. In a finished model, this housekeeping program will account for over ninety percent of the code necessary to run the model. The really substantive code necessary to tell the computer how to use, for example, the parameters of the consumption functions or investment functions is a relatively minor and easily written part of the total and has little to do with what the operator has to have in his head to run the model.

We have therefore written a prototype forecasting program known, somewhat unimaginatively, as FORP (for "forecasting program") which contains all this housekeeping programing. Much attention has been given to making the program easy to use for the various kinds of scenarios which we have found to be most frequently required. It makes extensive use of external files and of overlaying of programs to hold its core requirements and cost of operation to a minimum.

The simplest version of Forp, known as Slim-Forp, has all of this housekeeping program but almost no substantive programming. For example, it makes all final demands grow at four percent per year, and has no change in input-output coefficients or labor productivity. A single input-output table provides enough data to make Slim-Forp run. The format of the output is the same as will be produced by the finished model; the content of the output is, of course, rather uninteresting. Thus, when we start building a country model we can have an operating model within a day or so from the time the base-year input-output table is ready. Then we add features one by one. Usually consumption functions will be added first; then import functions, investment functions, employment functions, price and wage functions, or coefficient change functions can be added in any order when they are ready. At each stage we maintain a working model which grows in realism. We thus avoid the nightmare of trying to put all the pieces together at once only to get nonsense answers and no idea of where to begin to look for the error. Using our approach, we were able to have a Slim-Forp model of Germany running within a week after receiving a data tape; in the next three weeks we were able to add consumption, import, export, labor productivity, and coefficient change functions. Each addition required data, statistical analysis, and additional input cards, but only a few additional lines of Fortran were added to Forp.

B) Adaptability in Content

Having stressed the importance of standardization in housekeeping, we must emphasize equally the importance of adaptability in content. In order to exploit the full richness of data in each country, each country model works within the statistical system of that country. To have tried to establish on uniform statistical definitions not only the input-output tables but all of the time series needed for the model would have meant either that we greatly limited the scope of the models or that we spent man-decades or man-centuries in compiling the data, which would then be on definitions unfamiliar to the people who were to use the results.

From this principle it follows that the number of sectors in the input-output tables varies greatly from country to country. (The U.S. has the most with 190; Germany, the least with 48.) The international trade model, on the other hand, is based on export and import data reported in a common statistical system, the Standard International Trade Classification (SITC). Between the country statistics and the SITC statistics we have built bridges by regression equations, as we shall describe in Section IV.

Not only does the statistical classification change from country to country, so do the available statistics. For example, in the U.S., the personal consumption expenditure statistics contained in the National Income Accounts (NIA) are so much more aggregated than the input-output sectors that they are almost useless in the area of manufactured goods. Consequently, we have, at great pains, created consumption series at the level of the input-output sectors. In Belgium, however, the NIA consumption series are more detailed, so we have done our econometric work with these data. Into Forp we then introduce a "bridge table" which tells us what fraction of each of these consumption categories comes from each input-output sector. To take another example, for France, Japan, and the United States, time series on equipment investment by branch of industry are not further broken down by type of equipment. In Belgium, they are divided between Means of transportation and Other equipment. Naturally, we wanted to take advantage of this additional information, so for Belgium we estimated two separate investment functions for each industry and use both of them in Forp. Or again, the supply of gas has to be handled differently in the U.S. and Canada from the way it is handled in the European countries, where gas is produced domestically only as a by-product.

Thus, within the common housekeeping framework, the models are adapted to fit the nature of each country and its statistical system.

C) International Cooperation in Research

On each country model we have sought the cooperation of a research group within that country. For Japan, we have worked with the Japanese Long-Term Credit Bank; for France, with GAPSET, a new organization within the Chambre de Commerce de Paris; for Germany, with the Rheinisch-Westfalisches Institut fur Wirtschaftsforschung; for Belgium, with the Regional Economic Council for Brabant. Without these partners it would have been difficult to build any sort of model and impossible to build a model good enough to be useful to companies working within these countries. We feel that we have been extremely fortunate to find working partners who have assembled all the required data for us and worked hand-in-hand in the development of the model. What we have to show owes as much to them as to us.

II. BELGIUM - A TYPICAL COUNTRY MODEL

A) An Overview

Any model is based on a description of the economy. Macro models rely on the summary descriptions offered by the tables of the national accounts; input-output models rest on the expansion of these accounts to distinguish type of products and the users of each product. Figure 1 shows schematically the table used for the Belgian model. The output of

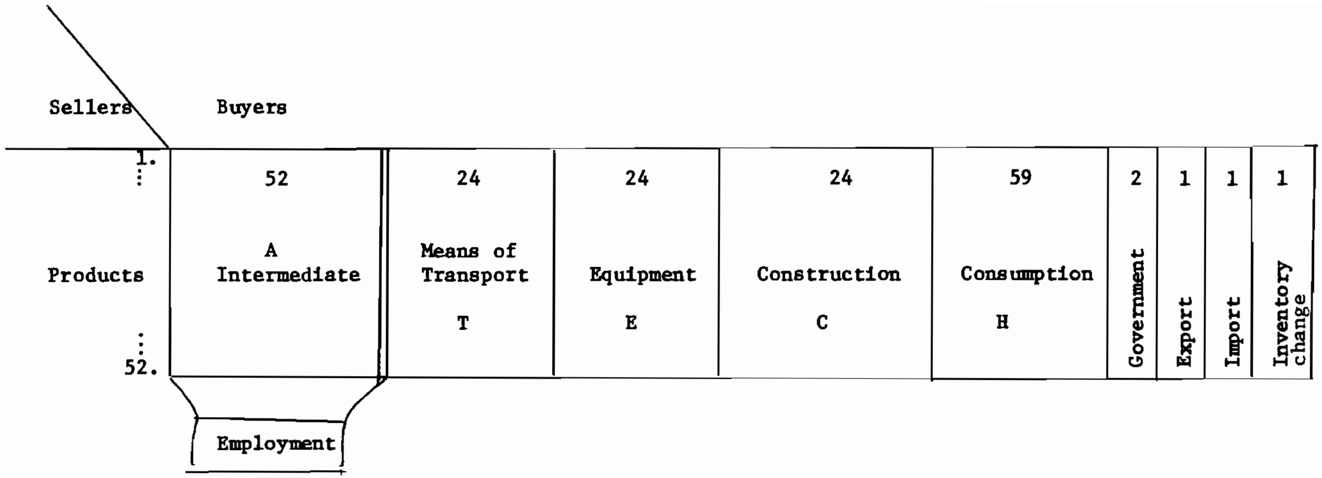

Figure 1. What the Belgium model shows for each year.

the economy is divided into 52 branches or products, such as Agriculture, Fishing, Coal, Coke, Electricity, Steel, Glass, Chemicals, Automobiles, Office machines, Meat, Milk products, Beverages, Clothes, Paper, Furniture, Railroads, Highway transport, Airlines, and Communication to mention twenty of the fifty-two. The sales of any one of these branches in a particular year are shown across a row of the table in Figure 1 in the column corresponding to the buyer. There are a total of 188 of these buyer columns as follows:

Matrix Name	Number of Buyer Columns	Content
A	52	Intermediate sales; the sale of one product to be used in making another, e.g. steel sold to auto makers.
T	24	The buyers are 24 sectors, aggregates of the 52, for which annual spending on capital investment in transportation equipment is available. The sellers are just two transportation equipment sectors and trade margins. Other rows of T are all zero.
E	24	Similar to T, but for capital purchases of all other types of equipment, of which there are presently five.
C	24	Similar to T and E, but for capital investment in new construction.
H	59	The "buyers" are the categories of consumption from the NIA. Most of these take their products from a single input-output branch, but some, such as "Other durables", draw from a number.
G	2	Two columns of government spending are distinguished 1) education 2) all other
	1	Exports
	1	Imports
	1	Inventory change
	188	

The elements to the right of the double line in Figure 1 are known as final demands. The sum of all the final demands is the gross domestic product.

The forecasts consist of tables such as this, one for each year out ten years or so into the future. The basic logic is to forecast the final demands by columns, (except for exports and imports, which are forecast element-by-element), distribute the column totals according to their percentage structure in the base year, sum up all the final demand columns, and calculate, by solution of linear equations, the outputs which would be necessary to yield these final demands, due account being taken of the requirements for intermediate goods. Thus, a final demand for clothes necessitates production not only of clothes but also of textiles, chemicals, electricity, coal, and so on. From the outputs so obtained, employment may then be calculated.

In order to forecast the personal consumption portion of final demand, however, we need to know personal disposable income. We start the process by assuming a future course for this variable. Logically, we may then revise it in either of two ways:

1) so that the resultant employment matches a projection of the labor force

2) so that the disposable income resulting from the wages, dividends, interest and rental payments, less the taxes, should be equal to the disposable income assumed in the consumption functions.

We use technique 1. All short-term macro-economic models use technique 2. Obviously, Number 2 requires a complete system of wage, income, and tax equations to spell out the disposable income implied by the industry outputs and employment. At present, this complete structure is available only for the U.S. and the Japanese models. Even for these models, however, we seldom use the second technique, because it assumes no changes in tax policy. For forecasting ten years ahead, it seems safer to assume that taxes will be revised to give satisfactory employment levels, and that is what technique 1 assumes. For one or two years ahead, we can simply use the disposable income forecasts from one of the standard macro models.

One further problem remains with the basic logic of solution: some of the final demands depend on the levels of output in the same year, namely investment, imports and inventory change. In the case of imports and inventory change, the dependence is substantial and direct in the sense that imports, say, of a product depend on the domestic demand of that same product. The import and inventory change equations are, therefore, simply included in the simultaneous solution of the equations for the outputs. This solution is accomplished by what is known as the Seidel process. In this process, initial guesses are made of the solution, then all of the demands for good 1 are computed and the guess for good 1's output revised to be equal to its demand. Then, with the revised value of good 1's output, the demand for good 2 is computed and its output revised, and so on through the whole list of 52 and then back to good 1 and through the whole list again and again until the solution converges. (Three or four times through is usually sufficient because we can both start with good guesses and also take the sectors in a sequence which puts the ones close to the consumer first — thus clothes come before textiles and automobiles before steel.) In this process, it is a simple matter to use the import and inventory equations each time the demand for a good is being calculated to say how much will be supplied by imports and how much be required for inventory building.

A different approach must be used to account for the dependency of, say, investment by the apparel industry on the output of apparel, for investment by apparel affects not only apparel output but output of machinery. Fortunately, this dependency is weak, as we shall see. We deal with it simply by calculating investment on the basis of our first guess of outputs, completing the Seidel solution of the simultaneous equations for outputs, then going back to the investment equation, recomputing investment, and then coming back through the Seidel computation. (Twice through this process is generally enough.)

When the outputs for one year have been computed in this way, we can move on to the next, and then onto the next. Thus, we build up the sequence of tables such as the one shown schematically in Figure 1.

Let us now turn to some of the types of equations actually used.

B) Consumption Functions

We have sought a form for our consumption functions which would give them several properties:

1) They must add up: the amount spent on all commodities plus the amount saved must equal income.

2) Proportional increases in all prices and income should have no effect on spending.

3) An increase in the price of one commodity, say gasoline, should be capable of stimulating demand for some other commodities, say railroad travel, while, possibly, depressing demand for other commodities, such as tires. In the language of economic theory, both substitutes and complements must be possible.

4) Price changes should alter the effect of income and non-income determinants of demand in approximately equal proportions.

5) They should possess what is known as Slutsky symmetry -- a unit increase in the price of chicken increases the demand for duck by the same amount as a unit increase in the duck price increases the demand for chicken.

6) Prices must be able to affect — either strongly or weakly — the proportion in which an extra unit of income is spent on various goods.

7) The asymptotic consumption pattern as income increases should depend upon relative prices.

We have shown in [2] that all of the existing systems of demand functions known to us -- linear expenditure systems, logarithmic models, "Rotterdam" models, translog models — fail to satisfy one or more of the simple conditions 1 - 7. We have devised a different system which meets them fairly well. For it, we have grouped the 59 consumption categories into ten groups: Food, Beverage and tobacco, Clothing, Energy, Household durables, Health care, Transportation, Household operation, Education, and Entertainment. Two of these are further divided into subgroups, namely

Group	Subgroups
Transportation	Public, Private
Food	Grain products, Animal products (ex. - butter) Fats and oils, Fruits and vegetables, Sweets and miscellaneous foods.

The form of the demand function for good i in group G and subgroup S is

$$(1)\ C_i = a_{1i} + a_{2i}t + a_{3i}\,(y/\bar{p}) + a_{4i}\Delta(y/\bar{p}) \cdot \left(\frac{p_i}{p_S}\right)^{-\lambda_S} \left(\frac{p_i}{p_G}\right)^{-\lambda_G} \left(\frac{p_i}{\bar{p}}\right)^{-\lambda_o}$$

where

C_i = consumption per capita in constant prices of good i in year t
y = disposable income per capita in current prices in year t
p_i = the price index of good i in year t

$$p_S = (\prod_{j \varepsilon S} p_j^{s_j})^{1/s_S} \quad , \quad p_G = (\prod_{j \varepsilon G} p_j^{s_j})^{1/s_G}$$

$$\bar{p} = \prod_{\text{all } j} p_j^{s_j}$$

where s_j is the budget share of commodity j in the base year,

$$s_S = \sum_{j \varepsilon S} s_j \ ; \quad s_G = \sum_{j \varepsilon G} s_j \quad ; \quad \sum_{\text{all } j} s_j = 1.$$

The a's and the λ's are parameters to be estimated statistically, and the conditions $\sum_i a_{4i} = 1$ and $\Sigma\, a_{3i} = \Sigma\, a_{2i} = 0$ are imposed to insure proper adding-up (condition 1) at the initial prices. As prices change, even these conditions do not guarantee adding-up and we have to attach a "spreader" to spread any difference between y and $\Sigma p_i\, c_i$ from equation (1) over all commodities, usually in the proportions given by the income coefficients, a_{4i}.

It is a property of these functions that the elasticities with respect to p_i of the demand for all goods not in the same group with product i are the same, say η_i^o. Likewise, the elasticities with respect to p_i of all other goods in the same subgroup with product i are the same, say η_i^s, as are all the elasticities within the same group but not in the subgroup (if any), say η_i^g. Finally, the elasticity of its own price is different. The statistical estimates of these three or four elasticities (depending on whether or not a group has subgroups) are shown in Table I, which also shows the income elasticities, the time coefficient (a_2) as a percent of the value of c_i in the last year of data, the average absolute percentage error (AAPE), and the autocorrelation of the residuals (RHO). The strongest price effects are

TABLE 1

Consumption Equations

FOOD

SECTOR	SUBGROUP	COMMODITY	INCOME ELASTICITY	TIME IN % OF LAST YR.	OWN	PRICE ELASTICITIES GROUP	SUBGROUP	GENERAL	AAPE	RHO
1	13	BREAD	.182	-.7	-.600	.011	.092	.008	1.0	.39
2	13	BAKERY PRODUCTS	.182	1.2	-.632	.008	.060	.005	5.6	.62
3	13	SPAGHETTI AND RICE	.182	-.0	-.683	.001	.009	.001	2.9	.26
4	14	MEAT	.364	1.1	-.508	.066	.137	.046	2.4	.52
5	14	FISH	.631	.4	-.633	.006	.012	.004	3.2	.34
6	14	MILK	.243	-.3	-.629	.009	.016	.005	4.7	.75
7	14	CHEESE	.243	1.7	-.633	.006	.012	.004	3.6	.62
8	14	EGGS	.243	-2.0	-.637	.004	.008	.003	5.5	-.04
9	15	BUTTER	.134	-2.6	-.560	.008	.042	.006	3.5	.69
10	15	MARGARINE AND OIL	.134	1.5	-.579	.005	.023	.003	2.6	.08
11	16	POTATOES	.000	-.6	-.628	.004	.021	.003	9.6	.09
12	16	FOREIGN FRESH FRUITS	.376	-.7	-.627	.004	.022	.003	3.7	.09
13	16	NATIONAL FRESH FRUITS	.376	.5	-.622	.005	.027	.004	7.8	.47
14	16	CANNED FRUITS	.376	1.5	-.645	.001	.004	.001	10.0	.51
15	16	FRESH VEGETABLES	.376	.0	-.607	.009	.042	.006	4.8	.38
16	16	CANNED VEGETABLES	.376	.6	-.640	.002	.009	.001	6.5	-.04
17	17	TEA AND ALIKE	.279	-.8	-.609	.007	.037	.005	4.9	.69
18	17	CHOCOLATE	.279	1.6	-.624	.004	.022	.003	4.1	.29
19	17	SUGAR AND SUGAR PRODUCTS	.364	-.3	-.616	.005	.030	.004	1.6	.20
20	17	OTHER FOOD	.364	2.0	-.618	.005	.028	.003	8.3	.53

BEVERAGES AND TOBACCO

SECTOR	SUBGROUP	COMMODITY	INCOME ELASTICITY	TIME IN % OF LAST YR.	OWN	PRICE ELASTICITIES GROUP	SUBGROUP	GENERAL	AAPE	RHO
21		WATER AND LEMONADE	.704	1.9	-.514	.008		.005	3.4	-.39
22		BEER	.243	.3	-.502	.020		.012	3.4	.50
23		ALCOHOLIC DRINKS	1.061	-.2	-.515	.007		.004	5.2	.21
24		WINE AND OTHERS	1.044	-.1	-.515	.007		.004	7.3	.40
25		TOBACCO PRODUCTS	.911	.0	-.506	.016		.010	2.6	.65

CLOTHING

SECTOR	SUBGROUP	COMMODITY	INCOME ELASTICITY	TIME IN % OF LAST YR.	OWN	PRICE ELASTICITIES GROUP	SUBGROUP	GENERAL	AAPE	RHO
26		CLOTHING	.983	-.5	-.515	.167		.031	2.2	.38
27		SHOES	.631	.6	-.656	.026		.005	3.1	.10
28		LEATHER PRODUCTS (EX SHOES)	1.663	-1.2	-.672	.010		.002	7.4	.63
29		WATCHES AND JEWELRY	1.323	-1.5	-.661	.021		.004	3.0	.56

ENERGY

SECTOR	SUBGROUP	COMMODITY	INCOME ELASTICITY	TIME IN % OF LAST YR.	OWN	PRICE ELASTICITIES GROUP	SUBGROUP	GENERAL	AAPE	RHO
31		COAL	-.607	-3.8	-.563	.036		.007	9.5	.50
32		GAS	1.250	-.2	-.587	.012		.002	3.6	.54
33		ELECTRICITY	1.214	.5	-.562	.037		.008	4.6	.78
34		FUEL OIL	1.214	.9	-.560	.039		.008	15.6	.54

HOUSEHOLD DURABLES

SECTOR	SUBGROUP	COMMODITY	INCOME ELASTICITY	TIPE IN % OF LAST YR.	PRICE ELASTICITIES OWN	GROUP	SUBGROUP	GENERAL	AAPE	RHO
35		TEXTILES AND GLASSWORK	1.129	[illegible]	-.882	.156		.012	1.5	.12
36		WOODEN FURNITURE	1.408	-.1	-.879	.159		.012	10.2	.74
37		METAL PRODUCTS	1.445	-.6	-.928	.119		.009	4.8	.70
38		APPLIANCES	1.214	.7	-.975	.073		.005	9.6	.59
39		RADIO AND TELEVISION SETS	1.263	-.9	-.989	.049		.004	19.6	.80
40		OTHER DURABLES	1.214	.3	-.991	.047		.004	8.7	.66

HEALTH CARE

SECTOR	SUBGROUP	COMMODITY	INCOME ELASTICITY	TIPE IN % OF LAST YR.	PRICE ELASTICITIES OWN	GROUP	SUBGROUP	GENERAL	AAPE	RHO
44		PERSONEL TOILET ARTICLES	1.214	.3	-.544	.021		.008	2.3	.43
45		MEDICAL CARE	.813	.8	-.483	.082		.031	2.2	.53

TRANSPORTATION

SECTOR	SUBGROUP	COMMODITY	INCOME ELASTICITY	TIPE IN % OF LAST YR.	PRICE ELASTICITIES OWN	GROUP	SUBGROUP	GENERAL	AAPE	RHO
46	18	AUTO AND CYCLES	1.639	-.2	-.198	.478	-.358	.016	4.8	.29
47	18	USERS COST OF TRANSPORTATIONS	1.372	.6	-.338	.665	-.498	.023	2.5	.58
48	19	TRAIN	.304	-1.5	-.294	.081	-.647	.003	6.2	.68
49	19	URBAN TRANSPORT	.304	.0	-.460	.101	-.813	.003	5.8	.73
50	19	OTHER TRANSPORT SERVICES	1.457	-.2	-.135	.061	-.488	.002	8.7	.75

HOUSEHOLD OPERATION

SECTOR	SUBGROUP	COMMODITY	INCOME ELASTICITY	TIPE IN % OF LAST YR.	PRICE ELASTICITIES OWN	GROUP	SUBGROUP	GENERAL	AAPE	RHO
41		DOMESTIC SERVANTS	2.683	-2.3	-.695	.037		.011	9.4	.75
42		CLEANING AND TOILET ARTICLES	.607	-.8	-.717	.015		.004	1.8	.55
43		MAINTENANCE	1.129	-.4	-.705	.027		.008	3.5	.74
57		FINANCIAL SERVICES	1.335	.0	-.687	.045		.013	4.2	.50
58		OTHER SERVICES	1.554	-1.5	-.720	.012		.003	2.7	.24
30		RENTS, TAXES AND WATER	1.141	-1.3	-.558	.174		.049	2.5	.77
51		COMMUNICATION	1.372	-.1	-.719	.013		.004	3.3	.72

EDUCATION

SECTOR	SUBGROUP	COMMODITY	INCOME ELASTICITY	TIPE IN % OF LAST YR.	PRICE ELASTICITIES OWN	GROUP	SUBGROUP	GENERAL	AAPE	RHO
54		JOURNALS AND BOOKS	1.068	-.5	-.413	-.262		.003	1.3	.29
56		EDUCATION	.206	1.1	-.234	-.083		.001	2.1	.68

ENTERTAINMENT

SECTOR	SUBGROUP	COMMODITY	INCOME ELASTICITY	TIPE IN % OF LAST YR.	PRICE ELASTICITIES OWN	GROUP	SUBGROUP	GENERAL	AAPE	RHO
52		ENTERTAINMENT	1.214	-4.7	-.542	.006		.003	7.5	.84
53		HOTELS,CAFES, RESTAURANTS	1.773	-1.6	-.503	.045		.024	3.5	.56
55		OTHER RECREATION	1.396	.0	-.525	.023		.012	3.2	.39
59		FOREIGN TOURISM	1.748	-.1	-.523	.025		.013	7.8	.31

in transportation. As expected, Automobiles and the User Cost (gasoline, tires, batteries, repairs) are complements to each other but substitutes for Public transportation. Except for the effect of the prices of Journals and books on Education (private), no other cross elasticities exceed .2 and all but eight are less than .05. That may seem disappointing; to us it was reassuring, for we had neglected these cross elasticities until the large changes in gasoline prices forced us to consider them. With the new functions, we can easily now take them into account, but it is nice to find that we were not overlooking something of great importance outside transportation.

C) Investment Functions

Investment data for Belgium, as we have mentioned, distinguishes twenty-four investing industries. Expenditures by each of these industries are divided into outlays on each of three types of goods:

Transportation equipment	(Moyens de Transport)
Other equipment	(Matériel)
Plant	(Bâtiment)

The data are purchases of new or used plant or equipment minus sales of used equipment at the prices at which it actually sold. At this level of detail, the data began in 1965 and were available through 1974. Longer series are available for total investment; but with an input-output model, the information on the type of investment goods is particularly important, so we limited our study to these ten years.

With only ten observations, we had to concentrate on estimating the essentials of investment behavior, namely, the capital-output ratio and the pattern of the lag between increases in outputs and the investment they stimulate.

Total investment is the sum of replacement plus expansion investment. If replacement is proportional to the stock of capital, and stock is proportional to output, or better, to smoothed output, then replacement is proportional to the smoothed output, thus:

$$\text{Replacement}_t = r\, k\, \bar{Q}_t,$$

where k is the capital output ratio, r is the replacement rate, and $\bar{Q}_t$ is smoothed output. Expansion investment we take to be just the capital-output ratio times a distributed lag on changes in output, thus:

$$\text{Expansion}_t = k \sum_{i=1}^{n} w_i \,\Delta Q_{t-i}$$

where

$$\sum_{i=1}^{n} w_i = 1.$$

Total investment, V, is therefore

$$V = r\, k\, \bar{Q}_t + k \sum_{i=o}^{n} w_i \,\Delta Q_{t-i}$$

or

$$(2)\quad V = k\,(r\,\bar{Q}_t + \sum_{i=o}^{n} w_i \Delta Q_{t-i})$$

with $\Sigma\, w_i = 1.$

For smoothed output we took

$$\bar{Q}_t = .5Q_t + .3Q_{t-1} + .2Q_{t-2} ,$$

where Q_t is output of the investing industry in 1970 prices. We tried three- and four-year lags (n = 2 or n = 3), but in nearly all instances selected the three-year lag. To enforce the requirement that the w's sum to 1.0, we set

$$w_2 = 1 - w_o - w_1$$

Substituting this equation into (2) gave the actual regression equation

$$(3)\ V = k\ (r\ \bar{Q}_t + \Delta Q_{t-2}) + k\ w_o\ (\Delta Q_t - \Delta Q_{t-2}) + k\ w_1\ (\Delta Q_{t-1} - \Delta Q_{t-2})$$

Only three parameters, k, kw_o, and kw_1, are estimated by the regression. For use in the forecasting model, kw_2 is calculated from

$$kw_2 = k - kw_o - kw_1$$

Only a few of the w_i's came out negative. They were set to zero and the other w_i's in the same equation increased proportionally to total 1.0.

The replacement rates were taken as follows:

	Percent Per Year
Plant	5
Railroad transportation equipment	10
Other transportation equipment	15
Other equipment	10

Output of Belgian industries has generally been rising so that the first differences were mostly positive. To insure the nonnegativity of the Δ Q's, however, we defined a "fading previous peak output" as follows:

$$\hat{Q}_{1955} = Q_{1955}$$

$$\hat{Q}_t = \max\ (Q_t,\ .95\ \hat{Q}_{t-1})$$

and then the ΔQ's for equation (3) were defined by

$$\Delta\ Q_t = \max\ (Q_t - \hat{Q}_{t-1},\ 0)$$

This device insures that a declining industry does not generate a negative investment and that, should it start growing and surpass the capacity of its deteriorated equipment, it would eventually again invest, even though it had not reached its previous output.

We remarked above that the effect of this year's output on this year's investment is weak. That is because generally $w_o < .4$; in the industry with the highest capital-output ratios, Electricity, gas and water, $w_o < .2$.

Table 2 attempts to show how well the equations fit over the historical period 1965-1974. The average absolute percentage error is less than 20 percent for two-thirds of the equations. To one accustomed to work with

TABLE 2

How Well Do the Investment Functions Fit?
Average Absolute Percentage Errors
1965-1974

	Means of Transport	Equipment	Construction
1. Agriculture	16	20	10
2. Fishing	45	54	-
3. Coal	exogenous - historically a declining industry		
4. Electricity, gas, water	23	18	26
5. Food and drink	8	5	8
6. Textile and clothing	16	8	17
7. Furniture and wood	9	12	16
8. Paper and printing	23	8	13
9. Chemical and petroleum	96	28	33
10. Glass, cement, ceramics	15	13	27
11. Metals	22	14	17
12. Machinery and metal products	29	15	29
13. Miscellaneous manufacturing	7	9	14
14. Construction	12	23	44
15. Trade, finance, hotels	8	12	9
16. Residential real estate	-	-	Different type equation
17. Railroads	20	73	18
18. Trucking	7	-	-
19. Water transport	20	-	24
20. Airlines	134	33	25
21. Communication	20	19	83
22. Other services	5	17	18
23. Education - government		exogenous	
24. General government		exogenous	

U.S. data, that does not appear to be a very good performance, but closer inspection of the data convinces us that not much would be gained by further econometric refinement of our equation. It works well enough in industries, such as Food and drink, made up of many small firms. Where the decisions of a single firm dominate the series, as those of Sabena do in the Airlines sector, wide fluctuations occur. Sabena spent seven times as much in 1970 as in 1971, and in 1972 one-third of what was spent in 1971. The equation spread about the right amount of spending out over the three years. Sabena, of course, could consider many more special factors than can any one equation in a national model. In industries with many small firms, the special factors balance out across firms. The big miss in Chemicals and petroleum - means of transport, is largely attributable to low actual spending in 1965, which was less than ten percent of the 1966 level. Other misses in this industry stem from the natural lumpiness of investment in large chemical plants and refineries. The large error in construction by Communication is connected with a political scandal concerning post office construction. The misses pleasantly remind us that there are men back of the numbers. They do not make the equations useless for forecasting 1985 or 1990; they merely caution us that the 1985 forecast is only for a "typical" year around 1985. Someone is sure to make the actual 1985 distinctive. Likewise, the fact that the errors are relatively larger for Belgium than for, say, the U.S., does not mean that business forecasting is harder for Belgium, precisely because a large part of the swing in demand shows up in imports. Belgian production itself is about as steady as that of other countries.

D) Imports

The import equations are of the form:

$$M_i = (a_i + b_i\ D_i)\left(\frac{p_{fi}}{p_{oli}}\right)^n$$

where

M_i = imports of commodity i in year t

D_i = demand for commodity i; it is discussed further below

P_{di} = the domestic (Belgian) price index for commodity i

p_{fi} = an index of foreign prices for commodity i.

More precisely, p_{fi} is a weighted average of prices in the other eight countries for commodities as similar as available statistics allow to commodity i in Belgium. The prices include the effects of exchange rate changes but not the effect of tariff changes. The weight on the price of a given country is equal to that country's share in Belgian imports of commodity i in 1970. The shares, however, are taken from the trade model and refer to the shares of the other countries in that model in Belgium's imports of the combination of commodities in that model which most nearly match Belgian product i.

In most equations, D_i is domestic demand, defined as output less exports plus imports. This is the definition used in all the other models, but for Belgium it soon became apparent that for some important sectors such as Chemicals and Machinery, the imports depended on the exports of the same product group. Chemical inputs, for example, into chemical exports might well be imported. This sequence of import-process-export, all within the same commodity classification, is so common in Belgium that we had to change the definition of D to include exports for a number of products.

Some examples for both types of D variable are shown in Table 3. The weighted averages (with 1973 import weights) of the import price elasticities is -1.5. As usual, the elasticities are highest for finished goods, such as Metal products (-3.0), Electrical machinery (-3.0), and Chemicals (-2.0), and low for basic materials, such as Steel (-.13), Agriculture (-.50), and Oil (.80). This table also shows the trend in percent per year of the foreign to the domestic price ratios. For most products, foreign prices have been falling relative to Belgian prices as viewed by the Belgian importer, that is, account taken of exchange rate changes. In projecting prices, however, we project each country's prices unadjusted for exchange rate changes. These changes may then be introduced independently into the model.

E) Exports

The export equations are similar in form to the import equation:

$$X_i = (a_i + b_i\ D_i)\ \left(\frac{p_{fi}}{p_{di}}\right)^{n}$$

The difference lies in the definition of p_{fi} and D_i. The p_{fi} is still a weighted average of other countries' prices, but here the weights are Belgian exports of i to the country, not Belgian imports. The D_i is now a weighted average of outputs in other countries of products similar to product i. The weights are Belgian exports of i to the country. Some of the results of estimating these equations are shown in Table 4. Belgian exports are, in total, very demand sensitive and also relatively price sensitive. Using the exports of 1973 as weights, the weighted elasticity exports with respect to foreign demand is estimated at 1.6 and with respect to price, -1.4. Further, Belgian prices, including exchange rate effects, have been, on average, increasing .3 percent per year faster than their foreign competition. The recent world recession and the general upward revaluation of the franc have both contributed to an adverse effect on Belgian exports. The industries where Belgian prices have fallen, on average, relative to foreign prices have been the growth-oriented sectors of the economy. For example, Iron and steel, Glass, Chemicals, Automobiles, and Plastics have had falling relative prices. On the other hand, Agriculture, Non-ferrous metals, Machinery, and Apparel have experienced rising relative prices.

This export equation, however, is a temporary expedient; the permanent replacement for it will be even simpler:

$$X_i = a_i + b_i\ E_i$$

where E_i is simply the imports of all other countries in the international trade model of Belgian products corresponding to domestic product i. The price effects and the foreign demand effects will all be accounted for within the trade model.

TABLE 3

Imports

Sector	Elasticities: Price	Elasticities: Demand	$\frac{P_F}{P_D}$	1973 Imports
Demand Excludes Exports				
1. Agriculture	-.50	.86	-3.4	79,444
5. Oil	-.80	.84	-0.4	62,606
9. Iron and steel*	-.13	-	3.3	45,525
23. Other food	-1.50	1.33	-2.2	35,923
27. Other textiles	-1.50	1.47	0.6	39,103
34. Other industry	-2.00	1.05	1.2	49,267
Demand Includes Exports				
10. Non-ferrous metals	-1.20	1.01	-1.7	61,567
14. Chemicals	-2.00	1.01	-0.2	83,897
15. Metal products	-3.00	1.17	-1.6	27,006
16. Machinery	-1.60	.80	-2.0	64,444
18. Electrical machinery	-3.00	.45	-4.3	55,872
19. Automobiles	-1.40	1.07	1.5	104,005
Average	-1.51	.99	-0.7	

TABLE 4

Exports

Sector	Elasticities		$\frac{P_D}{P_F}$	1973 Exports
	Price	Demand		
1. Agriculture	-.5	1.79	3.6	21,802
5. Oil	-1.75	1.15	0.0	23,424
9. Iron and steel	.00	1.18	-3.3	105,009
10. Non-ferrous metals	-1.00	1.29	2.4	56,847
11. Glass	-.60	1.13	-0.7	14,033
14. Chemicals	-2.00	1.27	-0.1	99,125
16. Machinery	-3.00	1.64	1.6	51,491
19. Autos	-1.80	1.70	-0.8	89,781
21. Meat	-1.50	2.53	-1.8	23,669
26. Apparel	-1.50	4.11	2.1	24,567
27. Other textiles	-1.50	2.08	-0.5	61,499
29. Wood products	-3.00	1.90	-0.6	18,655
33. Plastic products	-2.00	1.34	-0.9	10,667
34. Other industry	-2.00	1.35	-0.5	38,348
Average	-1.43	1.60	0.3	

F) Employment

The employment series were developed for thirty sectors of private employment for the years 1960 to 1974. They include both employees and the self-employed. For each series, the equation used to forecast is simply

$$\ell n\ (E/Q)_t = a + bt + c\ (\ell n\ Q_t - \ell n\ Q_{t-1}).$$

E is employment in one of the thirty industries, and Q is an aggregate of the outputs of one or more of the fifty-two sectors, selected, of course, to match the employment sector. The b term gives the average rate of change of labor requirements per unit of output. The estimated values of the b's (multiplied by -100 to make them percentage rates of productivity increase) are shown in the first column of Table 5. By American standards, they look high. The last term of the above equation is designed to take into account a lag between increases in output and increases in employment. A value of -.4 for c implies that only 60 percent of the increase in employment needed to handle an increase in output will actually be hired in the year in which the output has increased; hiring of the other 40 percent (corresponding to the -.4) will be deferred to the next year. The values of -c, the deferred shares, are shown in the second column of Table 5. Deferrals of more than fifty percent were not allowed. The last two columns show the $\bar{R}^2$ and the auto-correlation of the residuals, Rho. Poor fits appear in the machinery industries (Numbers 10-13), which also had poor fits for investment. Productivity in Rubber, which has the poorest fit, has gyrated widely; the equation actually does a surprisingly good job of tracking it.

The Belgian model still needs inventory change equations, and wage, price, and income equations. We hope they will be added in the next year. Even without these elements, it has been giving useful and sensible results.

III. SPECIAL FEATURES OF OTHER COUNTRY MODELS

We mention some of the noteworthy features of other models without trying to be complete.

A) Dimensions

First, we summarize the dimensions:

	Products	Investment Sectors	Employment Sectors
Belgium	52	24	30
Canada	92	42	42
France	78	29	29
Germany	48	1	48
Italy	44	23	44
Japan	156	22	22
U.S.	190	90	90

B) Input-Output Coefficient Change

All of the models, including the Belgian model, have had coefficient changes estimated on an across-the-row basis, all coefficients in a row

TABLE 5

Labor Productivity Equations

	Productivity -100*b	Deferral -c	$\bar{R}^2$	Rho
1. Agriculture and fishing	9.7	.50	.99	.59
2. Coal	3.0	.30	.81	.60
3. Coke	11.0	.10	.90	.65
4. Petroleum refining	12.5	.50	.98	.46
5. Electricity, gas, water	7.9	.36	.98	.74
6. Iron and steel	4.0	.50	.96	.23
7. Non-metallic minerals	5.5	.50	.98	.35
8. Glass		7.9	.33	.99
9. Chemicals	9.9	.48	.99	.47
10. Metal products	2.6	.50	.89	.39
11. Machinery	4.7	.40	.94	.50
12. Office and precision machinery	3.1	.38	.90	.58
13. Transportation equipment	3.5	.41	.82	.53
14. Food	4.3	.31	.98	.74
15. Beverages	4.7	.00	.97	.74
16. Tobacco	4.2	.43	.99	.23
17. Textiles	5.9	.49	.99	.67
18. Shoes and leather products	3.6	.15	.93	.42
19. Clothing	4.7	.49	.97	.78
20. Furniture and wood products	9.2	.50	.99	.71
21. Paper	7.5	.28	.99	-.04
22. Printing	2.8	.50	.89	.40
23. Rubber	3.9	.50	.70	.84
24. Plastics	13.2	.33	.99	.36
25. Miscellaneous manufacturing	7.4	.00	.94	.69
26. Construction	7.0	.45	.98	.34
27. Trade, hotels, repair	2.4	.50	.99	.52
28. Transportation-communication	3.2	.36	.94	.80
29. Finance	2.8	.50	.93	.57
30. Other services	1.7	.28	.94	.56

of the A matrix receiving the same percent per year change. In the U.S. model, we have also studied and projected trends in individual coefficients. We are also experimenting with the Diewert production function which makes a_i, the requirements of product i for producing some good, depend on the relative prices of goods competing with i, by the equation:

$$a_i = \sum_{j \in C} b_{ij} (p_j/p_i)^{1/2} \quad \text{with } b_{ij} = b_{ji}$$

where C is the set of competitive products. It may appear that the exponent 1/2 is rather arbitrary, but it can be shown that no other value for the exponent is consistent with efficient decision making by firms. Our experiments are on the competition among transportation modes and among metals and plastics.

C) Investment Functions

Long time series on investment in the United States make it possible to improve substantially on the investment functions used in Belgium. Replacement requirements are computed directly from long-past investments. Interest rates and other influences on the cost of capital enter, via a CES production function, into the determination of the desired capital-output ratio. Distributed lags of up to six years are allowed on the response to changes in output or cost of capital.

The Japanese equations are similar to those for the U.S.

D) Wages, Prices, and Income

Only the U.S. and the Japanese models have complete wage, price, and income sides. We describe the U.S. model, and that only schematically.

The structure of the model is very much influenced, of course, by the accounting framework within which it works. In the United States, annual accounts of the components of value added — wages, supplements, proprietor income, excise taxes, other indirect business taxes, capital consumption allowances, interest payments, and profits — are maintained only at a level of 56 industries. (They are not published at even this level, but may be obtained on request to BEA.) Wage payments, however, are available at much finer detail and can be aggregated to match 190 input-output sectors. For the base year of the input-output table, total value added is, of course, available. To calculate prices, we must have value added at the I/O sector level, so that we may use the equation

$$p = pA + v$$

where
- p is the row vector of prices
- A is the input-output coefficient matrix
- v is the row vector of value added.

These facts have dictated the following structure: We use the base year value added of each I/O sector as weights for making up a value-added-weighted index of output of each of the 56 sectors. Modeling of income is then done at this level, except that wage payments are modeled at a finer level. The non-wage components of value added of each of the 56 sectors are then prorated back to the constituent input-output sectors in proportion to their contributions to a non-labor-value-added-weighted index of labor income of the 56-order sector.

Labor compensation is determined in a two-step procedure: (1) a quarterly aggregate wage rate is estimated from a Phillips-type equation with lagged values of consumer prices and unemployment, together with the number of workers involved in collective bargaining negotiations and changes in the Social Security tax rate. (2) the ratio of each industry's wage rate to this average wage rate is made a function of lagged unemployment, current rates of inflation of consumer prices, the rate of change in employment in the given industry, and a time trend. From the wage rates, employment, social security taxes and other wage supplements, we get labor compensation for each of 100 industries which can be aggregated to the 56 industries. Excise and indirect business taxes are fairly readily forecast. The ratio of all other value added--profits, interest, capital consumption allowances, and proprietor income — to labor income is then made a function of such variables as changes in output of the industry, an output-to-capital stock ratio, the deviation of actual from trend labor productivity, or a time trend. All of these variables are available in the model. This non-wage value added is then prorated back to the 190 sectors to make up the v vector from which the prices are then calculated by the $p = pA + v$ equations. The prices then affect consumer demands, exports, imports, and input-output coefficients on the "real" side of the model. The income side of the model is completed by aggregate equations to determine personal income from total wage income and total non-labor-non-tax value added. Finally, personal income goes into a tax-collection function and out comes disposable income ready to go into the consumption functions if the model is being run with the income loop closed.

A somewhat anomalous feature of this model is that it determines the absolute price level without explicit consideration of the quantity of money. It can do that because, as it is usually run, it aims at a target level of employment. Hence, the unemployment influence on wages is given. To build a model to study monetary policy, we would need also equations for interest rates and influences of interest rates on consumption in addition to their present inclusion in investment. Thus, monetary policy would affect real output, which would affect employment, which would affect wages, which would affect prices. The model would then have to be run with the income loop closed. It is our feeling that the solution of this closed-loop system is just as well done on a much more aggregative model and the resultant disposable income and interest rates fed into the big model, whose results serve as a check on the aggregate model.

IV. THE TRADE MODEL

Space permits only a theoretical description of this model. The empirical results are described fully in [6] and more briefly in[7].

The trade model focuses on forecasting exports of 119 commodities of merchandise trade from nine developed countries. The OECD granted permission to use its Trade Series C computer tapes on bilateral trade flows for the years 1962-1972. For each year there were ten computer tapes -- five with export data and five with import data. The data, which on the tapes arrived by year by country by commodity, needed to be organized by commodity by country by year so that it could be studied econometrically in a time series.

The basic point of reference for the analysis are trade flow matrices, M, one for each of the 119 commodities. Each M is square and has as many rows or columns as there are countries in the model. The i^{th} row of M expresses the exports of country i to each of the other countries. The diagonal elements are all zero, except for our tenth country, a region called the "rest of the world" (or more simply "Others") where the remaining countries are aggregated together into one region to obtain intraregional flows. Thus, the total imports of country j are given by the column sums $M_{\cdot j} = \sum_i M_{ij}$, and total exports of country i is the row sum $M_{i\cdot} = \sum_j M_{ij}$. The matrix of market shares S_{ij} is thus obtained by dividing each column of M by its column sum. Hence, S_{ij} is the proportion of goods from country i in country j's imports.

Predicting the S matrix is the main burden of the trade model. The basic equation we shall use for doing so is:

$$(1)\quad S_{ijt} = S_{ijo}\, P_{ijt}^{\,b_{ij}}$$

where

P_{ijt} = the effective price of the good in question in country i, p_{eit}, relative to the world price as seen from country j, p_{wjt}. Mathematically, we could write $P_{ijt} = p_{eit}/p_{wjt}$.

Note that the exponent, b_{ij}, may be different for each exporter i. This is a significant generalization of previous formulations which had specified that the b's be the same for each exporter.

To insure that global exports equal global imports, the world price as seen by country j, p_{wjt}, is defined implicitly by the simple requirement that the sum of the shares of all countries in country j's imports should equal 1, thus:

$$(2)\quad \sum_i S_{ijo}\, P_{ijt}^{\,b_{ij}} = \sum_i S_{ijo}\, (p_{eit}/p_{wjt})^{b_{ij}} = 1$$

Equation (2) is linearly homogenous in the prices. Suppose all domestic prices, p_{eit}, are doubled; then a doubling of the world price, p_{wjt}, will leave the price ratio undisturbed. Another property of this definition of the world price is that the ratio of the shares of any two countries will change if a third country changes its price (provided neither country's share is zero and both do not have identical b's).

Equation (1) can also be written in terms of trade flows as:

$$(1')\quad M_{ijt} = S_{ijo}\, M_{\cdot jt}\, P_{ijt}^{\,b_{ij}}$$

The equality of exports and imports can be seen easily by summing (1') over exporting countries i and using the world price defined by (2):

$$\sum_i M_{ijt} = \sum_i S_{ijo} \, M._{jt} \, P_{ijt}^{\;b_{ij}}$$

$$= M._{jt} \sum_i S_{ijo} \, P_{ijt}^{\;b_{ij}}$$

$$= M._{jt}$$

This solution to the adding-up problem by the implicit definition of p_{wjt} should be noted carefully. The whole method rests on it.

One further aspect of equation (1') should be noted. The value flow, M_{ijt}, has been deflated by the exporting country's domestic price index. So we are dealing with volume flow. Note also that total imports of country j have been expressed (in volume terms) as the sum of all volume exports to it. Therefore, the proper deflator for imports to j does not contain the domestic price index of j (except when $M_{ii} \neq 0$, i.e., for intraregional flows).

The problem now is to find a set of substitution parameters (b's) and a series of world prices which are consistent with conditions (1) and (2). A simple iterative procedure was planned whereby values for the b's would be assumed and then (2) would be used to solve for the world price. Then (1) would be used to estimate the b's, and then using those b's, so ran the plan, the world prices would be recalculated, and so on. Unfortunately, this procedure did not converge, and a little reflection made it clear that it could not. Suppose that among the first b's we calculate, Canada's comes out highest on the first solution. The Canadian price will then carry a heavier weight than previously in the world price of the second iteration. On that iteration, the calculated world price will conform more closely to the Canadian price and, hence, an even higher value of the b for Canada will ensue.

After the failure of the simple procedure, a more complex non-linear estimation method was adopted. The non-linearity arises because the b's enter (1) not only directly, in the exponents, but also indirectly through the definition of the world price. The way out for us was to pick initial b_i and then find the b_i which would minimize

$$\sum_t \sum_i \left(S_{it} - S_{io} \sum_k \frac{\partial}{\partial b_k} \frac{p_{it}}{p_{t}}^{\,b_i} \Delta b_k\right)^2 .$$

In taking the partial derivatives required here it is essential that the dependence of p_w on the b_k be incorporated in the derivative. The value of Δb_k are then used to modify the b_k, and the process is repeated until it converges in the sense that the world price of one iteration differs but little from that of the previous iteration. With this procedure, convergence ceased to be a problem.

One further aspect of (1) needs to be noted. The effective price, p_{eit}, used thus far is defined as a weighted average of present and past domestic prices.

$$(3)\ P_{eit} = \sum_{\tau=0}^{5} W_\tau P_{it-\tau}$$

It is assumed that the weights, the w's, will vary from commodity to commodity; but, for a given commodity, will be the same for each importer. Data limitations are very constraining in this case. To estimate six lag weights for one country with eleven years of data is simply not a reasonable procedure; but to estimate those weights for all ten countries means we have 110 observations.

For non-price effects, a simple trend term was added to (1). The resulting form,

$$(4)\ M_{ijt} = S_{ijo}\ M._{jt}\ P_{ijt}^{b_{ij}} + g_{ij}\ t,$$

is not as formidable to estimate as first appears. (1) is used to estimate the b's and the world prices and the trend parameters, the g's, are estimated for the residuals. Since each g is estimated independently, the g's will not automatically sum to zero. If an adjustment to the g's is needed, then those with the best fit should be adjusted proportionally less than those with poor fits. Each g was adjusted in proportion to its standard error so that a zero sum was obtained.

To use the trade model fully to connect the country models, two additional steps are needed:

1) Develop equations for the total imports of each country of each of the 119 trade-model commodities. Each of the 119 will be related directly to the most appropriate sector's imports in the importing country's model.

2) Develop export equations for each country relating its exports of each sector to the sum of the imports from that country by all other countries of the one or more of the 119 commodities most closely matching the country's sector's definition.

These steps are not difficult, but are a bit time-consuming. When accomplished, we will have an international system of country models, each in that country's statistical system, linked by an international trade model in a common statistical system.

V. DIRECTIONS OF RESEARCH

The first and obvious goal is the completion of the system as planned. There can be no doubt about the technical feasibility of that goal, although several man years of work are still required.

When complete, however, its coverage of world trade will be rather uneven. Countries accounting for 57 percent of the world's imports (in 1972) will have detailed country models. The rest of the world, accounting for 43 percent of imports, will be represented only by a single aggregate model. The greatest need will then be in elaborating models for regions or countries within this "Rest of the World." One further country is an obvious claimant for its own model, namely the USSR, whose foreign trade in 1972 was about the same as that of Belgium or the Netherlands. The next country in size of foreign trade, Switzerland, has only about half as much trade as do these three countries. Consequently, that seems to be a good place to draw a line on country models as components of the trade model. To make any divisions of the rest-of-the-world sensible, it will need to include at least ten or twelve regions. If we had many more, the trade model would become prohibitively expensive to estimate and operate; if we have fewer, we encounter strange combinations of countries.

The models of each region would be very aggregate with three or four classes of consumer spending, equipment investment, construction, government spending, and aggregate employment; exports and imports, however, would be at the 119-commodity level. A typical input-output table could be used to construct weights for each of these components in indicators to be used in regression analysis of import demand for each of the 119 commodities. These equations could also use selected exports. Exports, of course, would be just the sum of other countries' and regions' imports from the given region.

The trade model could be completed in this way. We hope, however, that many small countries will want to build models which would draw on the system for detailed projections of their economic environment. In Austria, work is well-advanced on such a model. We have spoken with researchers in Spain, Korea, and Australia about their interest in building models to tie into the network. A group of closely related countries, such as Scandinavia or Eastern Europe, might well develop input-output models for all countries in the group and a trade model for intra-group trade, as well as a tie with the global trade model. The Eastern European and the Soviet models will be particularly interesting to build, for ways have to be found to express scarcities without relying on prices. Pioneering work in this direction has been done by Yaremenko [8] and others.

The possibilities for further fruitful work appear boundless; but at the same time, we are already producing results that can be helpful for private and public planning in an increasing number of countries.

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DISCUSSION

In reply to a question by Petri concerning iterations, Almon explained the procedure: in the US model, for example, first the real model is run with an assumed value, assuming that prices will continue their present trend; from the real model outputs they go over to the price model to determine surpluses, rates of change of output, etc.; these, in turn, will cause certain changes in the prices which are being brought back into the model, influencing demand, changing input/output coefficients, generating again the stream of output, etc. Usually, 2 or 3 loops will suffice.

Petri wondered whether this same iterative procedure is also applied concerning world trade prices and world trade interactions; Almon replied that this last interaction is yet to be done.

Krishnayya wondered how many man-years have gone into the development of the model so far. Almon was unable to answer, because it is no longer possible to assess how much effort went into the data collection. He can give a partial reply with respect to the FRG where 2 professional man-years (plus overhead) were required.

In reply to a question by Fritsch regarding the time horizon of the projections, Almon answered that it is generally 10 to 15 years; the US model at present runs to 1990. All models can easily be run further into the future but he feels that their greatest usefulness lies in the period of 3 to 10 years ahead. Anything beyond 15 years comes out simply as a straight line.

Richardson asked about the relationship between this model and the original Leontief project. Almon replied that there was no official relation, but substantial intellectual connection. His model is supported almost entirely by American companies who wish to use it for their decision making. Hartog wondered to what extent classical econometric methods, like regression analysis, have been used to determine the parameters. Almon replied that he was rather dubious concerning too mechanistic procedures; "goodness of fit" alone, in practice, need not yield the best estimate, in particular also because of the high collinearity. Econometric estimates need to be corrected by common sense and by other external information.

Part Two

FUGI - FUTURE OF GLOBAL INTERDEPENDENCE

Chapter 7
INTRODUCTION

Yoichi Kaya and Akira Onishi

INTRODUCTION

Movement toward global interdependence

Recently, in the field of economic sciences, as in other fields, the waves of change-with-the times are surging forward, signifying that the frameworks for the economic sciences which held in the past are losing their efficacy and becoming unable to respond to many of the changes inherent in the new conditions that typify the world scene.

This is in part because the angles of vision utilized by economists in the past have been too narrow. For example, to look at the economies of the major advanced industrial countries of Asia, America, and Europe, these economies have multitudinous links of an international character, and if there should be changes in the state of the economies in these major countries, these changes very soon make themselves felt through the entire world. Or, as may be seen in the case of the "oil shock," the "oil strategy" of the OPEC countries has not only produced a large impact on the economies of the industrially advanced countries, but has at the same time given rise to even more serious repercussions on the economies of many of the developing countries -- once again indicating the existence of a "systems structure" of mutual interdependence in the global economy.

Efforts to look squarely at the realities of this interdependence among countries and to systematize them within a framework of economic theory have up to now remained, by and large, outside the purview of economists. In short, economists in the past have focused their attention not so much on the economic relations among countries as on the economies of single countries, confining their discussions largely to such questions as the type of price mechanisms by which domestic economies move, the resultant allocation of resources under such-and-such a price mechanism, or the sorts of repercussions and effects on a country's economic tenor which might be induced by government expenditures.

But recently, in quite a different dimension from the above-mentioned problems, we are obliged to consider simultaneously a number of matters, any one of which has international extensions -- whether it be the much discussed theme of economic growth; whether it be problems of resources and energy; whether it be problems of food, population, inflation, or the natural environment; or whether it be inquiries into human values or the uses of information. The transnational character of these questions radically shakes the very foundations of any system which pretends to be based on a single country, and furthermore calls into question the meaning of "economic security."

Of course, it is possible that there may be cases in which one can solve problems at the level of a single country or region, but there are also times when an economic policy of a given country causes a very large negative effect on the economic security of other countries. We are now indeed at an historical stage characterized by a new and global economic order of interdependence. It is indeed this very fact that has raised the curtain on the "Global Age" that is now directly before us.

In brief, we are at this very moment facing an experience never known before. In regard, for example, to problems of natural resources and, in particular, of petroleum (which is the natural resource that is receiving the greatest attention on the international scene), the possibility that petroleum might in the future become exhausted was a problem which remained outside the framework of the science of economics as it existed heretofore. And of course there were no economists who carried on research or made predictions regarding, for example, what sorts of strategies the Arab oil producing nations might adopt in the event of a drying up of oil resources, or what sorts of impacts a situation of global oil depletion would have on the world economy.

Due to such conditions of inexperience, it is necessary that we search for indications of how the world economy is likely to change in the future and for the course that the coming international economic order ought to take.

As is generally known, it was the report of the Club of Rome entitled *The Limits to Growth* which, treating such questions as environment, resources, food and population as a single world system, first predicted that the world economy, under the constraints imposed by resources, could not continue to exhibit the same patterns of economic growth that had prevailed in the past. This report, the result of studies by the group around Prof. Meadows, and based on the world model developed by Prof. Forrester, attracted worldwide comment and interest.

A characteristic feature of the above model is that it takes the world as a single unit, dealing with such major variables as population, production, food, resources, pollution, etc., as totals for the entire planet. For this reason, the model was powerless when it came to analysis of so-called "North-South" relationships -- i.e., the economic relations between the developing and the industrially advanced countries -- which determine the framework for the global economic order. The "policy conclusions" from this world model are that in order to maintain a future balance among global population, resources, and environment, it will be necessary for industrially advanced countries to achieve a zero growth in production, and for developing countries to attain a zero population growth. However, this model does not make clear the sorts of effects on the developing countries' economies that would result from a zero growth in the important economies of the industrially advanced countries.

Moreover, criticism of the phrase "limits to growth" has arisen especially from among the developing countries. This is because the developing countries, in order to free themselves from economic poverty, have to increase production. And because increasing production is connected with growth, the idea of a "zero growth pattern" is difficult to accept. In the case of the industrially advanced countries, because they already have high standards of living, they can at least maintain present standards of living even if the rates of economic growth were to slow down somewhat.

Thus, if economic growth were to be stopped at the present point, even though such a situation might be accepted by the industrially advanced countries which are already ahead in resource consumption, such a proposition has given rise, among the developing countries, to arguments that it would be greatly to their disadvantage.

A subsequent task, then, came to be that of constructing a world model that, dividing the world into several regions, can delineate relationships of interdependence among them. The report entitled *Mankind at the Turning Point* presented by professors Mesarovic and Pestel at the West Berlin meeting of the Club of Rome in October, 1974, was an attempt to respond to the above problem [1].

They criticized the method of treating the world as a single unit as was done in the Meadows model [2] and instead divided the world into 10 regions as follows: 1) North America, 2) Western Europe, 3) Japan, 4) Australia and other advanced market economy regions; developing market economy regions in the four areas of 5) Asia, 6) Middle East and North Africa, 7) Rest of Africa, 8) Central and South America; centrally planned economy regions subdivided into 9) Soviet Union and Eastern Europe, and 10) China and other Asian socialist countries.

The Mesarovic and Pestel world model was constructed using the techniques of general systems theory, which are somewhat different from the "systems dynamics" techniques used by Prof. Forrester [3]. Insofar as it is not limited just to an "economic sector" but accommodates subsectors dealing with such things as population, food, energy, etc., it is similar to the model produced by the above-mentioned Meadows group, but is characterized by the especially large amount of attention paid to relationships among the factors of economic growth, population, food, and energy, particularly oil.

Mesarovic and Pestel, using the above model, deduce a number of forecasts corresponding to various scenarios.

For example, if the OPEC countries should adopt policies of raising the price of oil as a matter of strategy, this of course could, in certain cases, give rise to countermeasures on the part of industrially advanced countries, while opposition and contradictions would be expected to occur, and worldwide economic security might be lost, with all countries running into extraordinary crises.

This sort of strategy can be seen in due course to rebound negatively against the OPEC countries themselves and so it is seen that such action could by no means constitute a well-advised policy.

It may be concluded that there is a need for every country to put more effort into reasonable reforms, with international cooperation as a goal to be striven for. What constitutes the greatest brake on these needed reforms and international coordination is the perception of opposing interests among nations, arising from current conceptions of national sovereignty.

This situation is the greatest factor which necessitates change -- and immediate change -- in value outlooks. The tradition of each country acting in accordance with its own national ego is the basic evil which is causing a loss of control in coping with new problems at the global level. Comparing this sort of situation to the human body, if cancer cells should be allowed to grow and expand according to their own convenience, the body will be exposed to mortal danger. In the same way, if each country should behave in such a way as to pursue economic growth and "security" only in accordance with its own "national interests" or "national advantage," it is possible that such behavior could invite serious crises for the whole of humanity. Mesarovic and Pestel thus conclude that a new international economic order must be sought from the perspective of the whole of the human race.

The Tinbergen report entitled *Reshaping the International Order* [4], presented at the Algiers meeting of the Club of Rome in October, 1976, is an attempt to respond to questions such as those suggested above. This report takes the fresh approach of seeking a course for the new international order within the framework of "humanistic socialism." In other words, it is stressed that in order to realize a truly egalitarian society which guarantees human dignity and fundamental rights, it will be necessary to alter the present framework of international order and to build up a society of "humanistic socialism" through dialogue and solidarity between the industrially advanced countries and the developing countries.

As is well known, in the "Declaration and Program of Action for the Establishment of a New International Economic Order" adopted by the 6th Special Session of the United Nations General Assembly in April, 1974; in the "Charter of Economic Rights and Obligations Among Nations" of December of that year; and again in the adoption of the Lima Charter of UNIDO in March 1975, the demands of the developing countries have been focused on what is known as a "new international economic order." And at the same time, on the basis of the deepening relations of interdependence between the industrially advanced and the developing countries, a mood of dialogue and cooperation has gradually arisen to eclipse the more extreme aspects of North-South confrontation. The turning points in this trend may be said to be the Conference on Development and International Economic Cooperation held as a part of the 7th Special Session of the United Nations General Assembly in September, 1975, together with the Conference on International Economic Cooperation held in Paris in December of 1975. The same spirit was inherited by the 4th General Meeting of UNCTAD held in Nairobi in May, 1976.

The above-mentioned Tinbergen report, which, through a reexamination of the present international economic order, attempts to suggest directives for a new international economic order, has a rather different character from the research done using the world models of the Meadows group or of Mesarovic and Pestel. In short, the Tinbergen report places its main emphasis on research of a qualitative rather than a quantitative nature, and is characterized by its attempt to set up an analytic system linked to the specific ingredients of the international economic order for purposes of establishing mutual relationships among such things as economic development, price stabilization for primary commodities, multinational corporations, technology transfers, resources, environment, welfare problems, etc.

As we can see from the above, we have now arrived at an age in which it is not a matter of "putting old wine into new skins," but rather of putting into new skins things of a new dimension -- namely, the new ways of thinking and, indeed, the new civilization which are the requisites for opening new doors in world history. We will no doubt have to refine and purify the accomplishments of those who have gone before us and search for creative directions in which to apply some of these accomplishments to good purpose in the new age.

Project "FUGI"

Recognition of the inevitability of global interdependence as a result of the expansion of human activities in a limited space and of the indispensability of realizing a more equitable distribution of wealth among people on the globe is the main driving force of the authors conducting research under the name of project "FUGI", future of global interdependence.

People may raise many questions on the future of the world economy and industry. Some are related basically to its macro-economic aspect; what is the prospect of the "taking off" of developing countries amongst the stringent competition in the world market? What level of growth is acceptable to the modern industrialized society within the constraints of global resources and the environment? If the slowdown of advanced industrialized economies is inescapable, will it also be unfavorable to the developing economies? If yes, how will the slowdown be reversed?

If we notice that world trade is closely linked to the industrial production pattern in each region or country in the world, investigation of questions about the future of world industry as well as those about the macro-economy should also be included in a research effort of this kind. The most serious among a number of problems concerned with industrialization is the competition in the world market of manufactured goods between advanced industrialized countries and developing ones. The former countries have so far dominated the world market and the countries with scarce resources such as Japan still have to live on the export of these goods. Nevertheless, some of the latter countries are very poor in resources (except human resources) so that their future relies heavily on development of a manufacturing industry. Will the harmonious growth of these two kinds of countries be possible? If so, in what way? The answer to these questions could hardly be sought without an integrated approach to the future of world industry, for various different factors of the dynamics and characteristics of the economy and industry of each region or country should be taken into account in the analysis. This motivates us to conduct research through construction of a global multisector model.

The earlier approach by the authors was the exploration of the future optimum industry location patterns, with a normative dynamic input-output model as a main tool. The research report was presented at the 1974 Club of Rome conference in Tokyo and published under the title of *Global Constraints and A New Vision for Development* [5]. It is one of the consequences of this study that the industrialization of Asian developing countries may be accelerated by the move of the resource-rich advanced industrialized countries from the present structure to a more agro-oriented one and that a slowdown of the growth of rich countries may not necessarily be linked to the decline of poor ones if there is appropriate transfer of some manufacturing industries from the former to the latter.

The authors, however, have to confess that the model employed in this earlier approach is not free of a shortage of accurate data on the past history of industries, especially of developing countries, and that it is too bold to investigate more detailed scenarios of the future of the world industry and economy using only this model, since dynamic model errors may accumulate year by year and reduce the results of the computations to a pile of meaningless numbers. Difficulty in gathering accurate information on respective industrial sectors of developing countries, especially on the dynamics of production (parameters of the production function, for instance) is one of the serious barriers disturbing construction of multisector global models. The authors are therefore much concerned with how this difficulty has been overcome in other global modeling efforts such as Mesarovic - Pestel's and Leontief's [6].

Our choice was to build a model of T-shape structure, that is, a static input-output model linked to a dynamic macro-economic one (Figure 1). The vertical line or axis of the letter T corresponds to the time axis (built in the macro model) and the horizontal one to the sector axis (built in the input-output model). The framework of the macro-economy in a specified year generated from the former model is put into the latter in the form of exogenous variables. The corresponding industrial structures of different regions in the world are determined as a solution of a linear program optimizing a given criterion under given constraints related to the characteristics of the industrial production and international trade. This T-type model is, in the authors' opinion, the best suited to investigation of the long-term future of the world economy and industry, as the existing data on the dynamics of macro-economies are much more easily collected and much more reliable than those on the dynamics of respective industrial sectors.

The main defect of the T-type model is the lack of a linkage from the sector axis to the time axis, that is to say, the lack of a mechanism by which a change in the pattern of world industrial production may have an impact on the growth of economies in different parts of the world. This problem can, however, be greatly eased by the use of two means. The first is to relax the framework of the world macro-economy given to the static multisector model, or, to give upper and lower limits of macro-economic variables, determined from the macro-economic model, to the multisector model as constraints.

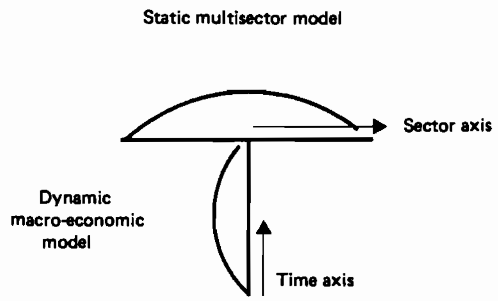

Figure 1. T-type structure of the model.

The second is to aggregate the results of the computer run of the multisector model in terms of the change in the macro-variables of the next year, and feed them back to the macro-economic model, thus closing the information link between these two models. The former approach was temporarily adopted and the latter is the target of urgent research.

The research group of project FUGI comprise three subgroups each of which belongs to a different institute. The first is the group at Soka University, with Onishi as leader; it is engaged in construction of a global macro-economic model, which is an extension of the multi-nation macro-economic model developed by Onishi. The second is the group at the University of Tokyo, with Kaya as leader; it is engaged in construction of a static input-output model of normative type. The third is the group at Osaka University, with Suzuki as leader. Their effort is to construct models of some important mineral resources, which may delineate the future vision of demand and supply of these resources in the scenarios generated by the first two models. These three subgroups have been playing their parts in the whole research project, keeping close contact with each other.

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The termination of the project is temporarily set to be the end of this year, but efforts to improve or modify the models will be continued for a long time.

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PROJECT "FUGI"

--- Future of Global Interdependence ---

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Chapter 8
THE GLOBAL MACRO-ECONOMIC MODEL

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1. Research aims and background

When we nowadays speak of "resource limitations " we must remember that, in a certain sense, the possibility is already before us that cases may arise in which limitations of certain resources will affect the entire planet in important ways.

For example, the possibility is now in sight that limited resources of petroleum may become depleted in the not-so-distant future. It is petroleum that is now the most immediate question before us, but one cannot, of course, say the possibilities are nonexistent that at some later time in the more distant future various other natural resources, such as copper or tungsten, will become exhausted. However, at the same time, humankind, faced with dwindling resources, will probably discover new possibilities for substitutes. In other words, as dwindling resources inevitably acquire a higher "scarcity value," humankind will probably be able to find a way out of this predicament by developing other substitute resources, by recycling, etc.

However, at the present moment immediately facing us, long before we run up against the above kind of physical restrictions on resources, matters such as the relationships between the developing and the industrially advanced countries (including difficult North-South problems) or conflicts and contradictions between resource-possessing countries (which are not necessarily from among the ranks of the developing countries) and non-resource-possessing countries are everyday realities which constitute great political and economic issues.

The developing countries, looking with displeasure on the present world economic order, whose management (including the management of resource development) has up to now been centered very predominantly in the industrially advanced countries of the so-called "North ", are demanding the right to justice and equality in international society and are strengthening their consciousness with regard to participation in the formation of a new world economic order.

After the Second World War, one of the very foremost aims of the developing countries, having achieved liberation from colonial status, was to find ways to attain economic self-standing as a follow-up to political independence. This meant getting rid of formerly existing colonial-type economic structures and aiming at conversion to economic characteristics and industrial and trade structures similar to those possessed by the industrially advanced countries at the present time. Expressed in another way, a large portion of the developing countries nurtured the intention of escaping from a pattern of international division of labor by which it was almost entirely the industrially advanced countries which manufactured industrial goods, while the developing countries supplied primary products such as industrial raw materials and foodstuffs. This was, then, in a certain sense, a strategy for a shift to an industrialized society, albeit in most cases a strategy for industrialization on a solid agricultural base.

As for the stated goal of building self-reliance on the basis of domestic economies, favorable conditions for bringing such a goal to fruition were, for a large and resource-endowed country like China, present. However, the majority of the developing countries are small nations and, as before,escape from economic reliance on other countries proved quite impossible. Moreover,to radically change the structure of exports proved to be a difficult and long-range task. Thus, most of the developing countries were made to shoulder the dilemma of having to proceed with development within an economic system whose trade structure remained, as before, similar to that of colonial times, relying to an overly large extent on the export of primary commodities.

One must recognize the fact that the industrially advanced countries continue, as before, to occupy an important and, in a sense, central position in the present international economic order and that the growth patterns of developing countries are greatly affected by the sorts of growth patterns in the industrially advanced countries. If, for example, within the industrially advanced countries there should be substantial development of products which substitute for certain natural raw materials,trade in those raw materials is likely to show a relative slackening off, and in such cases there has heretofore operated a mechanism whereby the economic growth of the developing countries which rely on exports of those materials will be suppressed.

When the industrially advanced countries enter an economic slump, prices of a whole array of primary commodities tend to fall precipitously. It is at times when economic conditions in the industrially advanced countries are restored and these countries again begin to make larger purchases that the prices of primary commodities tend to rise. Thus, economies which rely to too great an extent on the export of primary commodities are very sharply affected by changes in worldwide economic climate.

Therefore, the developing countries must think about how, in the process of aiming at a stabilization in the prices of primary commodities, they can break free from the above type of "economic growth" and attain greater economic security. At the same time,beginning with the First General Meeting of UNCTAD in 1964, the developing countries, with a view to expanding their exports of manufactured and semimanufactured goods, have presented the industrially advanced countries with strong demands for freer markets and for adjustments in the industrial structures of the latter. At the Fourth General Meeting of UNCTAD in May, 1976, focal points of the discussions, aimed at price stabilization of primary products, included the possible creation of internationally controlled buffer stocks of primary commodities and a system of price "indexation" with respect to export prices of manufactured goods from the industrially advanced countries.

However, in the event of such an "indexation" of primary commoity prices, it is still not very clear what sorts of influences on the world economy would be brought about, or whether or not this would be the first step toward the solution of the "North-South problem". The reason for this statement is that nothing of this nature can be known with any degree of assurance without first transforming into a model the dynamic "systems structure" of the world economy, characterized by interdependence among the developing and the industrially advanced countries, and then, with the use of computers, proceeding with an attempt to obtain credible forecasts.

In this connection, we may say that the aim of developing our Global Macro-Economic Model (GMEM) is to make clearer the systems structure of "North-South" economic relations throughout the world, to forecast long-range trends in the economic development of global society as we go forward toward the 21st century, and to provide guidelines for making correctives in the course to be followed toward a desirable world economic order.

2. Basic structure of the Global Macro-Economic Model

As we can see from the above, all world economic models take the whole of global society as their objects of study, but one might classify these models, according to the approach: 1) those which treat aggregate figures for the whole world; 2) those which divide the world into several regions linking up sub-models for each region; and 3) those which divide the world into economic units corresponding to each individual nation, attempting to clarify the systems of economic interdependence among them.

A representative example of the first approach is the Forrester world model[1], a representative example of the second approach is the model developed by Mesarovic and Pestel [2], and Klein's "Link Project" [3] and our own Multi-national Economic Model [4] are examples of the third approach. The Global Macro-Economic Model (GMEM) that we now have available for use was developed on the basis of the Multi-national Economic Model, about which a report was given at the General Meeting of the Club of Rome in October, 1974 [5].

With this Global Macro-Economic Model as a core, we have been engaged in constructing a more truly comprehensive world model which will link up such various sub-systems as education, scientific research and development, welfare, food, resources, energy, pollution, environment,"degree of sensitivity" to mutual interdependence among countries, and indexes of a given society's degree of industrialization and degree of movement toward a "post-industrial" stage.

The Global Macro-Economic Model (GMEM) links 15 areas of the world, subdivided as follows:

I. (Advanced market economies)

1) Japan, 2) United States, 3) Canada, 4) Extended European Community, 5) Australia and New Zealand, 6) Other areas with advanced market economies

II. (Developing market economies)

7) East Asia, 8) Southeast Asia, 9) South Asia, 10) Other parts of Asia, 11) Near and Middle East, 12) Africa 13) the Caribbean and Latin America

III. (Centrally planned economies)

14) Soviet Union and Eastern Europe, 15) China and other centrally planned economies in Asia

While the GMEM represents a system linking together "sub-models" which reflect the special characteristics of each of these 15 regions, each sub-model, in turn, is composed of "sub-sectors" as follows: i) Production; ii) Expenditures on gross regional product at constant market prices; iii) Profits and wages; iv) Prices; v) Expenditures on gross regional product at current market prices; vi) Official development assistance and private overseas investment.

These regional sub-models are mutually linked through the flows of trade, official development assistance and private overseas investment.

The most important distinguishing feature of this Global Macro-Economic Model is the systems structure which is utilized for determining inter-regional trade. The system at work is one whereby economic growth in each region does not take place completely on a basis of self-reliance, but rather with a framework of interdependent relationships characterized by trade and financial flows.

This model treats official development assistance (ODA) from the industrially advanced regions to the developing regions as a generally-agreed-upon policy aim of government and intergovernmental bodies. Official development assistance from the industrially advanced countries is of course distributed among several different developing regions, and this distribution ratio may be conceived of as a "policy parameter."

The GMEM recognized that the present situation is one whereby increases in official development assistance and in private overseas investment depend very largely on income levels in the industrially advanced regions, and whereby, on the part of the developing regions, such aid is seen as offering considerable promise as a supplementary factor for production, helping, in turn, to increase incomes in those regions. Thus, official development aid, together with trade, creates an important link in the interdependent relationships among the developing and the industrially advanced regions.

In designing the model, particular attention was given to the various UNCTAD discussions and propositions on stabilizing prices for the major primary commodities exported from the developing countries, in an attempt to make the model as receptive as possible for considering such questions.

3. Analysis of forecasts given by the model

As explained above, in this study we attempted to make projections of the world economy from 1976 to 1985, using a Global Macro-Economic Model and giving fundamental attention to the interdependent relationships among the above-mentioned 15 regions. (For details of the Global Macro-Economic Model used, see Chapter 11 at the end of this part.)

First of all, in order to make forecasts using the Global Macro-Economic Model, one must presuppose a certain "scenario." A scenario may be drawn in various ways, depending, as it were, on changes made in the model's structural parameters, or in one or another exogenous or policy variable.

Scenario 0 -- The Effects of a Stabilization of Oil Prices

The first scenario to be considered is one that supposes oil prices to remain stationary between 1977 and 1985. In such a case, just what kinds of economic growth patterns could be expected in the world's various regions, and what could be expected in regard to the economic gaps between "North" and "South" ?

If oil prices should remain pegged at the current (1977) prices until 1985, one could expect in the advanced market economies a gradual return to high rates of growth averaging more than 5% yearly. These growth rates could be expected to reach about 7.5% in Japan; about 4.3% in Australia and New Zealand; about 5.6% in Canada; about 5.2% in the USA; about 5.3% in the expanded EC; and about 5.3% in other countries with advanced market economies.

In the developing market economies of Asia, Africa, Central and South America, one could forecast achievement of the 6% yearly economic growth rate which is the target of the "international development strategy" proposed for the United Nations Second Development Decade (1970-1980). The average growth rate, over the period 1975-85, for the non-oil-producing developing countries would be approximately 6.1%. A regional breakdown would indicate growth rates in East Asia of 8.1%; in the ASEAN countries of 6.3%; in West Asia of 5.1%; in the Middle East of 12.0%; in Africa of 5.9%; and in the Caribbean and Latin America of 6.2%.

In the centrally planned economies the prospect would be for an average growth rate of 5.8%. This figure would be the composite of average rates for the Soviet Union and Eastern Europe of about 5.4%, and for China and the other socialist countries in Asia of about 6.9%.

Thus, if oil prices were to remain fixed at 1977 levels, world energy consumption, and especially the consumption of oil, would continue to increase, with annual economic growth rates in the various regions reaching the approximate figures given above. The industrially advanced countries would continue with fairly high rates of growth, while in the developing regions the oil-producing countries of the Middle East could achieve super-high growth and most of the non-oil-producing regions would surpass the UN targets.

As a result of such a stabilization in oil prices, it could be expected that the international balance of payments problems in the industrially advanced and non-oil-producing developing regions would gradually improve.

Among the industrially advanced regions, the balance of payments of the USA would be much benefited, even though its growth rate, in comparison with its past performance in the 1960s, would advance by no more than one percentage point. In Japan, if the predicted growth rate of 7.5% should continue, there would be anxiety lest the balance of payments falls into the negative in the 1980s. Thus, even if oil prices should remain at a stabilized level, problems could be expected if Japan's economic growth were allowed to stay for a prolonged period above 7%. The balance of payments in the Western European region would tend to improve, but it would not be able, without keeping its growth rate to less than 5%, to free itself from a situation of payments deficit. The balance of payments in the non-oil-producing developing regions is extremely sensitive to movements in the prices(of prices)of primary exports. Thus, under conditions of stabilized oil prices, coupled with a scenario whereby prices of other primary products continued to rise by 3 to 5% yearly (approximating trends already in evidence), those regions showing an improvement in international balance of payments would gradually increase. The payments deficits in "East Asia", "ASEAN", and "Other Asian and Pacific Countries" would continue, with a probable trend toward reduction in the size of these deficits.

If oil prices should continue at present levels, there would appear in the Middle East region a trend toward rapid decrease in the ratio of trade surpluses to GRP. But could such a situation be easily countenanced by the Middle East OPEC countries?

If oil price rises were to be stopped at the present level, it is evident that with a yearly economic growth in the developed market economies of more than 5% and of about 6% in the developing market economies, the consumption of oil will continue steadily to increase, with the accompanying dilemma that we rapidly approach the barrier of physical restrictions on oil supply. This increase in oil consumption would, under the circumstances posited, be a fact of life so long as substitute energy sources do not substantially replace oil as the result of further development and much greater supply capacity. This would be true even in the case of transition on a global level toward a more energy-conserving industrial structure.

Scenario A -- <u>The Indexation of Oil Prices</u>

Here it is hypothesized that oil prices would be indexed with respect to general price deflaters of the industrially developed regions for the 1977-1985 period, increasing by approximately 10.3% yearly (as compared with a 7% increase in Scenario O). With the industrially advanced countries,the impacts from such a 10.3% yearly price increase would not be uniform. While strong impacts would be felt in Western Europe and, most especially, in Japan, a sort of "polarized structure" would be in evidence among the industrially advanced countries whereby the effects on such regions as the USA and Canada would not be so great. Among the developing regions, the impact differential, as seen between oil producing and non-oil producing countries, becomes even sharper. While the ratio of trade surpluses to GRP remains approximately unchanged in the Middle East region, in the case of "East Asia", the ASEAN countries and the other developing regions, the ratio of payments deficits to GRP increases.

Within the industrially advanced regions, Japan's payments surplus falls precipitously and it becomes difficult to maintain a growth rate in excess of 7%. If efforts are made to stabilize the balance of payments and to maintain the yen rate, Japan would probably be forced to reduce its economic growth rate to an average yearly level of 6% at the most. If the decision should be made to try to keep annual growth above 6% in response to the stimuli of a good domestic economic climate, energy imports would in such a case have to be further increased, and the country would have to face the dilemma of payments deficits, devaluation of the yen, and increased upward pressures on prices. Under the conditions of Scenario A, all the advanced market economies (and most especially Japan) would be forced, to a greater or lesser extent, to lower their growth rates, with the result that the average growth rate for the regions of advanced market economies over the years 1975-85 would be about 5.0%. The average for the years 1980-85 would probably be about 4.7%.

On the other hand, growth rates in the non-oil-producing developing regions do not decrease to the extent that one might suppose, averaging 6.1% over the ten-year period 1975-85. The average rate for 1980-85 is about 6.2%. Thus, it would probably be possible, though just barely, to achieve the target growth rate set by the United Nations International Strategy.

In the Middle East OPEC countries, on the other hand, the average growth rate over the years 1975-85 would remain nearly unchanged at approximately 12.0%. In the regions of centrally planned economies, the average growth rate remains unchanged at approximately 5.8%. The developing regions, in order to respond to the very great pressures of population and in some cases increasing unemployment, are making every effort to increase the tempo of their economic growth and therefore are likely to choose to try to maintain growth rates even under conditions of an unfavorable turn in international balance of payments as a result of oil price increases.

The ASEAN countries, which have very close economic relations with Japan, are especially susceptible to influence by any decrease in Japan's rate of economic growth. As a consequence of a one-point drop in Japan's growth rate, the growth rate in the ASEAN countries could be expected to drop from 6.2% in 1975-80 to an average of 6.1% for the period 1970-85. The growth rate for 1975-1985 could be expected to stand at 6.1%. While in "East Asia" the growth rate would not decline so appreciably, the ratio of payments deficit to GRP could be expected to show a noticeable increase due to the combined effects of increased oil prices and decreased exports to Japan (as an accompaniment to Japan's lowered growth rate). Insofar as this payments deficit were not offset by an inflow of funds from abroad, "East Asia" would also ultimately find itself having to pursue a lowered growth rate.

On the other hand, in the Middle East region, the ratio of payments surplus to GRP would be maintained. This payments surplus would , then,to a greater or lesser degree, be reflected in the form of payments deficits on the part of the non-oil-producing developing regions. There would also be a tendency, of course, for payments deficits to appear in most of the advanced market economies. But the general impact born by the world economy as a result of oil price increases would be typified by a situation of the weak being at a great disadvantage with respect to the strong, with the sorry spectacle of seeing most of the bills for collection turn up ultimately at the door of the former. The real problem would be that of how to rescue the non-oil-producing developing countries which would become victims of the oil price increases.

Scenario B -- Decreasing the North-South Gap

Here, we ask whether, under the supposition of a further widening in the income gap between the North and South, there can be policies designed to diminish this gap. In this connection, if the industrially advanced regions slow down their rates of growth, what sorts of impacts will this have on economic development in the developing regions? Our forecast is that so long as there is no change in the structure of the present world economic system centered about the industrially advanced countries, a lowering of the tempo of economic growth in the industrially advanced regions is likely to cause a lowering of the tempo of economic development in the developing regions, which have strong links to the former, especially through trade and official development assistance. Thus, so long as the present mechanisms of world industry and trade move according to patterns seen heretofore, it may be understood that zero growth in the industrially advanced regions would not contribute to diminishing the North-South gap but would only have the effect of tending to freeze and perpetuate the present state of inequality.

In relation to the building of a new international economic order for the 21st century, and with the supposition of a more equitable distribution of natural resources to the various regions of global society, we ask whether, if it were possible in conjunction with a slowdown in the tempo of economic growth in the industrially advanced countries, a great increase in the flow of funds (official development assistance, private foreign investment, etc.) to the developing regions could contribute to diminishing the North-South gap. Of course, unless the additional flow of funds from the industrially advanced to the developing regions were greater than the export reductions in the developing regions which would likely accompany a falling back in the tempo of economic growth in the industrially advanced countries, the tempo of economic development in the developing regions would not be expected to rise. If the rates of economic growth in the industrially advanced regions were decreased, it would be necessary to elevate these regions' official development assistance and imports from the developing regions considerable above present levels in order to avoid a lowering of growth rates in the developing regions. In such a case, the balance of trade of the industrially advanced regions with respect to the developing regions would tend to take a favorable turn, and so such an increase in the flow of funds and trade would be a rational policy.

Therefore, this scenario considers the impact on the world economy in the case of an attempt to decrease the North-South gap (in addition to the indexation of oil prices) through decreased growth rates of the advanced market economies in achieving 0.7% ODA target and higher export performance of the developing market economies (except the oil-exporting Middle East). In this scenario, growth rates of the advanced market economies decrease from 5% to 3% by a reduction in non-housing investments. While the export coefficients from the developing market economies have hitherto been derived from the period 1960-1973, Scenario B hypothesizes a 15% upward revision from 1977 to 1985.

As may be expected, the non-oil-exporting developing market economies' growth rates are very sensitive to any such policy showing a trend toward improvement, although the growth rates of the advanced market economies would be decreased. It is thus seen that such a policy would be rather efficacious for decreasing the North-South gap. But at the same time it must be pointed out that such a policy would also have some negative effects on stabilizing oil prices since the advanced market economies would have been affected by a trend toward "stagflation" with the higher oil price annual average increase of 11.0% for the period 1975-1985.

According to the computer forecasts for Scenario B, the advanced market economies will have an annual average growth rate of 3.2% from 1975 to 1985, while yearly growth rates of the developing market economies average 6.4% for the same period. The OPEC countries (i.e. the Middle East region) and centrally planned economies have an average growth rate of 12.0% and 5.8% respectively (as shown in Chapter 11).

Scenario C -- The Indexation of Prices of Primary Commodities (Coupled with Oil Price Indexation)

It is common knowledge that the non-oil-producing developing countries which have fallen victims to oil price rises are in the process of demanding, before UNCTAD and the Conference on International Economic Cooperation (CIEC), increases in the prices of other primary products. The problem posed by Scenario C is whether or not a contribution to solving the "North-South" problem would be made by a stabilization in the prices of primary products, arrived at by dialogue and cooperation among the industrially developed and developing countries and carried out simultaneously with an increase in oil prices.

Under conditions of simultaneous indexations of the prices of oil and other primary products, the regional economy in which the impact would be greatest is needless to say, that of Japan. According to the forecast results of Scenario C, whereby oil and primary commodity prices rise by 10.5% yearly, Japan's growth rate falls from 7.5% to 6%; however, if in addition there should be a corresponding rise in the general prices, Japan's growth rate would be hard put to achieve the figure of 6%. If the growth rate should exceed 6%, this country would have to face a payments deficit and would probably be pushed into a vicious circle of currency devaluation and rising prices. On the other hand, other industrially advanced countries (such as the USA, Canada, Australia and New Zealand, Western Europe) would not suffer negative effects to the same degree as Japan from an increase in export prices of primary commodities. For example, the USA's economic growth rate over the period 1975-85 would average about 4.9%, (or 4.4% over the period 1980-85), while the international balance of payments would be fairly stable.

In the case of those non-oil-producing developing countries which rely on exports of primary commodities, the balance of payments is seen to be definitely improved. In the case of "East Asia" and the ASEAN countries,there are trends, to a greater or lesser extent, for increases in the volume of payments deficits to be held in check. Unlike Scenario A, in the case of the Middle East region, there appears a trend for the ratio of payments surplus to GRP to begin to decrease somewhat, albeit not markedly.

Thus, in a scenario in which there is indexation of prices of other primary products alongside the indexation of oil prices, one may see a commonality of interests in the "Southern" countries, including both OPEC and the non-oil producers. Scenario C would be rather harsh for Japan, which among the industrially developed countries has the highest ratio of dependence on imported oil and other primary commodities. But if Japan alone were to persist in stubborn opposition to such a state of affairs, it is not unlikely that this could result in producing serious fissures in the cooperation and dialogue which is needed among the industrially advanced and developing countries. It is in this sense that Japan will face a policy dilemma. In other words, in the case of a continuing rise in oil prices while increases in the prices of other primary products are relatively suppressed, as in Scenario A, problems are created for the non-oil-producing developing countries. If then, the prices of other primary commodities are raised in order to give more purchasing power to the non-oil-producing developing countries, the development of these regions will be speeded (even though payments deficits continue to grow because import prices may increase even more than export prices), but Japan's economy will be forced to have a lower growth rate.

One way out of this dilemma would be to try to improve the terms of trade by compensating,in part,for increased oil and primary commodity prices through the increased prices charged for the export of those goods or services of a "knowledge-intensive" type that are relatively invulnerable to price competition. And at the same time, if development and purchasing power in the non-oil-producing developing countries were stimulated by a strengthening of development aid, such aid could be expected ultimately to redound to the benefit of the industrially advanced countries in the form of increased exports. Such policies, if carried out in unison, through cooperation and dialogue among the industrially advanced and developing countries, could indeed contribute toward a solution of the "North-South problem".

4. Policy Recommendations

From the above forecasts for the year 1985, made with the use of the Global Macro-Economic Model, the following types of policy recommendations should be considered.

It may be predicted that the period from now until the 21st century will be a transition from patterns of energy consumption based on oil to other substitutes such as atomic and solar energy, coal and natural gas. We are living in an era of "energy revolution" and great questions remain as to how we will cope with the difficulties caused thereby, including rising energy prices under conditions of physical limitations on oil supplies. As we all know, the developing countries, as they approach the 21st century, are seeking a rectification of the differentials in income between "North" and "South". They see this task from the point of view of more just distribution of income in the global society, which is related to the task of forming a new international economic order. The methods suggested envisage a slowdown in the tempo of economic growth in the industrially advanced regions, and at the same time an acceleration in the tempo of economic growth in the developing regions. For this purpose the oil-producing countries are demanding increases in the price of petroleum resources, which should, they say, at least go up according to a sliding scale that is in keeping with increases in export prices of manufactured goods from the industrially advanced countries. "Oil-producing countries" are not, of course, all alike, and the interests of large-scale exporters like Saudi Arabia or Iran may not necessarily coincide with those of small-scale exporters. However, the leadership in pricing and supply of oil exports to the future world market will probably be exercised in consonance with the sorts of policies taken by Saudi Arabia, the single largest oil-exporting nation during the last part of the present century. According to the forecast results discussed above, if oil supplies remain available and if prices should remain unchanged, the annual rate of economic growth in the industrially advanced regions would reach nearly 5.5% and the consumption of petroleum energy would continue to increase steadily. Among the developing countries, the oil producers would average 12% annual growth, while non-oil producers would be able to maintain a growth rate in excess of 6%. In their pursuit of industrial expansion, the various developing countries may be expected to transform themselves into industrialized societies characterized by high energy consumption. The result, seen with an eye to the longer-range future, is that we will, it seems, be rapidly approaching a barrier of physical limitations on petroleum supplies.

So long as substitute energy sources are not developed more rapidly to give us the practical expectation that they can serve as replacements for oil, the world economy will most likely, in the early 1990's, have to face a serious energy crisis. If the world's various countries cannot avoid opposing each other with regard to dwindling oil resources and cannot construct a pacific new international economic order based on multinational cooperation and a sense of common purpose, the future of the world economy could turn dark indeed. Therefore, both short- and long-term policies are needed in order to waylay such crises well before any real crisis condition might occur.

Most importantly, as has been pointed out above, the greatest task through the end of this century and into the 21st century will be how to construct the new international economic order that will enable a stable development of the world economy. The aims of such a new international economic order may be said to be a more just utilization of global resources and greater equality in matters of welfare. But to realize these aims it will be necessary to effect organic linkages between long-term strategies, on the one hand, and short- and middle-term strategies on the other hand.

The most important of the short- and middle-term strategies will be to break free from the after-effects of the "oil shock" of the autumn of 1973. The impact on the world economy from the "oil shock" (viz., a four-fold increase in oil prices) may be summarized in the term "stagflation". As we can see in the processed data given by the Global Macro-Economic Model, as a result of these oil price hikes many of the industrially advanced countries, and especially countries like Japan that are very vulnerable to the vicissitudes of imported natural resource supplies, are still being visited by rather serious setbacks in economic climate. When the advanced market economies of Japan or Western Europe are faced with serious setbacks in business climate, even the economy of the USA, due to the interdependent character of the world economy, cannot by itself grow as the citizens of that country might wish, and is drawn simultaneously into a recessionary trend.

But as distinct from the depression of the 1930's, the recession which we are currently facing as an accompaniment to oil price increases is characterized by the "stagflation" of rising prices under conditions of sluggish economic expansion. In a former day, when Keynes argued for policies to stimulate effective demand as the method of recovery for the advanced market economies, these economies were characterized, rather, by sluggish growth under conditions of falling prices. Thus it was supposed that even if policies to stimulate effective demand were adopted in order to elevate rates of plant operation hampered by unemployment, there would be no inflation as a result. However, today's advanced market economies are faced with choices of a trade-off between policies to restrain prices and policies to stimulate economic growth. And in countries like Japan which depend to a high degree on oil imports, there are readily observable limits to the extent that policies to stimulate effective demand can be adopted at a single-nation level.

For example, if policies should be taken to stimulate the economy through increases in government expenditure and/or large-scale tax reductions, imports of petroleum energy would rise, making for apprehension lest the international balance of payments falls into deficit. Should export drives be launched to prevent such a fall, there is the possibility of inviting antagonisms from other countries. On the other hand, if the balance of payments records a deficit and at the same time inflationary pressures mount as a result of policies to stimulate the economy, it is possible that Japan's exchange rate would fall, bringing higher costs for imported oil as a result. It is characteristic of today's advanced market economies that the restraints imposed by payments balances are made more severe by rises in the price of petroleum energy. This is a dilemma which is shared to a greater or lesser degree even by the USA, whose degree of reliance on oil from abroad is relatively low. If the USA alone should increase its rate of economic growth through stimulation policies, imports from regions like Japan and Western Europe would increase, but exports to those regions with their more sluggish economic climate would not increase so much, with the result that the USA's balance of payments would suffer, and there would operate a tendency toward dollar devaluation and domestic price hikes. Thus, even in the case of the USA, it is difficult for any one country, acting alone, to adopt a policy of enlarging effective demand.

In today's global society, it is inconceivable that anti-recession measures in the industrially advanced countries could be taken in disregard of the interdependent relations among them and the requisite cooperation that derives therefrom. It is especially necessary for those industrially advanced countries which have relatively stable prices but strained conditions of payments balance (e.g., the USA, West Germany, Japan) to mutually adjust their policies for stimulating effective demand and in so doing to work together to adjust the course of their economies toward expanded health. Seen from a global viewpoint, anti-recession policies, arrived at cooperatively by the industrially advanced countries, are also in the interests of the developing countries, since maintenance of a suitable level of stable economic growth in the industrially advanced countries is a prerequisite for additional purchasing power in the developing countries. Needless to say, a prerequisite for effecting a stabilization of primary commodity prices, which is one of the most important problems for a new international economic order, is to stabilize prices and to dampen fluctuations in economic climate in the advanced market regions.

Other necessary items on the agenda for raising levels of purchasing power in the developing countries are a suitable and stable increase in the prices of primary commodities, increases in development aid, the establishment of rules governing the behavior of multinational corporations to insure that they are utilized beneficially by all concerned, and expanded exports of manufactured and semi-manufactured goods from the developing countries, through the intermediary of technology transfers. These various policies must be pursued in a coordinated way, and at the same time organically functioning international mechanisms must be developed to expedite those policies.

And then, too, more rational types of "international division of labor" among the industrially advanced and developing countries must be sought. The industrially advanced countries have a relative advantage in the export of goods and services which are highly "knowledge-intensive" while the developing countries have a relative advantage in the export of goods and services which are purely labor intensive. But it is desirable that there be changes in the "North-South" structure of industry and trade which has hitherto followed this line of division. In considering the structures of North-South relations, which have in the past been built up in accordance with such a line of division, doubts arise as to whether or not a significant change can in fact be realized in the absence of a change in present systems of managing the world economy and in the values which people presently hold. This problem is closely related to the question of the long-term courses of development to be expected within the global society.

According to the forecasts from the Global Macro-Economic Model, in the event that an indexation of oil prices is unavoidable during the period from 1977 to 1985, the tempo of economic growth in the industrially advanced countries would be around 5%, while the tempo of economic growth in the developing regions would not decline, greatly, enabling them to maintain an annual growth of 6%. However, in contrast to a tempo of population growth in the industrially advanced countries of around 1%, that in the developing countries is somewhat above 2%. This means that the percentage gap in per capita incomes would continue to widen. Income inequality in the global society would increase, and the tendencies toward sharper opposition between the South and North would likely become more pronounced.

The international redistribution of income accompanying the rise in oil prices has added further complexity to the economic relationships between the North and South. And among the developing regions, income inequalities will become more pronounced as a result of the widened gap in economic growth rates between the oil-producing and the non-oil-producing countries. Can policies be devised which will reduce this gap?

So long as there is no change in the present systems structure of the world economy, centered as it is on the industrially advanced countries, any decline in the tempo of economic growth in the industrially advanced regions may be expected, most noticeably through the links of trade and official development assistance, to strongly hinder any quickening in the tempo of economic development in the non-oil-producing developing countries.

The forecasts provided by the Global Macro-Economic Model show that so long as the structure of the world's industry and trade continues as heretofore, a simple diminution in the rates of economic growth in the industrially developed regions would not contribute to a rectification of the North-South gap, but would merely have the effect of tending to freeze the status quo. If, however, from a standpoint of a more just distribution of resources within the global society in line with developing a new international economic order, a slowdown in the tempo of economic growth in the industrially advanced regions (to be effected by holding down consumption of petroleum energy and other resources) could be accompanied by an increase in the flow of funds from the industrially developed regions to the developing regions (in the form of official government aid, private foreign investment, etc.), some contribution to reducing the North-South gap can be expected. One should add that, in such a case it would most likely be necessary that any decline in the volume of exports from the developing regions, which might arise as a result of a lowered tempo of economic growth in the industrially developed regions, might be compensated by a rise in export prices. According to our model, if an indexation of prices of primary commodities exported by the non-oil-producing developing regions were made over the period 1977-1985, the payments deficit in these regions could be expected to take a favorable turn, thus contributing to an accelerated economic development.

In order to spur favorable economic change in the developing countries, it will be necessary to encourage a process of industrialization with a modernizing agriculture at its base. In order for North-South economic relations to be restructured into a new type of international economic order, it will not do for the developing regions to remain always in the position of mere exporters of primary commodities. It will be necessary to effect a changeover to a horizontal trade structure whereby industrial manufactures are exchanged among members of these various regions in the same way that trade is presently carried out among the industrially advanced countries. For this purpose, it will be necessary to encourage the transition to industrial societies within the developing regions. As the developing countries effect this transition to an industrial society, it will, in view of the increasing pressures of growing population, be impossible to avoid a great pressure on global resources.

At present, the effective demand for resources and energy is highly skewed in the direction of the industrially advanced countries, but the developing countries are actively seeking a rectification of this pattern. In consideration of our planet's resource limitations, however, it is most unlikely that the developing countries' transition to an industrial society should mean following in the very same footsteps trodden by today's major industrially advanced countries with their patterns of very high resource and energy consumption. And the countermeasures to be taken by the industrially advanced regions will, from the point of view of a more just utilization of global resources, necessarily mean the unavoidability of devising a changeover from the high resource and energy consumption patterns that have prevailed heretofore to an economic system designed to effect energy and resource conservation. From the point of view, also, of controlling large-scale consumption of resources and energy and giving encouragement to recycling, it is desirable that prices of primary products, in the same way as oil prices, be kept at fairly high levels, even though one must admit some apprehension lest rising resource prices act as an additional spur to world inflation.

According to calculations derived from the Global Economic Model, if prices of primary products remain within a range of gradual increases which allows a rational process of adaptation by the world economy, (say, 10% per year or less), no aggravation of world "stagflation" is caused. However, if price increases go above a certain level, world stagflation is worsened and an intensification of conflicts and antagonisms in North-South relations and between resource-possessing and non-resource-possessing countries is likely to follow.

It cannot be denied that what originally acted as a trigger and served as the fundamental justification for the large-scale hike in oil prices was inflation in the regions of advanced market economies. Since the beginning of the decade of the 1970's, inflation in the countries with advanced market economies has become a deeply built-in feature of those countries' economic makeup. This spiraling inflation depends very largely on such factors as wage costs, demand pressures, and imbalances in currency circulation and income growth. So long as efforts to control these factors do not meet with success, inflation may be expected to proceed apace, while rises in the prices of oil and other resources are likely to increase by a greater margin than would otherwise be the case. In order to break free from the type of vicious circle, seen in the "international transmission of inflation", it is no longer possible even for the U.S. economy to hope to find solutions through the efforts of one country acting alone. To one-sidedly criticize only the raising of oil prices by producer countries can do little more than lead to a contest of "mud-slinging." There is only one method for reaching a suitable solution: namely, in an environment of scarcer global resources (especially oil), a global harmonization of economic policies among countries can be achieved not by mutual antagonisms but through the steady promotion of dialogue and a sense of common purpose between the "South" and "North."

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DISCUSSION

Petri asked whether, for trade, there are separate equations for every major good, or a single export equation and import equation for each region. Onishi replied that trade is treated in an aggregate way. Details can best be studied from the model structure. The price of exports is a price index of aggregate figures, but the price can be explained by many factors. Bruckmann and Linnemann pointed out that, according to the model, all computer produced graphs displayed seemed to stabilize very quickly to become straight lines, in spite of sharp fluctuations in the past. Onishi replied that this depends partly upon the nature of the model, which is long-term; short-term fluctuations are deliberately neglected. This is why the results seem to display a tendency towards stabilization. In fact, if the model is run beyond 1985, the straight-line tendencies begin to change; some regions accelerate much faster.

In reply to a question by Chant concerning unemployment, Onishi stated that unemployment originally was treated as an endogenous variable but it was later made exogenous because of the strange results obtained.

Questioned by Gahan and by Menshikov, Onishi admitted that investment is the weakest part of the model, and is in the process of being improved. Gahan continued to ask about the statistical sources; Onishi replied that they are in part confidential, unpublished data.

Helmer expressed some uneasy feeling whenever confronted with such a complex model; the more complex a model, the more one wonders whether some very important factors might not have been omitted, especially in the long run; developments will depend crucially upon unforeseeable factors - technological breakthroughs, labour unrest, etc. Should, therefore, such a model not contain explicitly a decision-making function? With this function, responses to unforeseen developments could be designed. Onishi replied that the purpose of the model is not to predict the future but rather to produce different policy scenarios. No model before 1973 recognized the oil crisis of that year. If a model had been set up in 1970 - how could it have handled the oil crisis of 1973?

Chapter 9

THE GLOBAL INPUT-OUTPUT MODEL

Yoichi Kaya
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1. SCOPE OF THE MODEL

It is common understanding that a developing economy depends heavily on changes in the pattern of international trade and hence on the international division of labor. The main aim of building a global input-output model is to construct scenarios of the international division of labor that are desirable in the sense of helping or accelerating development of developing countries, and are consistent in the sense of satisfying various socioeconomic constraints such as supply-demand balance of goods in the world and long-term trends of international trade.

The model here employed is a static one with exogenous variables given by the global macroeconomic model described in Chapter 8. The alternative approach is to construct a global dynamic input-output model like the Leontief-UNEP model [1] and the authors' former model [2], but eventually it was abandoned mainly because of the difficulty in gathering reliable data on the parameters of the production functions of the goods. Data on the parameters of production functions in the macroeconomic sense are, in a large number of countries, the most reliable and available, mainly from the United Nations Yearbook on National Accounts. The linkage of a dynamic macroeconomic model to a static input-output model is thus almost an inescapable consequence.

Regional and sectoral division in the model is shown in Table 1. The regions in Table 1 correspond to those in the global macroeconomic model, except that East Asia and ASEAN in the latter are aggregated into region 7 in the former, West Asia and Other Asia in the former into region 8 in the latter, and Asian centrally planned countries including China are temporarily excluded in the latter because of a shortage of reliable data on their economies.

2. MODEL STRUCTURE

Mathematically speaking, the global input-output model employed here is a normative model, optimizing a set of criteria unde.. the given set of equality and inequality constraints. The structure of the model can then be completely clarified by describing what the variables are and what criteria and constraints are to be given.

Table 1. Regional and sectoral division.

Region	Sector
1. Japan	1. Agriculture, forestry, fisheries
2. Oceania	2. Mining
3. Canada	3. Foods, beverages, tobacco
4. U.S.A.	4. Textiles, wearing apparel, leather, wood products, furniture
5. EC countries	5. Pulp, paper, printing, publishing
6. Other developed countries	6. Chemical products including petroleum and coal products, rubber, glass
7. East Asia and ASEAN	7. Metal and metal products
8. South and West Asia	8. Nonelectrical machinery
9. Middle East	9. Electrical machinery
10. Africa	10. Transport equipment
11. Latin America	11. Construction
12. European centrally planned countries	12. Electricity, gas, water
	13. Merchandise and services
	14. Transportation and communication

Variables

The variables of this model are of two kinds, $\{_jx_i*\}$ and $\{_jy_i*\}$. $_jx_i*$ denotes the gross domestic product of sector j goods in region i and $_jy_i^*$ the net export of sector j goods in region i, where * means the value at 1970 constant prices. $_jy_i^*$ is then the export on a freight-on-board (f.o.b.) basis minus import on a cost, insurance, and freight (c.i.f.) basis. For the purpose of simplifying the model, y_i^* are assumed to be zero for the sectors of tertiary industries (j = 11 ~ 14). In other words, these sectors are assumed self-sufficient in each region. This seems a valid assumption, considering that each region is fairly large and can be considered almost a closed system as far as tertiary industries are concerned.

The framework of the macroeconomy in the year concerned is given from the global macroeconomic model described in Chapter 8. The variables concerned with the framework include gross domestic product, total export, total import and commodity price index of each region but only the variables related to the domestic final demand are used as inputs to the global input-output model. They are ΔS_i*, C_i*, and g_i* where

ΔS_i* = increase in stocks of region i (at constant prices)
C_i* = private final consumption expenditure (at constant prices)
g_i* = government final consumption expenditure (at constant prices)

Criteria

The criterion function subject to optimization with regard to $\{_jx_i^*\}$ and $\{_jy_i^*\}$ is a linear combination of the four criteria as in Eq. (1)

$$J = W_AJ_A + W_BJ_B + W_CJ_C + W_DJ_D \rightarrow \min \qquad (1)$$

where W_A, W_B, W_C, and W_D are weighting parameters. Details of these criteria will now be described.

The criterion for maximizing capital efficiency, J_A, is

$$J_A = \sum_i W_{Ai} \sum_j {}_jC_i \; {}_jx_i^* \rightarrow \min \qquad (2)$$

${}_jC_i$ is the capital coefficient of sector j of region i. In other words, ${}_jC_i \; {}_jx_i^*$ is equivalent to the capital stock of sector j of region i. $\{W_{Ai}\}$, the weighting parameters, are normally chosen equal over all regions. In this case, J_A corresponds to the total capital stock of the world required to keep the given final domestic demand of all regions in the world. This means that the minimization of J_A is equivalent to maximizing the capital efficiency, given the total output. (Strictly speaking, there is a slight difference between the total of gross domestic products and the total of final domestic demands, due to the total of net export that should be in theory close to zero.)

The criterion for minimizing labor cost, J_B, is

$$J_B = \sum_i W_{Bi} \sum_j {}_jS_i \; {}_jx_i^* \rightarrow \min \qquad (3)$$

${}_jS_i$ is the labor cost per unit production of sector j in region i. Since W_{Bi} is normally chosen as unity over all regions, minimizing J_B is almost equivalent to minimizing the total labor cost of the world, given the final domestic demand of all regions.

The criterion for maximizing employment in manufacturing industries, J_C, is

$$J_C = - \sum_i W_{Ci} \sum_j {}_jl_i \; {}_jx_i^* \rightarrow \min \qquad (4)$$

where ${}_jl_i$ is the employment required for a unit of production of sector j in region i. Contrary to the cases of J_A and J_B, selection of $\{W_{Ci}\}$ should differ largely from region to region because of differences in employment situation. A typical example of the choice of $\{W_{Ci}\}$ is to set all $\{W_{Ci}\}$ other than those of regions 7 and 8 (developing Asian countries) to 0, where the urgency of developing labor-intensive industries is widely recognized.

The choice of weighting parameters in the above way inevitably introduces an increase of the gross domestic products of regions 7 and 8 by increasing net exports of the regions. In other words, the criterion J_C includes both those of increase in employment and of increase in net export.

The criterion for minimizing energy consumption, J_D, is

$$J_D = \sum_i W_{Di} \sum_j {}_jE_i \; {}_jK_{vi}^{-1} \; {}_jx_i^* \rightarrow \min \tag{5}$$

${}_jE_i$ is the energy consumption per unit production of sector j in region i and ${}_jK_{vi}^{-1}$ is the inverse of the ratio of value added of sector j in region i (${}_jK_{vi}^{-1} \; {}_jx_i^*$ corresponds to the gross output). The importance of this criterion again differs from region to region. For EC and Japan, for example, this criterion is the most significant one. The selection of values of weighting parameters depends largely on what kind of scenarios are to be envisaged.

Constraints

Various constraints on ${}_jx_i^*$ and ${}_jy_i^*$ are introduced in the optimization scheme, reflecting the socioeconomic characteristics of these variables:

The demand-supply balance equation of a regional economy is by definition as follows:

$$\mathbb{k}_{vi}^{-1} \cdot \mathbb{X}_i^* = A_i \cdot \mathbb{k}_{vi}^{-1} \mathbb{X}_i^* + (S_i^* + C_i^* + g_i^*) \, \mathbb{d}_i + \mathbb{Y}_i^* \quad , \tag{6}$$

where

$\mathbb{k}_{vi}$ = a column vector of the ratio of value-added of region i
A_i = technological coefficient matrix of region i
$\mathbb{d}_i$ = a column vector of final demand pattern (the sum of the components is unity)

$\mathbf{X}_i^*$ = a column vector comprising ${}_jx_i^*$ as each component

$\mathbf{Y}_i^*$ = a column vector comprising ${}_jy_i^*$ as each component

The global demand-supply balance of all goods is the second constraint. The world total of net exports, $\sum_i {}_jy_i^*$ of each region should be zero because any exported goods from a region should be imported by some other regions. It, however, differs from zero for the following reasons. The first is the difference between f.o.b. values normally used as the measure of exports, and c.i.f. values used as the measure of imports. The c.i.f. value of goods is theoretically larger than the f.o.b. value, because the former includes insurance and transport costs. The fact that the net export ${}_jy_i^*$ is equal to the export in f.o.b. value minus the import in c.i.f. value indicates that the world total of ${}_jy_i^*$ differs from zero. The second reason is the existence of statistical discrepancies between the export data and the import data, which are collected almost independently.

Taking this situation into account, the world total of net exports of each product is set between predetermined upper and lower bounds:

$$L_j \le \frac{\sum_i {}_jy_i^*}{\sum_i \frac{1}{{}_jK_{vi}}\, {}_jx_i^*} \le U_j \qquad (7)$$

where L_j and U_j denote lower and upper bounds in excess of the production of sector j normalized by the world total of gross outputs of sector j. According to historical data, the excess differs from sector to sector, but hardly ever exceeds a few percentage points (plus or minus) of a mean.

In ordinary scenarios, however, it is preferable to choose L_j and U_j very close, to avoid a change in the world total of gross domestic product in each sector, which may greatly reduce the usefulness of comparing different scenarios. In this case, L_j and U_j are set at -0.01% and +0.01%, respectively.

The third constraint is on departing from the past trend of international trade. The status of international trade is a function of many factors such as the demand-supply balance of goods, price and/or nonprice competing power of each country or region, relative price of goods, and so on. The past trend is considered a reflection of these factors in a unified form, and thus has been used in many predictions. It is also utilized in this model, as the basis for determining upper and lower bounds of net exports of goods.

The width of the feasible region of net exports, i.e., the width between upper and lower bounds, may be adjusted according to the scenarios to be envisaged, but the central value of the region is set to be the estimate from the past data at least at the initial stage of the process of determining the feasible region of net exports for those sectors and regions for which the trade models give a good fit. There, however, remain several problems in the process, that is, a shortage of reliable data on developing countries, a mismatch between macroeconomic and sectoral data, and too rapid a growth or decrease in net exports of some goods during the observation period, which may lead to exaggerated future estimates (for example, a simple extrapolation of a rapid increase in the import of automobiles by the United States from 1961 to 1972 tells almost what percentage of the total national income will be consumed).

It is then essential to adjust predicted values of net exports so as to eliminate or at least reduce undesirable consequences as described above. Details will be described later in a separate section.

The fourth constraint is on departing from the past industrial structure of each region. The past pattern of industrial production of each region should also be taken into account as a constraint limiting the mobility of change. Upper and lower bounds of the production of each sector in each region are determined on the basis of past trends, except some of the primary industries, for which the upper bound may be determined as the upper limit of availability of natural resources in that region. Details will be given in a later section.

The fifth constraint is on employment in the manufacturing industry. The manufacturing industry plays a key role in most advanced countries and will do so in many developing countries, especially in Asia. Employment in the manufacturing industry in these countries is a crucial factor to be taken into account in the model. This is expressed in Eq. (8).

$$\sum^{m} {}_{j}l_{i} \; {}_{j}x_{i}^{*} \geq r_{i}P_{i} \qquad (8)$$

where P_i is the total population, r_i is the given lower bound of the ratio of employment in the manufacturing industry to the total population, and $\sum^m$ denotes the summation with regard to manufacturing industries. There may be no controversy on choosing r_i to be the present value at least for developing countries.

The sixth constraint is on the income of employees in the manufacturing industry. The requirement of minumum labor cost may lead to the industrial structure, particularly in advanced industrialized countries, in which low-income employees are dominant. This should be avoided for the welfare of employees, so the following constraint is introduced.

$$\frac{\sum^{m} {}_{j}s_{i} \; {}_{j}x_{i}^{*}}{\sum^{m} {}_{j}l_{i} \; {}_{j}x_{i}^{*}} \Big/ \frac{\cdot x_{i}^{*}}{P_{i}} \geq r_{i} \qquad (9)$$

where P_i denotes the total population of region i and the left side of the equation corresponds to the average income of employees in manufacturing industries in region i, normalized by the gross domestic product per capita.

The last constraint is on change in the structure of manufacturing industries. It has been pointed out [3] that change in the structure of manufacturing industries has some characteristics due to interlinkage between different industries. The multivariate analysis applied to the past data of several dozen countries (for details, see [4]) shows that a certain linear combination of the products of value added of manufacturing industries lies within a narrow zone, of which the central value is given as a function of the gross domestic product per capita of the country concerned.

This is formulated in the following way

$$\left| \sum^{m} {}_{j}\alpha_{i} \cdot {}_{j}x_{i}^{*} - f\left(\frac{\cdot x_{i}^{*}}{P_{i}}\right) \sum^{m} {}_{j}x_{i}^{*} \right| \leq \delta \cdot x_{i}^{*} \qquad (10)$$

where $f(\frac{\cdot x_i^*}{P_i})$ is a function of the gross domestic product per capita of the country or region concerned, and ${}_j\alpha_i$ and δ are the parameters determined from the data analysis.

3. INPUT-OUTPUT TABLES

This section describes how to determine present and future values of parameters of the input-output tables of the regions corresponding to those in Table 1. These parameters constitute the heart of the global input-output model.

Difficulties in Treating National Statistical Tables

There are many difficulties in treating input-output tables, which will be used as the base data for regional tables.

There is a lack of reliable tables for many developing countries. Input-output tables have been published so far in most advanced, industrialized countries and some of the developing countries. Shown in Figure 1 is the distribution of the countries whose input-output tables are available to the authors.

It is easily seen that very few tables are available for African countries, including the countries in Middle East. Furthermore, some of the tables apparently available to the authors are unreliable and even lack the consistency required for input-output tables, such as the equality relation between the sum of components of a row and that of the corresponding column. Estimation or revision of the parameters of the tables of these countries, or of the regions including them, is indispensable in the process of global modeling.

There are differences in the methodology for treating input-output tables. The value of available input-output tables are

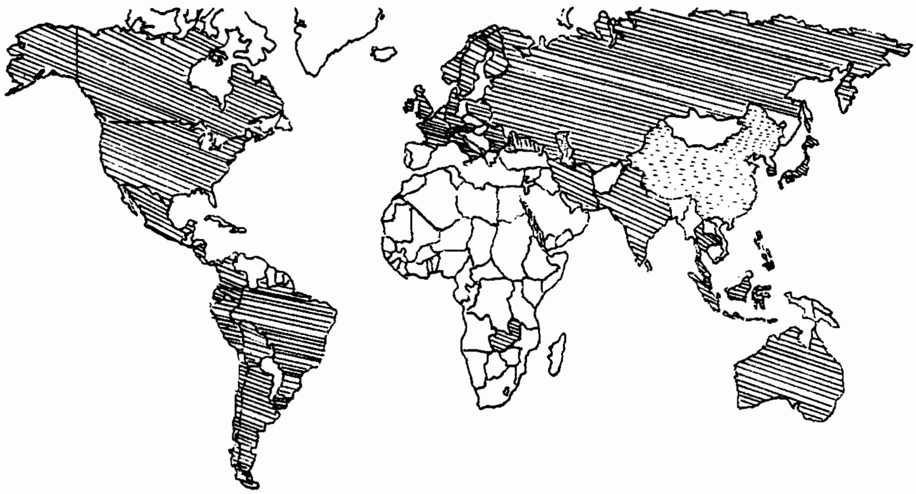

Figure 1. Distribution of input-output tables available to the author.

greatly reduced also by differences in the methodology used in treating the tables. The most serious among them is the difference in treatment of imports.

According to United Nations report, "Problems of Input-Output Tables and Analysis" [5] there are four alternatives for treating imports, of which three have been widely used. The first of these is to distribute all imports along the row of a similar domestic sector. In other words, any inputs to a sector are treated the same, regardless of whether it is a domestic product or an imported good. (For simplicity, let this be called the table of competing import type.) The second is to distribute only those imports that are judged to be competing with domestic products along the row of the corresponding domestic sector, and to distribute other noncompeting imports in a separate row. (Let this be called the table of noncompeting import type.)

The third is essentially to construct two input-output tables, one for domestic flows and the other for imported goods. These tables may be merged into the table of competing import type.

For the purpose of investigating the supply-demand balance of each good in the whole world, which is one of the objectives of global modeling, the tables of competing import type are best. The tables of noncompeting import type hardly exhibit the total demand of each sector of a country, as the imports which are used as input to a sector and considered to be noncompeting are aggregated as an element at the bottom of the corresponding column, regardless of what components constitute the imports. It is rather ironic that the tables of noncompeting import type are recommended in the above report because of high stability of parameters and adequacy of data requirements. Only about half of the tables in the authors' library are of noncompeting import type, and can hardly form the basis of a global input-output model.

Another kind of difficulty is the difference in specification of the input-output tables concerned with dividing industries into sectors and valuation of the transactions (in producers' prices or in purchasers' prices). Hence, aggregation or disaggregation of sectors according to some given standard is an important and indispensable step in processing the country's input-output tables. Disaggregation of a sector, however, is in general hardly possible without some knowledge about the characteristics of the sectors. For instance, refinery products constitute a sector together with crude petroleum, which in the authors' model is the output of the mining sector. The separation of the latter from the former table is done under the assumption that the input to the refinery sector from the mining sector is composed only of crude petroleum.

Conversion of a table evaluated in purchasers' prices to one evaluated in producers' prices is also a tedious task and hence avoided. (The table for France was converted from purchasers' prices to producers' prices by using the conversion factor for Japanese tables. This method is clearly too simple and bold to be applied to many tables.)

Data Analysis

The final target of the work on input-output tables is to estimate structural parameters of the tables (technological coefficients, ratios of value added, and the pattern of final domestic demand of the regions in a certain specified year in the future, say 1985. The procedure comprises two steps: first, estimation of future values of parameters of the available country tables, and second, construction of regional tables using the results of the first step. The second step will be described in detail in the next section.

There are in principle two kinds of methods for the prediction of input-output tables. The first method is to determine parameters, given their values in the initial year and the future values of the sums of rows or columns. The so-called RAS method is a typical one in this category. This method, however, is not applicable in the global input-output model of this project because only the framework of regional macroeconomies is given *a priori*. The second, which then seems the only possible means, is an application of multivariate analysis to the present data. Since the time series data of input-output tables are hardly available except for a few countries, the analysis should be based on cross-section data.

The ordinary regression analysis is, however, hardly applicable in its usual form, for the following reason. Let ${}_iU_j$ be a column vector such as

$$ {}_iU_j = \begin{pmatrix} {}_ia_{1j} \\ \vdots \\ {}_ia_{nj} \\ \vdots \\ {}_ik_{vj} \end{pmatrix} \qquad (11) $$

where ${}_ia_{lj}$ denote technological coefficients of sector j in country i, and ${}_ik_{vj}$ denotes the share of value added of sector j. ${}_iU_j$ is subject to the following equations.

$$ \sum_l {}_ia_{lj} + {}_ik_{vj} = 1 \qquad (12) $$

$$ {}_ia_{lj} \geq 0 \quad , \qquad \text{except some specific } {}_ia_{lj} \qquad (13) $$

The least-square estimates of ${}_ia_{lj}$ and ${}_ik_{vj}$, subject to constraint (12) may be obtained by using Lagrange multipliers, but it is not guaranteed that they can satisfy constraint (13). Nevertheless, they might be used as estimates provided that changes in the values of these parameters with time (as a function of the independent variables, say GDP per capita) are small and the fit of the estimates is high. These conditions are unfortunately not satisfied.

Computational results show that the fit of a large number of the estimates is very bad, and the target year for which input-output tables are to be estimated is, in the authors' project, at least 15 years ahead of the reference year (1970). Therefore, many of the estimates of the parameters easily violate (13).

The authors' approach is based on the concept of permitting each parameter only a small change that is statistically significant from the cross-section analysis and leaving the remainder as a constant part of local character.

Combinatory use of the regression analysis and the principal component analysis (P.C.A.) is a useful means for this purpose. The key idea is to disaggregate ${}_iU_j$ into a vector of common character, ${}_iU_j^C$, and a vector of the character specific to region i, ${}_iU_j^R$.

$$ {}_iU_j = {}_iU_j^C + {}_iU_j^R \tag{14} $$

${}_iU_j^C$ is a common function of variables of the macroeconomy such as GDP per capita, but ${}_iU_j^R$ is a vector different from country to country, not expressible in a functional form common to all countries. If the change of ${}_iU_j$ with time is completely expressible only by ${}_iU_j^C$, and ${}_iU_j^R$ is a constant vector, the value of ${}_iU_j$ in a future year, say t_S, is estimated by

$$ {}_iU_j(t_S) = {}_iU_j^C(t_S) + {}_iU_j^R \tag{15} $$

The problem then is to estimate ${}_iU_j^C$ from the data of ${}_iU_j$. With very few exceptions, P.C.A. is a useful tool for separation of ${}_iU_j^C$ without violating constraints (12) and (13) because the total contribution of ${}_{i}U_{j}^{c}$ is usually rather small. The steps of the whole process are described in the following.

Conversion into 1970 prices First of all, the input-output tables evaluated in a year other than 1970 should be converted into 1970 constant prices, although most of the authors' tables are fortunately from 1970. Deflators by sectors are calculated based on United Nations World Industrial Statistics and applied to the tables concerned.

A few countries such as Argentina, however, show a very big fluctuation of price indices, so the use of the price data of these countries may bring about considerable error. The tables of these countries are therefore used without any further modification.

Normalization of the data Let ${}_{i}U_{1j}$ be component 1 of ${}_{i}U_{j}$, and define ${}_{i}u_{1j}$ as

$$ {}_{i}u_{1j} = \frac{U_{1j} - \frac{1}{k} \cdot U_{1j}}{[\sum_{i} ({}_{i}U_{1j} - \frac{1}{k} \cdot U_{1j})^{2}]^{1/2}} \qquad (16) $$

where $\cdot\, U_{1j}$ is the sum of ${}_{i}U_{1j}$ with respect to i. ${}_{i}u_{1j}$, i = 1,...,k, thus defined is a set of data with zero mean and the total variances of unity.

Application of P.C.A. to ${}_{i}u_{j}$ ${}_{i}u_{j}$ denotes a vector composed of components ${}_{i}u_{1j}, \ldots, {}_{i}u_{nj}$. Now let the eigenvalues of the covariance matrix of ${}_{i}u_{j}$, i = 1,2,...,k, be $\lambda_{1}^{j}, \ldots, \lambda_{n}^{j} (\lambda_{1}^{j} \geq \cdots \lambda_{n}^{j} \geq 0)$ and let the corresponding eigenvectors be $L_{1}^{j}, \ldots, L_{n}^{j}$, and define a vector ${}_{i}z_{j}$ such that

$$ \begin{aligned} {}_{i}u_{j} &= L^{j}\ {}_{i}Z_{j} \\ &= L_{1}^{j}\ {}_{i}Z_{1j} + \cdots L_{n}^{j}\ {}_{i}Z_{nj} \end{aligned} \qquad (17) $$

where $L^{j} = (L_{i}^{j} \cdots L_{n}^{j})$ (18)

Then it is known from the theory of P.C.A. that the contribution of the variability of ${}_iZ_{1j}$, i = 1,...,k, to the total variance of ${}_iu_j$ is $\lambda_1^j/\sum_i \lambda_i^j$, the largest of the components of ${}_iZ_j$, and that of ${}_iZ_{2j}$, i = 1,...,k, is $\lambda_2^j/\sum_i \lambda_i^j$, the second largest, and so on.

Regression analysis of ${}_iZ_j$ It was seen from the results of P.C.A. that the first, second, and/or third components contribute dominantly to the total variance of the data. It was then expected that some of these components may represent a part of ${}_iu_j$ of common character. Regression analysis of these components clarified that for almost all sectors (i.e., all j's) one or two components of ${}_iZ_j$ are expressible as functions of GDP per capita, and that parameters in these functions are significant, although the goodness of fit of the regression equations is in many sectors unsatisfactory. It was then decided to use these functions to construct ${}_iU_j^C$, the part of ${}_iU_j$ of common character. The essence of this method is to extract a small component that is statistically significant and common to all regions, and to leave other components as constant parameters specific to each region. This is based on the concept that too little a change is better than too big a change. The authors believe that the effectiveness of the methodology used here will be enhanced by the accumulation of more reliable data than now exists.

Construction of ${}_iU_j^C$ *and* ${}_iU_j^P$ Suppose that ${}_iZ_{1j}$ is expressible by a function of GNP per capita of country i. Let the function be

$$ {}_iZ_{1j} = f_j(.x_i^*/P_i) \tag{19} $$

where $.x_i^*$ denotes GDP at constant prices and P_i denotes the total population. Define ${}_iU_j^C$ as

$$ {}_iU_j^C = L_1\ {}_iZ_{1j} \tag{20} $$

and construct ${}_iU_j^C$ as a vector of which each component is

$$ {}_iU_{1j} = \frac{1}{k} \ .U_{1j} + \sum_i ({}_iU_{1j} - \frac{1}{k} \ .U_{1j})^{2^{1/2}} \ .{}_iu^c_{1j} \qquad (21) $$

where ${}_iu^c_{1j}$ is component 1 of ${}_iu^c_j$. It is then easily seen that the sum of the components of ${}_iu^c_j$ is equal to unity regardless of the value of ${}_iz_{1j}$ selected and that constraint (12) is automatically satisfied. This is due to the fact that constraint (12) holds for all data of ${}_iU_j$. ${}_iU^R_j$ is than determined as

$$ {}_iU^R_j = ({}_iU_j - {}_iU^C_j) \text{ at 1970 prices} \qquad (22) $$

The contribution of ${}_iU^C_j$ to ${}_iU_j$ is in most sectors 20-30 percent in terms of contribution to the total variance. The results show that violation of (13) occurs, but only in a very few elements, which may be appropriately replaced by zero.

The above process is applicable to column vectors of the technical coefficient matrix but also to a vector representing the pattern of final domestic demand. Details of the data analysis are in Appendix II of Chapter 11.

Construction of Regional Tables

The world is disaggregated into 12 regions as shown in Table 1. Since the input-output tables available so far are those of countries rather than of regions, each of which may include more than two countries, a process of converting a set of country tables into a region table was developed. The process differs from region to region owing to the number of countries included in each region, and the difference in availability of country tables.

For Region 1 (Japan), Region 3 (Canada), and Region 4 (U.S.A.), a region corresponds to a country, so modification of country tables is needed.

For the other regions, if all input-output tables of the countries constituting a region are available, the table of that region may be constructed as an aggregate of all country tables, after standardization into the same units. In most regions, however, availability of input-output tables in the standard form (in the authors' model, a table should comprise 14 sectors of the type of competing imports estimated in 1970 producers' prices) is limited so that the region table must be constructed with some of the standardized country tables and partial data of the tables of other countries. The steps are as follows.

1 Construct a table that will be used as a basis for the region table. The base table may be an aggregate of the tables of several countries, or possibly the table of a country within the region (for instance Australia for region 2). For region 10 (Africa), the table of Argentina is adopted because reliable tables of African countries are unavailable.

2 Collect data of the gross outputs and the value added of countries in the region and modify the base table. The above kinds of data are available in many countries from United Nations World Industrial Statistics. Then the technological coefficients a_{ij} and the ratios of value added are modified in the following way.

$$k_{vj} = \frac{v_j^0 + \sum_i {}_iv_j}{\dfrac{v_j^0}{k_{vj}^0} + \sum_i {}_iG_j} \tag{23}$$

$$a_{ij} = a_{ij}^0 \frac{1 - k_{vj}}{1 - k_{vj}^0} \tag{24}$$

${}_iv_j$ = The product of value added of sector j in country i

v_j^0 = The product of value added in sector j in the base table

${}_iG_j$ = The gross output of sector j in country i

k_{vj} = The ratio of value added in sector j of the resultant table

k_{vj}^0 = The ratio of value added in sector j of the base table

a_{ij} = Technological coefficient of the resultant table

a_{ij}^0 = Technological coefficient of the base table

By choosing the ratios of value added and technological coefficients in the above way, the gross output and the product of value added in each sector of the region table is consistent with the present data.

3 Disaggregate the resultant table into two parts, one of common character and the other of regional character. Estimate the future table as described above.

This process is useful to determine technological coefficients and ratios of value added, but the pattern of final domestic demand thus obtained has the serious defect that products of value added estimated from this pattern are inconsistent with real data.

Take the case of Latin America, for which an aggregated table of those of Argentina and Peru is adopted as the base table. Each parameter of the Latin American table is then estimated as a sum of a part of common character (a function of per capita income) and of a part ot regional character, which however is essentially of Argentina and Peru rather than of the whole of Latin America. Outputs of the resultant table may well be different from real outputs of the region.

In order to overcome this difficulty, the process described in 4 below is adopted, under the assumption that variability of the pattern of final domestic demands among different nations is much larger than those of technological coefficients and ratios of value added. (The validity of this assumption is still in question, but its adoption seems almost inescapable in order to realize outputs consistent with real data.)

4 Calculate the final domestic demand of each country in the region in 1970 by the following equation:

$$d_i^* = (I - A_o)\hat{k}_{vo}^{-1}x_i^* - y_i^* \quad (25)$$

where

A_o = The technological coefficient matrix of the region table

k_{vo} = The vector of ratios of value added of the region table

X_i^* = The vector of products of value added of country i

y_i^* = The vector of net exports of country i

d_i^* = The vector of final domestic demand of country i

X_i^* is taken from the United Nations Yearbooks on National Accounts and World Industrial Statistics It is clear that d_i^* thus obtained is consistent with the present data of the country's economy. (Strictly speaking, there are slight differences between X_i^* and y_i^* found in the above references and those for the input-output table, but they are neglected for the time being.)

The next step is to construct the table of the region. One of the possible methods is to aggregate the terms of country character and to add the aggregated term to the term of common character, with per capita income of the region as the independent variable. But the method employed here is to estimate the output of the whole region as a weighted mean of X_i^*'s times the gross regional product, and to estimate the final domestic demand d_r^* of the region according to Eq. (25), in which X_i^*, y_i^*, and d_i^* are substituted into equations for the whole region. d_i^* is then disaggregated as before into two terms, which are used to construct a regional table for the future.

The disadvantage of the latter method is that the industrial structure of the whole region is considered the same as those of countries where the data are available; the advantage is that the outputs of the input-output model are consistent with present available data.

Other Considerations

It has been the main assumption in the preceding analysis that change in the parameters of input-output tables with time is due to change in the gross regional product per capita. Nevertheless, the change in parameters is in many cases caused by technological progress, which is in some cases only slightly related to economic growth.

A typical example is the technology to save energy, whose importance was stressed in almost all countries after the oil embargo in 1973. The introduction of the effect of progress in this technology on the parameters of the input-output tables is an important and interesting target of further research.

4. INTERNATIONAL TRADE

It goes without saying that characteristics of international trade are one of the key factors in the future international division of labor.

There are a few alternatives for treating international trade, of which an example is to distribute the world total of tradable goods over regions according to a specific logic. It would be best if an indicator that included the competing power of a region in the world market of a good were estimated for each region and employed in the logic based on the principle of relative advantage. The authors have investigated the possibility of establishing such an indicator through the analysis of past data on international trade and industrial production, but the results were unsuccessful.

Another possibility is to investigate in detail each trade flow (by sector and by region) one by one, taking various factors influencing the flow into account, and to organize the forecast of the respective flow. This will have to be done in the future when time permits. It is avoided for the time being because the task is very time consuming.

Regression Analysis of the Data

Eventually, the simplest method was adopted in which the future values of exports and imports are estimated by regression analysis of the data from 1963 to 1972, with GRP as independent variables. Adoption of other variables such as the world total of the trade and export price indices as independent variables has been investigated but finally suspended because it did not improve the fit of the estimates. The following are the final equations:

$$ {}_je_i^* = {}_jA_i(.x_i^*)^{{}_j\beta_i^E} \tag{26} $$

$$ {}_jm_i^* = {}_jB_i(.x_i^*)^{{}_j\beta_i^M} \tag{27} $$

$$ {}_Me_i^* = C_i(.x_i^*)^{{}_M\beta_i^E} \tag{28} $$

$$ {}_Mm_i^* = D_i(.x_i^*)^{{}_M\beta_i^M} \tag{29} $$

where ${}_Me_i^*$ and ${}_Mm_i^*$ denote the total export and the total import of region i, respectively. It should be noted that the total export and import are estimated independently of the export and the import of each sector.

It is expected that the fit of the estimates of ${}_Me_i^*$ and ${}_Mm_i^*$ is so good that they may be used to compensate for cumulative errors in estimation of ${}_je_i^*$ and ${}_jm_i$. Results of the regression analysis are illustrated in Table 2, where *** indicates the element for which the correlation coefficient of the corresponding estimate R is larger than .95, ** corresponds to the element with R between .95 and .90, and * to R between .90 and .70; otherwise, R is below .70.

It is seen that the fit of the estimates is high for almost all trade flows of advanced industrialized regions but low for those of developing regions, particularly regions 8, 9, and 10. Details of the results are shown in Appendix II of Chapter 11.

Requirements to Improve the Estimates

The estimates obtained in the above analysis exhibit the characteristics of the trends of international trade, but have a few defects that should be improved. The first is that some estimates suffer from extraordinarily high growth of the trade

Table 2. The pattern of correlation coefficients.

***	0.95 ≦ R	
**	0.90 ≦ R	< 0.95
*	0.70 ≦ R	< 0.90
blank	R	< 0.70

	MACRO	SEC- 1	SEC- 2	SEC- 3	SEC- 4	SEC- 5	SEC- 6	SEC- 7	SEC- 8	SEC- 9	SEC-10
R (EXPORT)											
REG- 1	***	*	**		***	***	***	***	***	***	***
REG- 2	***	***	**	**	***	***	***	***	***	***	***
REG- 3	***		***	***	***	***	***	*	***	*	**
REG- 4	***			*	**	***	***		***	***	***
REG- 5	***	***	*	***	***	***	***	***	***	***	***
REG- 6	***	***	*	*	***	***	***	***	***	***	***
REG- 7	***	*	***	*	***	***	*	*	**	***	*
REG- 8		*	*		*			*	*	**	*
REG- 9	***	*	***		***			**	*	*	*
REG-10	***	*			***		*	*		*	
REG-11	***	**		**	***	***	*	*	***	**	***
REG-12	***	*	*		***	***	***	**	***	*	*
R (IMPORT)											
REG- 1	***	***	***	**	***	***	***	*	**	***	**
REG- 2	**	*		**	***	***	***	*	**	***	*
REG- 3	***	*	*	**	***	**	***	**	***	***	***
REG- 4	***	*	*	**	***	***	***	***	***	***	***
REG- 5	***	**	***	**	***	***	***	***	***	***	***
REG- 6	***	***	***	*	***	***	***	**	***	***	***
REG- 7	***	**	***	*	*	**	***	**	***	***	**
REG- 8									*		
REG- 9	***	*		**	***	***	***	***	***	***	*
REG-10	***	***	*	**	*	***	*	**	**	**	*
REG-11	***	***	***	*	***	**	***	***	***	***	*
REG-12	***				***	***	***	*	*	***	**
R (NET)											
REG- 1	**	***	***	***	*	*	*	**	***	***	***
REG- 2	*	***	***		**	*	*	*	*	**	*
REG- 3			***	*	***	**	*		*	*	
REG- 4	**				***			*	*	*	**
REG- 5			***	*		**	***		***	**	***
REG- 6			***		**	***	***	*	*	*	
REG- 7	*				***	**	*		***	**	**
REG- 8					*				*		
REG- 9			***	**	*	***		***	***	***	*
REG-10				**	*	**	*	*	**	**	*
REG-11	**	**			*	*	**	*	***	***	*
REG-12						*	*	**	*		

flow concerned during the data period. The import of transport machinery by the USA is a typical example, for which the regression analysis of the data may give a value larger than 7 for ${}_j\beta_i^M$, the elasticity factor of imports to GRP in Eq. (27). The corresponding estimate will then be at least $2^7 = 128$ times the present value if GRP doubles. There is little doubt that the growth rate will be reduced well before the above high level is attained. A process to modify such estimates is thus required.

The second defect is that the estimates may not satisfy a few basic requirements decribed below.

Matching of the estimate of total trade with those of sectoral trade. By definition, the following equation should hold.

$$ {}_M e_i^* = {}_\cdot e_i^* = \sum_j {}_j e_i^* \tag{30} $$

$$ {}_M m_i^* = {}_\cdot m_i^* = \sum_j {}_j m_i^* \tag{31} $$

Since all the estimates are done independently, there is no guarantee that (30) and (32) hold.

The condition that all products of value added should be non-negative. Given the final domestic demand of region i, f_i^*, or the sum of the increase in stocks and consumption and net export y_i^*, or the difference between export and import, the vector of products of value added X_i^* is calculated as

$$ X_i^* = \hat{k}_{vi}(I - A_i)^{-1}(f_i^* + y_i^*), \tag{32} $$

where $\hat{k}_{vi}$ is a diagonal matrix of ratios of value added. All components of X_i^* should be positive or equal to zero. When y_i^* in (32) is replaced by its estimate, however, this requirement may not be satisfied.

The condition that the world totals of supply and of demand of a good should be balanced. By definition, Eq. (33) should hold.

$$\sum_i y_i^* = 0 \tag{33}$$

This equation, however, does not hold for the actual data of international trade, owing to the difference between f.o.b. values and c.i.f. values and to the statistical discrepancy between the data of exports and of imports. It will be seen in Appendix II of Chaper 11 what discrepancy exists between the actual values of y_i^* and its theoretical value, i.e., zero.

Nevertheless, the computer runs using Eq. (33) need not be ignored, for they correspond to the condition of supply-demand balance of each good, although the values on the right-hand side of (34) (say, the values of 1970 estimated from the actual data) may differ from zero.

The estimates of exports and imports obtained through the regression analysis are modified so as to satisfy the above three requirements.

Steps of Modification of the Estimates

The estimates of exports and imports by sectors and by regions are modified through the following 6 steps. The final objective is to obtain the estimates of net exports

$$y_i^* = e_i^* - m_i^* \tag{34}$$

which are consistent in the sense that they satisfy all the requirements described in the preceding section. We must also determine the upper and lower bounds of y_i^* between which y_i^* may exist.

1 Preprocessing of results of the regression analysis. The national data on international trade from 1963 to 1972 are aggregated into the data of interregional flows and then subjected to regression analysis, which yields the estimates according to Eqs. (26) to (29). After that, parameters ${}_j\beta_i^E$ and ${}_j\beta_i^M$ in the above equations are modified so that the exports and imports that show excessively high growth ratios are reduced according to the graph in Figure 2.

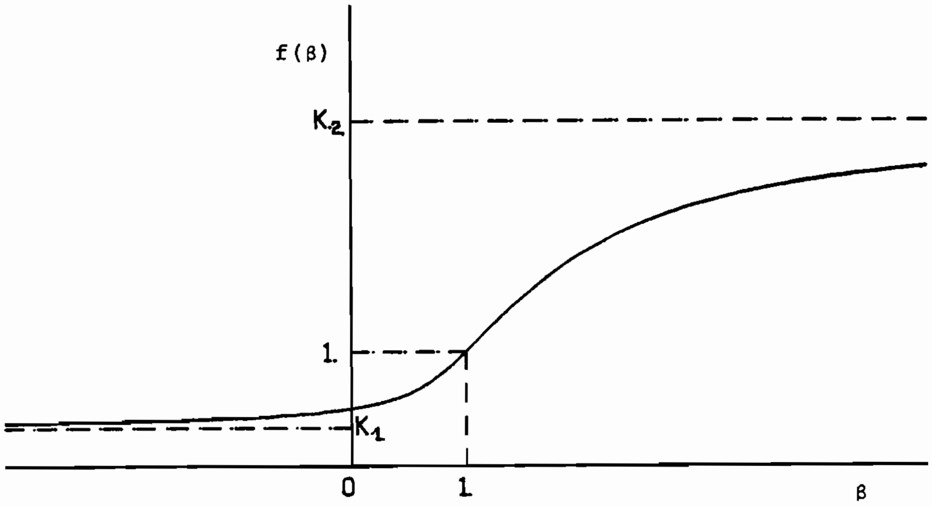

Figure 2. The graph of f(β), the function for modifying the elasticity factor β.

2 Determination of initial values of international trade. If the fit of an estimate of both export and import is relatively good (i.e., R is more than 0.95), the difference of the estimates of export and import and 2 times the standard deviation are chosen for the point estimate of net export and the allowable region of the estimates of imports and exports.

If on the contrary both of the estimates do not fit well, the upper bound of net export is determined as

$$ {}_jU_i = \text{(maximum past export per GDP - minimum past import per GDP) x present GDP} \tag{35} $$

and the lower bound as

$$ {}_jL_i = \text{(minimum past export per GDP - maximum past import per GDP) x present GDP} \tag{36} $$

The point estimate of net export is then determined as the middle value between the upper and lower bounds.

If the estimates of export or import, for example, the estimate of export, fits well, the first term of the right-hand side of (35) is replaced by the estimate of export plus twice the standard deviation, and the first term of the right-hand side of (36) is replaced by the estimate of export minus twice the standard deviation.

3 Matching of macroscopic data with sectoral data. As described before the fit for total trade will be generally better than for sectoral data. Efforts to adjust both macroscopic and sectoral data to satisfy (30) and (31) are required. This process will be described in detail in Appendix II in Chapter 11.

4 Modification of y_i^* to satisfy the constraint that X^* is non-negative. Once the net export, or the difference between export and import of each sector in region i, y_i^*, is obtained from the preceding step, the gross output Z_i^* of region i is determined by Eq. (37)

$$Z_i^* = (I - A_i)^{-1}(f_i^* + y_i^*) \tag{37}$$

where f_i^* is the final domestic demand in the region. To be examined at this stage is the constraint that all components of X_i^* must be non-negative by definition. When this requirement is not satisfied, all negative components of X_i^* are replaced by certain small positive values (temporarily, $.005 \cdot x_i^*$).

Using the new x_i^* modified above, y_i^* is recalculated by Eq. (38),

$$y_i^* = (I - A_i)\hat{k}_{vi}^{-1}X_i^* - f_i^* \tag{38}$$

5 Modification of y_i^* to satisfy the constraint on the balance of demand and supply in the whole world. As described in Chapter 8, the demand and supply of each good must be in principle balanced in the world as a whole. This requirement is equivalent to the following equation:

$$\sum_i (y_i^* + \Delta y_i^*) = 0 \tag{39}$$

where y_i^* is a set of net export vectors obtained at the end of the preceding step and Δy_i^* is the amount of correction. Δy_i^* is here chosen to be proportional to the GRP of the region, i.e.,

$$y_i^* = C.x_i^* \tag{40}$$

where C is a constant vector. Substitution of (40) into (37) yields C and then y_i^* to satisfy the constraint. The new y_i^* thus determined is fed back to step 4 when y_i^* violates the constraint that X_i^* is non-negative, but otherwise the next step is performed.

6 Modification of the upper and lower bounds of y_i^*. The value of y_i^* obtained in the preceding steps is in this model considered as a point estimate of net export subject to the basic constraints described so far. The problem is then how to determine the allowable region of y_i^* around the point estimate. The earliest time to set the width of the allowable region is at the first step as a result of the initial data analysis; but this seems significant only when the change in y_i^* in the next steps is comparatively small. These bounds, however, are violated in a number of components of all y_i^*, so that a process of redetermining the upper and lower bounds of y_i^*, of which the middle value may be the point estimate, is required. The new upper and lower bounds of y_i^* are here determined according to the principle that the larger the correction the wider the new width of the allowable region, with three times the initial width being the upper bound of the width.

In the computer runs, the point estimate of y_i^* here obtained is used as y_i^* in the standard case, and upper and lower bounds of y_i^* are put into the optimization schemes as a set of constraint parameters.

5. OTHER DATA

Analysis of the Characteristics of the Production Pattern of Manufacturing Industries

As described in section 2, the production pattern of manufacturing industries may yield some functional relations that can be considered as the characteristics of the industrial structure. Multivariate analysis is applied to the data to extract these characteristics. First, data on products of value added of manufacturing industries (16 sectors and 36 countries, from 1969 to 1971; the number of samples is 95) are collected from the United Nations Yearbook on Industrial Statistics, and data on GDP per capita are taken from the United Nations Yearbook on National Accounts. These data are processed in the following way.

1 Calculate the vector of the normalized industrial structure of which $d_{ij}(i = 1,\dots,95;\ j = 1,\dots,16)$, is defined as the product of value added of industrial sector j divided by that of the total manufacturing industry of country i.

2 Applying the principal component analysis (P.C.A.) to the d_{ij} calculated above, we obtain eigenvectors $l_{jk}(j = 1,\dots,16;\ k = 1,\dots,16)$ and eigenvalues $\lambda_j(j = 1,\dots,16)$. The cumulative proportion of total variance $(\sum_{j=1}^{i} \lambda_j, i = 1,\dots,16)$ is shown in Figure 3.

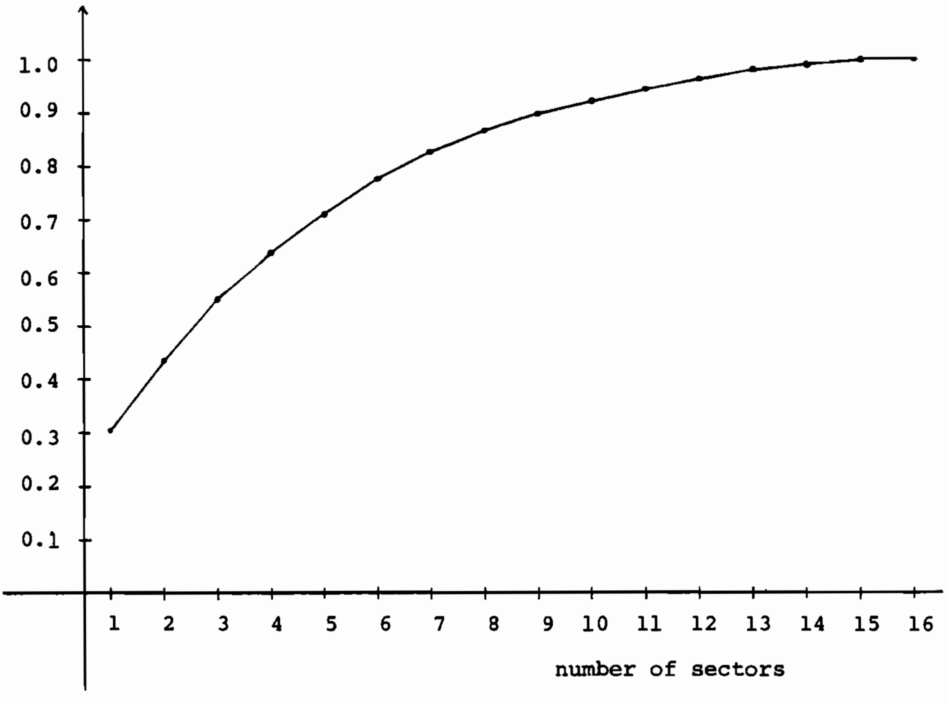

Figure 3. The cumulative proportion of total variance.

3 In order to reduce the number of industrial sectors to be used, we calculate values of factor loadings, which are defined as $\sqrt{\lambda_j} l_{jk}$ (k = 1,...,16) corresponding to the two largest eigenvalues, and we portray these 16 points, each of which represents an industrial sector, on a two-dimensional graph as shown in figure 4. This figure roughly illustrates the degree of similarity between each set of two industrial sectors. The sixteen industrial sectors are then aggregated into 9 sectors based on the information from this figure.

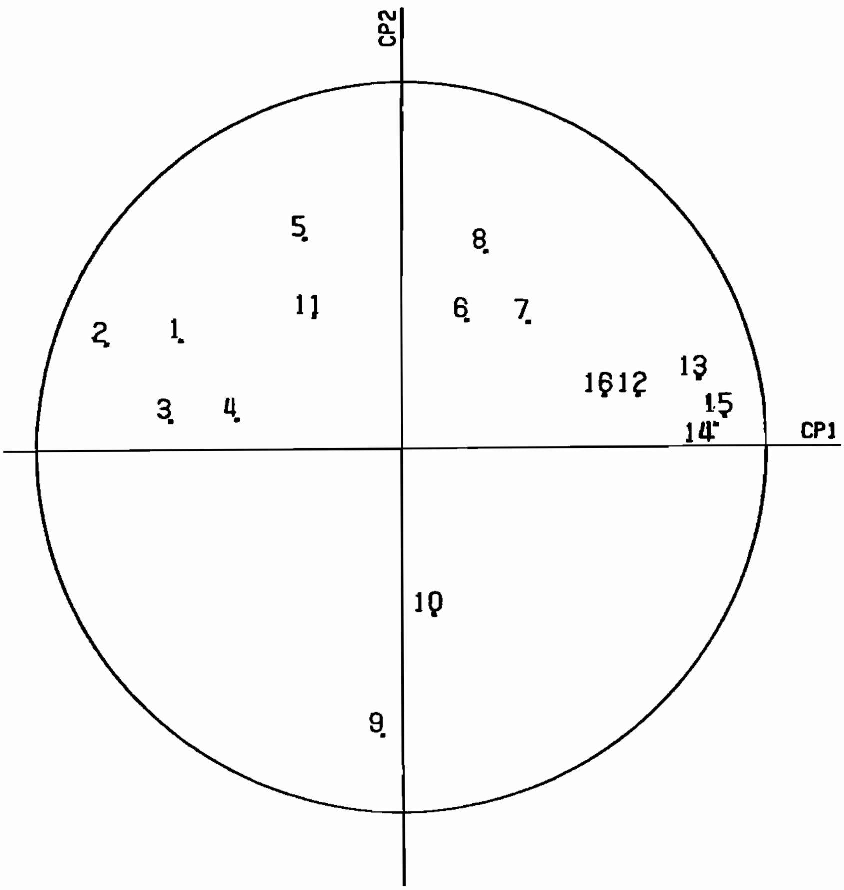

Figure 4. Distribution of sectors in the CP1-CP2 graph.

4 Aggregate the original data d_{ij} into that of 9 sectors.

5 Apply again the principal component analysis to these aggregated data and obtain eigenvectors d_{jk} $(k = 1,\ldots,9)$ and eigenvalues λ_j $(j = 1,\ldots,9)$.

6 To check whether the principal components, and other components z_{ik} $(i = 1,\ldots,95)$, which are defined as $\sum_k \alpha_{jk} d_{ik}$, may be expressed with a good fit as a function of GDP per capita. The result is shown in Figure 5, which shows that only the principal component corresponding to the largest eigenvalue has a statistically significant functional relationship with GDP per capita. This equation is then adopted as the basis of constraint (10).

Capital Coefficient

The capital coefficient ${}_iC_j$ is here defined as

$$ {}_iK_j^* = {}_iC_j \cdot {}_iX_j^* \tag{41}$$

where ${}_iK_j^*$ is the capital stock of sector j in country or region i, and ${}_iX_j^*$ is the product of value added of sector j in country i. * indicates 1970 constant prices. Estimation of ${}_iC_j$ for primary industries, especially agriculture, has been one of the authors' greatest concerns, but difficulty in gathering the data of developing countries and wide variation of data within a (developing) country or region has hindered their use in the model. It is one of the targets of future research to obtain reliable data on ${}_iC_j$ of primary industries.

Measuring capital coefficients of manufacturing industries is also a difficult task, even in advanced industrialized countries. The authors have collected the data from the World Industrial Statistics, which, however, has very few data on developing countries. The capital coefficients are derived from the following equation:

$$ \sum_{t=t_0}^{t} {}_iI_j^*(t) = {}_iC_j({}_iX_j^*(t) - {}_iX_j^*(t_0)) \tag{42}$$

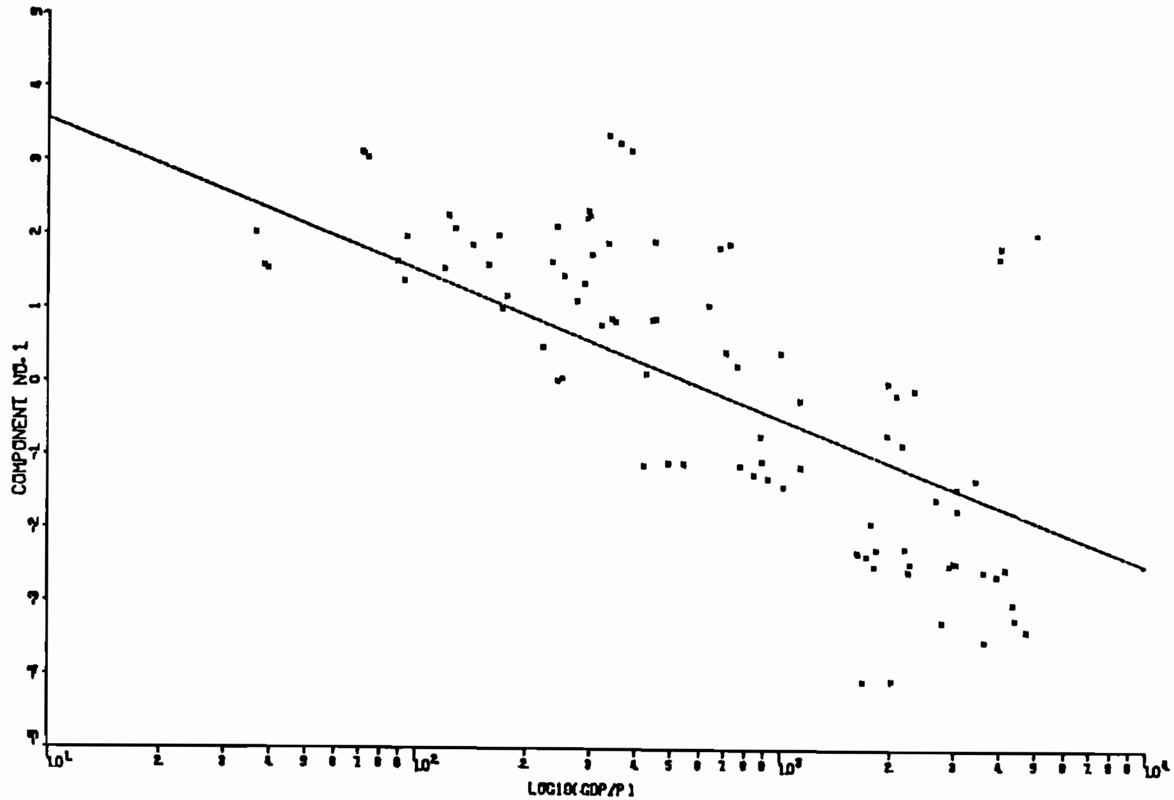

Figure 5. Relation between factor loadings in the principal component and GDP per capita.

where ${}_iI_j$ is the increase in stock over the region, and ${}_iX_j(t_0)$ is the product of value added in the year.

It is most desirable to select t_0 sufficiently far in the past so that ${}_iX_j^*(t_0)$ is negligible, but t_0 is chosen between 5 and 10 years from the limited availability of reliable data. There may be differences in ${}_iC_j$ among countries or regions, but it is hard to obtain reliable data on ${}_iC_j$ in all regions concerned. The values of ${}_iC_j$ used in the model are the same in all regions, and are obtained as the average of the values of countries for which there is data.

Labor cost and employment (number of employees) per unit production, by sector of manufacturing industries, and by region constitute crucial parameters of the criteria to be optimized. The 1970 values are for the time being employed for the former, and will be replaced by 1985 values estimated through the regression analysis on the time series data of each region. For the latter, estimates in 1985 obtained from cross-section analysis are employed. The results are shown in the appendix to this part, Chapter 11.

There is no doubt that employment in agriculture is one of the crucial factors in development, but the fact that a great part of underemployment may disappear under the name of employment in agriculture prevents the appropriate use of this factor in the model.

The estimate of the average income per employee in each manufacturing sector is obtained as the ratio of labor cost to employment per unit production, all of which are obtained in the preceding process.

6. COMPUTATIONAL RESULTS

The global input-output model described so far is a useful tool for envisaging the future of global interdependence through the ever-expanding network of international trade. The target year is for the time being set at 1985.

Scenarios and Cases

Macroscenario corresponds in this chapter to the framework of the macroeconomy in 1985 given by the Global Macroeconomic Model, GMEM. *Case* corresponds to the scenario envisaged by this global input-output model with the corresponding scenario parameters (for example, weighting parameters in the criterion function.) Each combination of a macroscenario and a case yields a computer run, or a complete scenario. Two scenarios are adopted here, i.e., macroscenario A and macroscenario B, both of which correspond to the scenarios described in Chapter 8.

Macroscenario A The oil price as an index of manufactured goods

In this scenario, the future of the macro world economy is envisaged, under the premise that the oil price becomes an index of prices of manufactured goods produced in developed countries. This premise does not seem so unusual, considering the monopolistic situation in the trade of petroleum today, so scenario A may be called the "standard" scenario.

Macroscenario B The scenario reducing the North-South gap

In this scenario, the growth of advanced industrialized ecomomies will be reduced by 10 percent when compared with scenario A, and the growth of developing economies will be accelerated by an increase in the flow of funds from the developed economies. The implication of this scenario has already been described in Chapter 8, and it is expected that the industrialization of developing countries will be more advanced in this scenario. The gross regional product of each region for these two scenarios is obtained from GMEM and listed in Table 4.

Contents of cases are illustrated in Table 3. It should be noted that alternative cases are chosen to clarify the possible range of development of developing regions and the effect of a change in the behavior in international trade of an advanced region on the industrial structure of other regions. Cases 2 and 3, for instance, yield the upper and lower bounds of the share of manufacturing industries of developing countries in the world, given the macroscenario, or the scenario on the world economy.

Table 3. Cases of computer runs.

No.	Abbreviated name	Contents	Change in modes of operation, or in parameter values
1	Standard	extrapolation of the trends of international trade, modified so as to be consistent with basic requirements (see note)	simulation
2	LDC MAX	maximization of the total production of manufacturing industries in developing regions	$\sum_{i}^{LDC} \sum_{j}^{m} {}_j x_i^* \longrightarrow \max$
2-1	LDC MAX + JAPAN TRADE	suppression of growth of exports of Japan in case 2	reduction of maximum elasticity of exports of Japan from 3.0 to 1.5
3	LDC MIN	minimization of the total production of manufacturing industries in developing regions	$\sum_{i}^{LDC} \sum_{j}^{m} {}_j x_i^* \longrightarrow \min$
4	PRIORITY ON COST	minimization of capital and labor costs over the whole world	$\sum_{i}^{world} \sum_{j}^{m} ({}_j c_i \, {}_j x_i^* + k_j s_{ij} x_i^*) \longrightarrow \min$
5	PRIORITY ON LDC EMPLOYMENT	maximization of employment in manufacturing industries of developing countries	add $-\sum_{i}^{LDC} \sum_{j}^{m} {}_j l_{ij} x_i^*$ to the criterion of case 4

NOTE: The basic requirements include:

a) matching of the estimate of total trade and the sum of sectoral trade

b) that all products of value added be non-negative

c) that world totals of demand and of supply be balanced in respective sectors

LDC is the sum of the regions from region 7 to 11, excluding region 9.

Table 4. Gross regional product ($\$10^9$; 1970 prices).

REGION NO.		1970 VALUE		SCENARIO A (1985) INDEXATION OF OIL PRICES			SCENARIO B (1985) REDUCING NORTH-SOUTH GAP		
					RATIO	GROWTH RATE		RATIO	GROWTH RATE
1	JAPAN	189.4	(6.2%)	455.5	(7.3%)	(6.0%)	393.0	(6.9%)	(5.0%)
2	OCEAN	42.6	(1.4%)	75.7	(1.2%)	(3.9%)	65.7	(1.2%)	(2.9%)
3	CANAD	85.8	(2.8%)	167.9	(2.7%)	(4.6%)	141.7	(2.5%)	(3.4%)
4	USA	977.2	(31.7%)	1749.7	(27.9%)	(4.0%)	1513.5	(26.7%)	(3.0%)
5	EC	612.7	(19.9%)	1136.2	(18.1%)	(4.2%)	926.6	(16.3%)	(2.8%)
6	DC O	229.9	(7.5%)	459.0	(7.3%)	(4.7%)	373.3	(6.6%)	(3.3%)
7	SE.A	44.7	(1.5%)	128.4	(2.0%)	(7.3%)	137.7	(2.4%)	(7.8%)
8	SW.A	78.9	(2.6%)	146.8	(2.3%)	(4.2%)	158.7	(2.8%)	(4.8%)
9	M.EST	23.7	(.8%)	153.3	(2.4%)	(13.2%)	153.3	(2.7%)	(13.2%)
10	AFRIC	27.7	(.9%)	61.0	(1.0%)	(5.4%)	62.4	(1.1%)	(5.6%)
11	L.A.	180.2	(5.9%)	443.3	(7.1%)	(6.2%)	446.2	(7.9%)	(6.2%)
12	CPC.E	586.4	(19.0%)	1298.6	(20.7%)	(5.4%)	1298.6	(22.9%)	(5.4%)
13	DC	2724.1	(88.5%)	5342.6	(85.1%)	(4.6%)	4712.5	(83.1%)	(3.7%)
14	LDC	355.2	(11.5%)	932.8	(14.9%)	(6.6%)	958.4	(16.9%)	(6.8%)
15	WORLD	3079.3	(100.0%)	6275.3	(100.0%)	(4.9%)	5670.8	(100.0%)	(4.2%)

The future of the world economy was investigated based on the computational results corresponding to the cases in Table 3. The results will be discussed in the following section. The authors, however, recognize that the model still suffers from a few defects, so the results should be considered intermediate rather than final.

A Macroscopic View of the Future of Manufacturing Industries

Industrialization of developing countries is a crucial issue, because it has been considered the vehicle for a modernized society. The Declaration and Plan of Action resulting from the UNIDO conference held in Lima in 1975 calls for the expansion of the share of developing countries in the world manufacturing industries from 7 per cent at present to 25 percent by the year 2000. According to the authors' model, the corresponding value in 1970 is estimated at 7.56 percent, which is slightly larger than the United Nations estimate. This discrepancy results from a few differences in the data and methodologies in the two estimates. For instance, the authors' model does not include the region of centrally planned Asian countries, while the United Nations estimate does. Taking this discrepancy into account, and assuming that the rate and the pattern of growth of the world economy from 1985 to 2000 will be the same as from 1970 to 1985, the share of the developing countries in the world manufacturing industries in 1985 should be around 1.9 times the 1970 value, or 14.3 percent.

It is easily seen from Figure 6, in which the 1985 values in various scenarios are shown, how ambitious the United Nations target is. Even for B-2 the value is 13.6 percent, 0.7 percent below the target, though almost all efforts for accelerating the industrialization of developing countries are assumed. Rather, it seems much more probable that the value in 1985 will be between 10 and 11 percent, which seems a remarkable increase when one recalls the long stagnant period in the past.

The increase will be primarily attained by the growth of light industries, but also partly by the growth of heavy industries (from sector 6 to 10), in Latin America and the Middle East. Region 7, East Asia and ASEAN will also show a remarkable advance

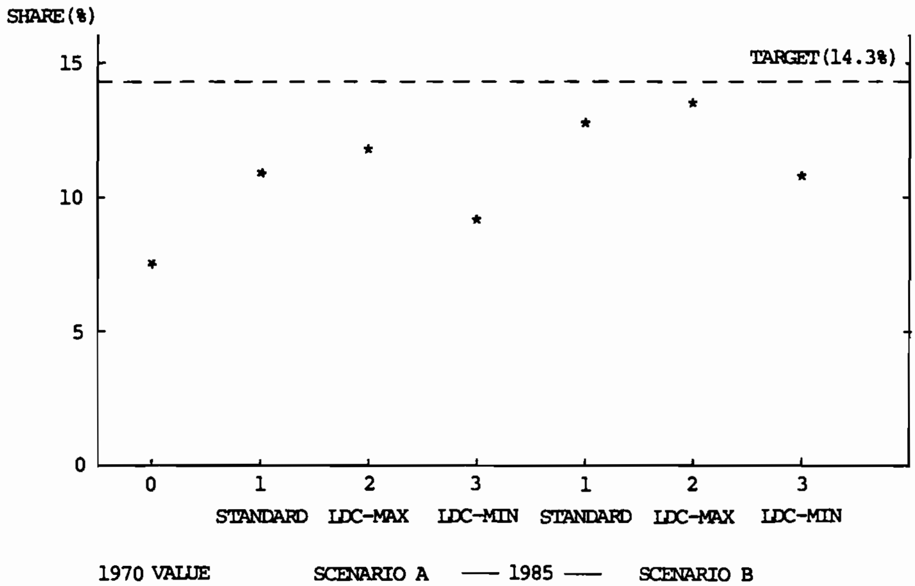

Figure 6. The share of developing countries in the world production of manufacturing industries.

in industrialization but the contribution to the total of developing countries is much less than in the above two regions. It should be noted that the situtation of region 8, West and South Asia, is very serious; it will show only a slight advance in industrialization even in the most favorable case. The share of the manufacturing industry in GRP will be maximized in scenario B-2 at 15.8 percent, only 1.2 percent above the value in 1970. In contrast, the corresponding value in region 7 will be 19.4 percent even in the worst case, scenario A-1; this is a 2.3 percent increase over the value in 1970. This indicates that a high priority will have to be placed on the development of region 8.

Perspective of the Geographical Distribution of Manufacturing Industries

Scenario A-1 may be considered as the most probable. Investigation of the details of this scenario may then be useful to see the general perspective of the world industry.

In Figure 7 (a) to (g), shares of each region in the world production of various manufacturing industries are shown in comparison to the values in 1970.

Sector 3, the food and beverage industry, supplies itself, roughly speaking, and so is neglected in the following discussion.

For sectors 4 and 5, those of light industries, there will be a remarkable change in the division of labor between developed and developing regions. The share of any of the former regions will decrease while those of the latter regions will increase, except region 8. For sector 6, the most striking is the drastic increase in region 9, the Middle East. This is probable because the governments in this region put much emphasis on the development of this sector, but more detailed analysis and discussions are needed to confirm the probability of this change.

For sector 7, iron and steel and other metal industries, the growth of the share of Japan is remarkable. It may be understandable from this result that international pressure is increasing on the export of iron and steel from Japan.

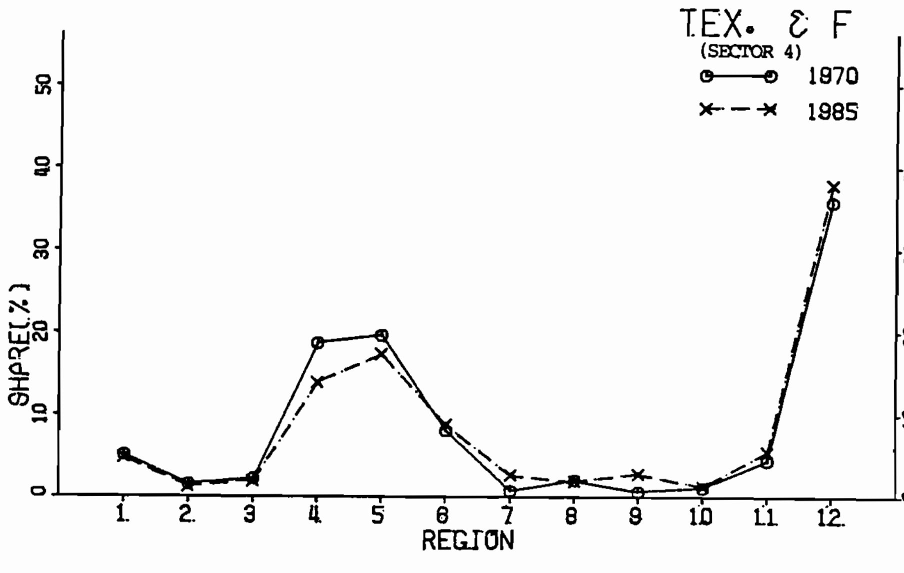

Figure 7 (a). Shares of value added in the world for sector 4.

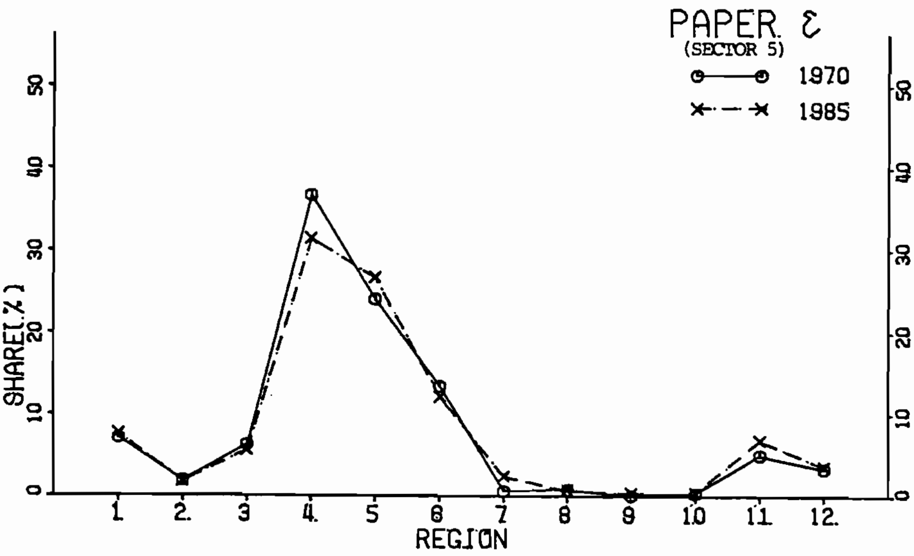

Figure 7(b). Shares of value added in the world for sector 5.

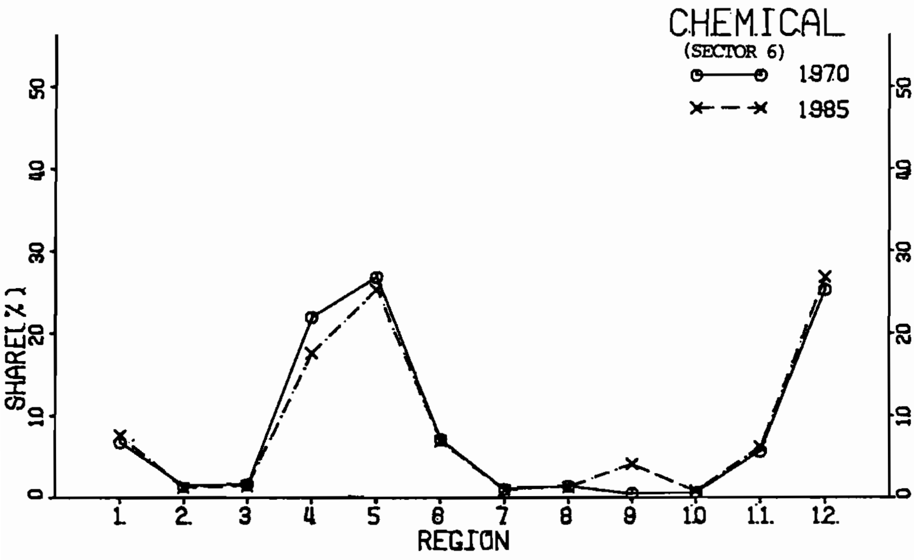

Figure 7(c). Shares of value added in the world for sector 6.

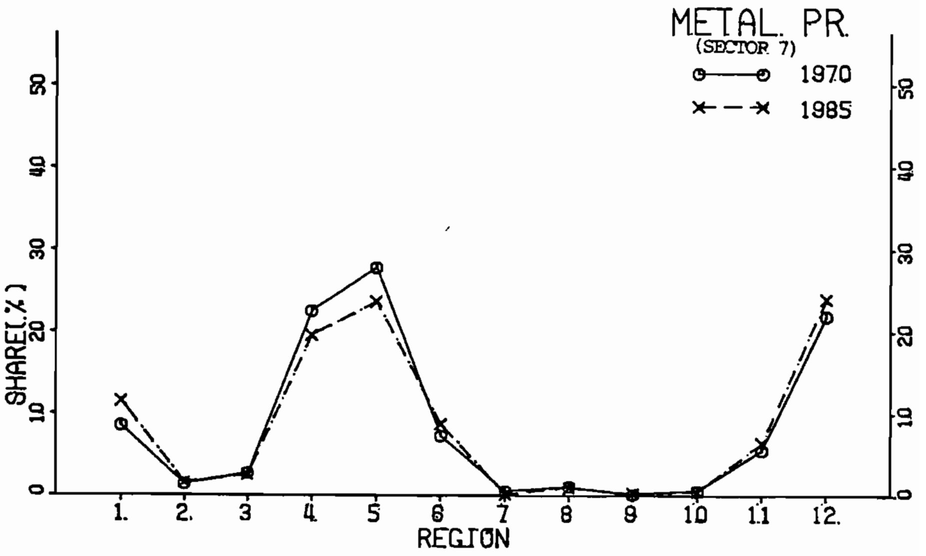

Figure 7(d). Shares of value added in the world for sector 7.

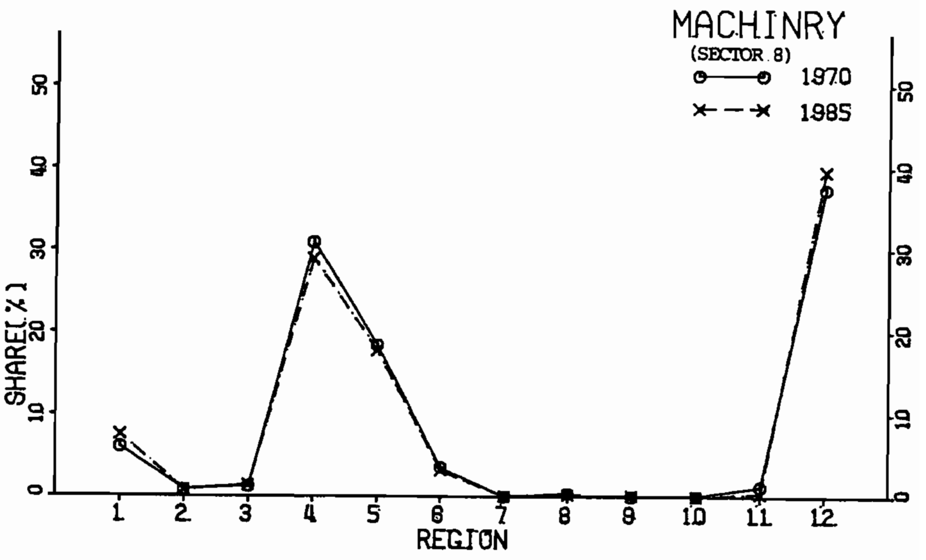

Figure 7(e). Shares of value added in the world for sector 8.

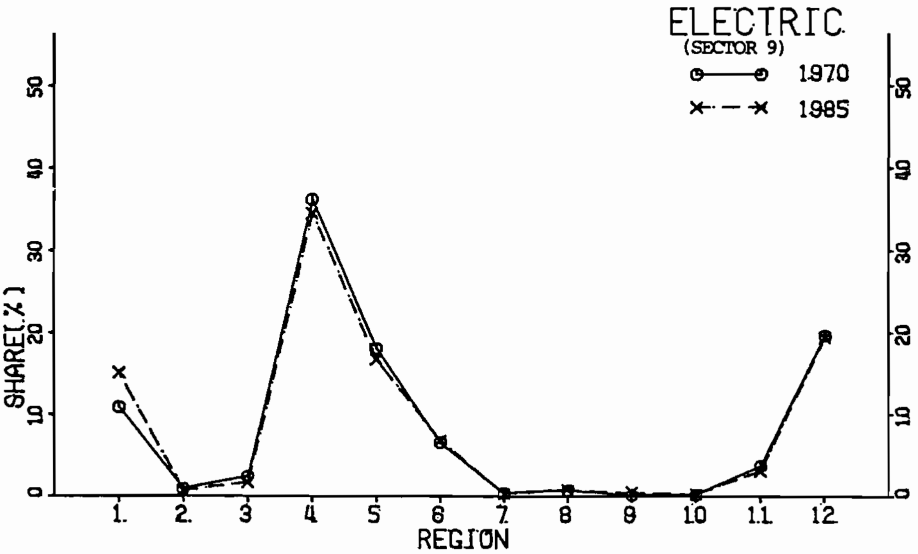

Figure 7(f). Shares of value added in the world for sector 9.

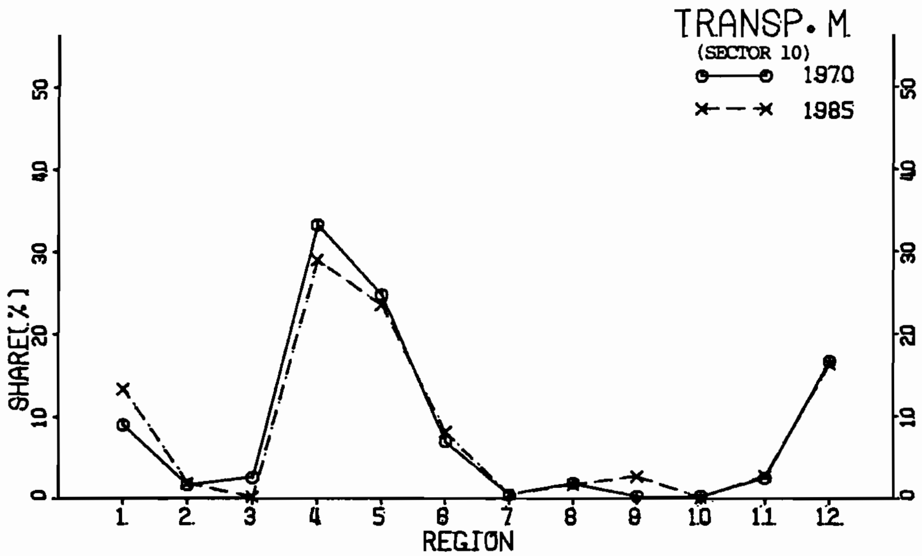

Figure 7(g). Shares of value added in the world for sector 10.

For sectors 8 and 9, the pattern of geographical distribution of production will change only slightly, except that Japan will expand its share in sector 9 but lose a little in sector 8. The Japanese are worrying about this for they believe the future of Japan will much depend on the growth of sector 8, which includes various kinds of plant technology.

For sector 10, again the expansion of Japan and the stagnation of the USA are noticeable. Canada also shows a decrease in production.

This is brought about by the rapid increase in the import of this sector during the data period, but it is questionable whether people in Canada will leave the situation as it is in the scenario. More analysis and discussions are needed to clarify this point.

Possibility of Increase in Employment in Developing Countries

There is little doubt that an increase in employment brought by industrialization is much more important in Asian countries than industrialization itself, for the population is the most valuable resource and probably the only one in most of these countries. Case 5 in Table 3 corresponds to the scenario of maximizing the employment in the manufacturing industries of developing countries, except region 9, where the labor force will be too small. In contrast, case 4 corresponds to the scenario of putting high priority on reduction of both capital and labor costs; comparison of the results of these two scenarios may show how much improvement in employment can be expected by expanding employment.

The employment being discussed here is in manufacturing industries but does not include employment in primary and tertiary industries. This is done partly because of the difficulty of collecting accurate data on the number of people *fully* employed in these industries, but also because the main objective of industrialization in densely populated Asian countries has been the increase in employment.

Figure 8 shows the employment/population ratio of each developing region (except region 9) for different scenarios, along with the value in 1970. The employment in regions 7 and 10 will be

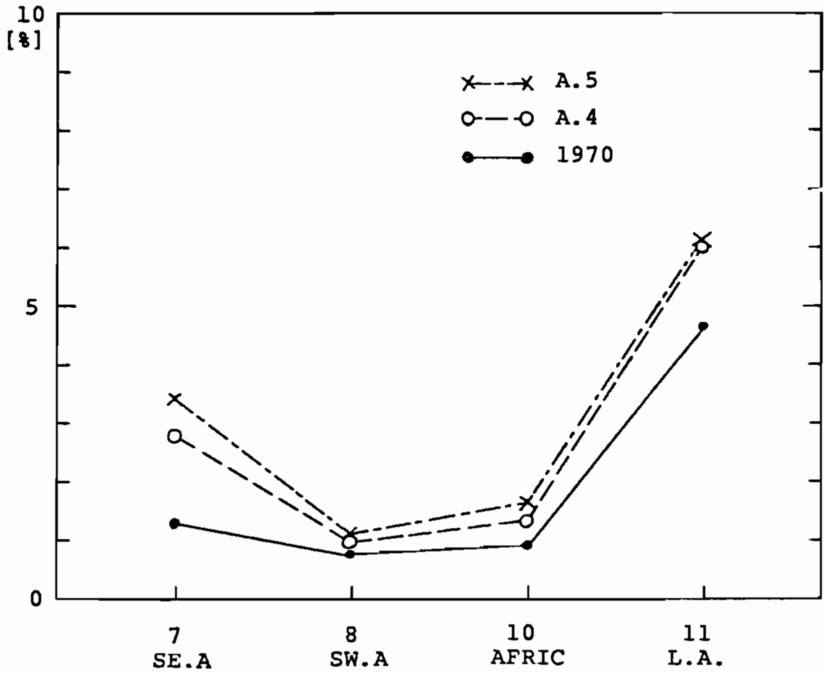

Figure 8. The ratio of employment in manufacturing industries to the total population for regions 7 to 11, excluding region 9.

considerably increased while the situation of region 8, the region most seriously struggling for more employment, will be improved only slightly. This shows how the gap between West and East in Asia is widening. Efforts to increase the competitive power of labor-intensive industries in the international market are urgently needed in South and West Asia.

Effect of Suppressing the Exports of Japan

Examination of the various scenarios shows that net exports of industrial goods of Japan will inevitably increase and, as has been pointed out in other developed countries, may disturb the development of other regions.

In order to see the effect of a change in the exports of Japan, the following scenario (case 2-1) is investigated. As described in section 4, the estimate of the exports of each sector is expressed as

$$_je_i = {_jA_i}(.x_i^*)^{f(_j\beta_i)} \tag{43}$$

where the function $f(_j\beta_i)$ is shown in Figure 2. $f(_j\beta_i)$ is introduced for the purpose of reducing the effect of an abnormal growth of exports during the data period, set close to $_j\beta_i$ around unity and limited to a specific value K (in ordinary scenarios K = 3) as $_j\beta_j$ goes up. In scenario 2-1, K for Japan is reset to 1.5, one-half of K for other regions. This brings about the reduction of the net exports of industrial goods of Japan as expected (see Figure 9), and the increase in net exports of other regions.

Shown in Figure 10 is the distribution of change in the production of manufacturing goods brought about by a reduction

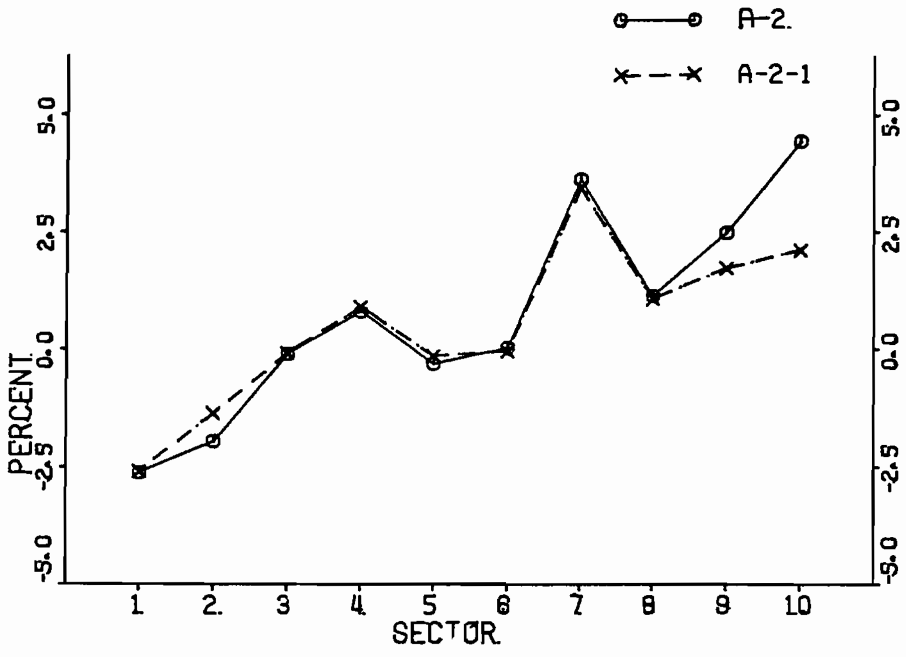

Figure 9. The pattern of net exports by sector of Japan.

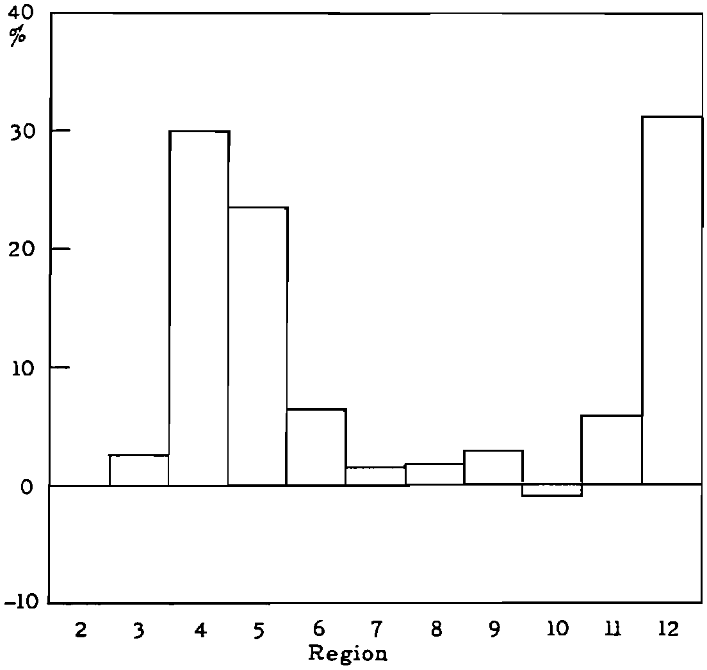

Figure 10. The distribution of the effect of a change in Japanese trade in sectors 3 to 10 on the trade of other regions; total change = 100.

of Japanese exports. Values are normalized as the ratio to the total reduction of production of manufactured goods in Japan. It is seen from the figure that developed regions, especially the USA, the EC and the CPC, will be affected, but the developing regions only a little. Figure 11 is the distribution pattern of change in the production from sectors 8 to 10 and is almost the same as the pattern in Figure 10. It reflects the situation that the growth of Japanese exports is mainly in the market where only developed countries compete with each other, i.e., the market of machine industries, from sector 8 to 10. This result confirms the fact that the competition of Japan will be only with the advanced industrialized world.

The global input-output model is a useful tool for investigating alternative scenarios of world industry in the future. Those described in this section are only examples. It is also

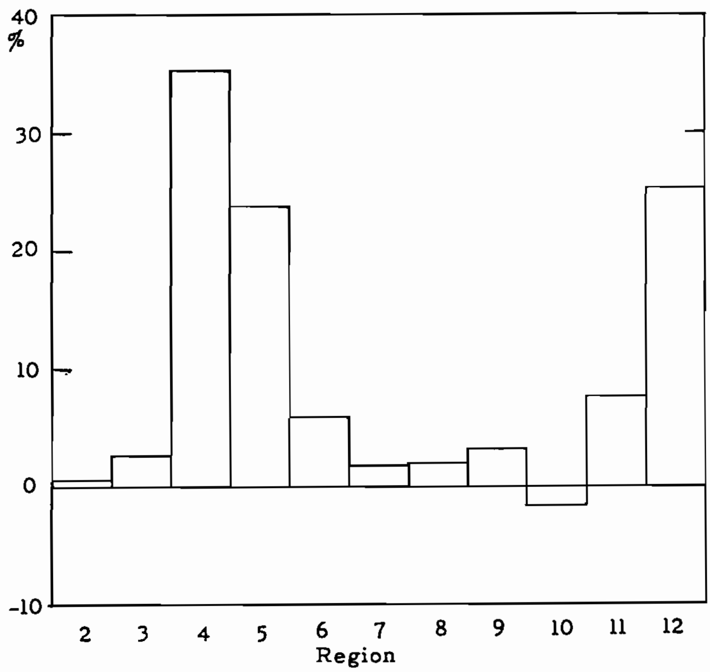

Figure 11. The distribution of the effect of a change in Japanese trade in sectors 8 to 10 on the trade of other regions; total change = 100.

the authors' concern where and to what degree the interests of developing countries are parallel to those of advanced industrial countries, and what change will be needed if the world economy does separate into regional blocks even though this is undesirable. These issues should be investigated, and the model structure reinforced in further research.

7. THE DIRECTION OF FURTHER RESEARCH

Project FUGI is still under way and we plan to continue the work at least another year because the models are not complete enough to envisage detailed scenarios of the world future. The following are the points that will be investigated in future research.

Reinforcement of Data and Revision of Model Parameters

Although much effort has been made to collect reliable data on the world economy and industry, such as those of the input-output tables, the authors recognize that there is room for reinforcing the data bank and then for revising some parameters of the global input-output model. Parameters concerned with labor cost and employment per unit production of each manufacturing industry by region, for instance, are for the time being determined from the cross-section data of a specific year, say 1970, but may be replaced by estimates from statistical analysis of the time-series data of each region. Updating of the data is another task, because the data used so far are those up to 1972, although collection of the data by sector in the world is a far more difficult task than the collection of macroeconomic data. Furthermore, there is no doubt that the construction of more reliable and standardized input-output tables has to be continued.

Elaboration of the Structure of Primary Industry Sectors

Primary industry sectors, i.e., sector 1--agriculture, forestry, and fishery, and sector 2--mining, are different from other sectors because the production in these sectors depends on the physical characteristics of the region such as land area or distribution of mineral resources. Very few constraints from these physical factors have been introduced into the model, except the upper bound of crude petroleum production in the Middle East.

It is clear that development of primary industries not only in developing countries but in advanced industrial countries with abundant land and resources will play a key role in the future international division of labor, so that more elaborate analysis is required of the possibilities for primary industries in each region. It should be noted that physical data such as potential arable land or reserves of mineral resources may be more or less available, but collection of the data concerned with the exploitation costs of these resources, which may differ widely from resource to resource and from region to region, is far more difficult. Efforts along this line have been made but more time is needed for fruitful results.

Construction of the Dynamic Linkage to GMEM

The global input-output model has so far been linked to the global macroeconomic model, GMEM, in such a way that GMEM gives the basic framework of the future world economy *in a specific year*, which constitutes a set of exogenous variables to the global input-output model.

The authors realize that these two types of models may be linked better by feeding the outputs of the input-output model of each year back to GMEM, because the change in industrial structure will effect every aspect of the macroeconomy. The structure of this linkage of the models will be one of the main targets in further research.

Disaggregation of Net Exports into Interregional Exports and Imports

The state of international trade is represented in this model by net exports, i.e., export in f.o.b. minus import in c.i.f., by sectors and regions. This has been an almost inevitable choice from a computational point of view because the total number of variables in this case is only the number of regions, n, times the number of sectors of transferrable goods, k, while the number of variables for interregional exports and imports is $n^2 x\ k$. For $n = 12$ and $k = 10$, which are used in the model described in this paper, the former is 120 while the latter is 2,880. So many variables can hardly be treated in an ordinary mathematical program.

Nevertheless, it would be desirable if some information on interregional exports and imports, such as the trade matrix by sector, were derived, corresponding to the net exports of the global input-output model. One useful piece of information would be about the feasibility of the net export pattern in a certain scenario, in the sense that all interregional exports and imports corresponding to that net export pattern are realizable (nonnegative and smaller than certain upper bounds). The feasibility may be checked through the technique of linear programming, provided that the number of variables is greatly reduced by some means. The methodology for disaggregation of net exports is thus to be investigated during further study.

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DISCUSSION

For global input/output models, Petri stressed the importance of adjusting in some appropriate way the differences in the relative prices between various countries. One unit of a particular commodity produced in a particular country does not correspond to a unit of the same commodity produced in a different country. Neglecting this problem may lead to very misleading results. Kaya replied that differences in relative prices were, as far as possible, taken into account, for instance, when confronting the agriculture of Japan with the agriculture of the Soviet Union or of developing countries. But there is no ready-made solution available for this very important problem.

Petri and Almon pointed out that if, in current prices, columns add up to unity, this need not also be the case when working with constant values for different years, as displayed in the tables.

Hartog elaborated on the difficulty of distinguishing between a true change of an input/output coefficient and "noise", a problem aggravated if one constructs input/output tables for countries where fewer data are available. In reply, Kaya pointed out that he tried to use whatever information was available, e.g., from specialized studies of particular industries.

Almon questioned the objective functions chosen. As an example, he cited "maximizing employment in manufacturing industries" - a goal which, seen with US eyes, would not be considered progressive: the more developed a country, the lower is employment in the manufacturing sectors (and the higher in services). Kaya replied that the objective functions are flexible enough to include or exclude particular criteria. The objective functions shown here are just examples.

Chapter 10

GLOBAL METALLIC RESOURCES MODEL

Yutaka Suzuki and Kazuhiko Shoji

1. INTRODUCTION

The development of the world economy inevitably causes more consumption of resources. The limited carrying capacity of the earth becomes an urgent question and the age with abundant natural resources is now past. *The Limits to Growth*, the first report to the Club of Rome, shows the results of a computer simulation in which nonrenewable natural resources are exhausted within the first half of the twenty-first century. This result has had a strong impact all over the world.

The amount of usable natural resources adopted in *The Limits to Growth* is quite small, because it refers to the current reserves. In fact, the exhaustion of resources, excluding fossil fuels, is not imminent [1]. If the price increases or the technology advances in the future, ores with lower grade or that are difficult to access will become economical to recover. We do not intend to say that resources are unlimited. As the grade is lowered, the indispensable capital and energy needed to extract the ores increases exponentially. The price of resources also increases and it becomes necessary to utilize resources more effectively.

As for energy resources, a lot of research and forecasts have been done so far. However, it seems that only rough analyses have been made for the supply-demand situation of metallic mineral resources in the future. In the first half of this paper, we forecast the world supply-demand situation of metallic resources as a whole. Then, taking copper resources as an example, we analyze the future situation of resources and supply-demand on a regional basis by using a simulation model.

2. STATUS OF METALLIC MINERAL RESOURCES

Resource estimates

Classification of resources on the basis of the degree of certainty

Our major interest in resources is to determine how much there is and how long we can depend on them in the future. Resource estimates are usually obtained with geographical, economic, and technological conjectures. Therefore, it is necessary to classify resource estimates on the basis of the degree of certainty. Generally, the more geographical the conjectures, the lower the certainty of the resource estimates. The more economic or technological the conjecture, the lower the certainty that the resource can be recovered economically. Brobst and Pratt proposed a classification shown in Figure 1 [2] that we will adopt. The categories are defined as follows:

Identified resources: Specific bodies of mineral-bearing rock, whose existence and location are known, which include reserves and conditional resources

Reserves: Masses of rock, whose extent and grade are known, which may be extracted at a profit with existing technology and at present price levels

Conditional resources: Masses of rock whose extent and grade are known but which can become reserves only when certain conditions of economics or technology are met

Hypothetical resources: Undiscovered resources that we may still reasonably expect to find in known districts

Speculative resources: Undiscovered resources that may exist elsewhere

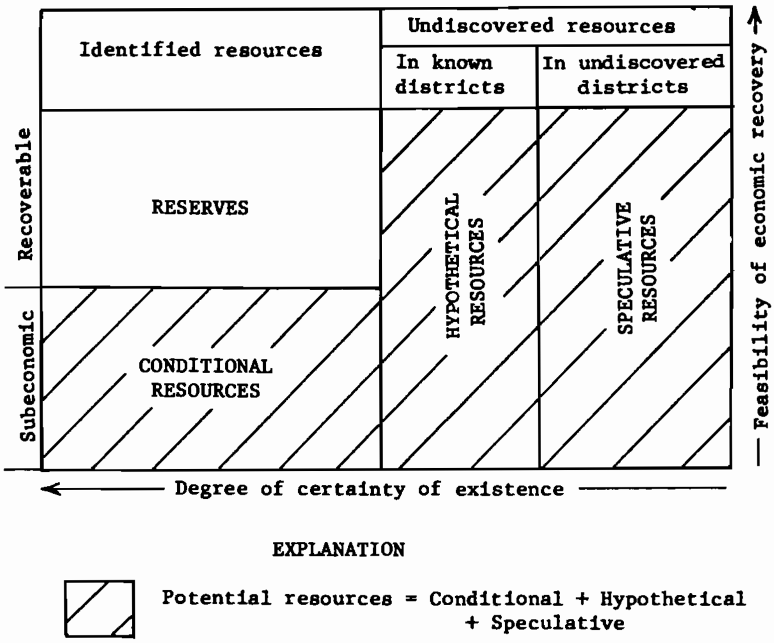


Figure 1. Classification of mineral resources.

Relation between abundance in the earth's crust and reserves

The supply capacity of metallic mineral resources largely depends on their abundance in the earth's crust. Lee and Yao recently investigated mineral abundances in the oceanic crust, on the continents, and in the earth's crust as a whole; their results are shown in Table 1. Also shown are ultimate metallic masses, which are individual crust masses multiplied by corresponding abundances, reserves in 1970, the lowest grades of ores which are economically recoverable with existing technology, and concentrations of ores in comparison with abundances in the crust. In Figure 2 reserves and ultimate metallic masses are plotted as the variables that depend on abundances in the continental crust. Almost all reserves are gathered around a solid line in Figure 2, which proves the existence of a clear correlation between reserves and abundances in the crust.

We have been recovering various metals mainly from the continental crust and this situation will be almost unchanged in the

Table 1. Abundance, content, and reserves of some metals in the earth's crust.

	Total earth's crust (1)		Oceanic crust (1)		Continental crust (1)	
	Abundance PPM	Content $10^{12}t$	Abundance PPM	Content $10^{12}t$	A Abundance PPM	Content $10^{12}t$
Aluminum	83000	2000000	84000	750000	83000	1300000
Iron	58000	1400000	75000	670000	48000	720000
Zinc	94	2300	120	1100	81	1200
Nickel	89	2100	140	1200	61	920
Copper	63	1510	85	760	50	760
Lead	12	290	10	89	13	200
Uranium	1.7	41	1.0	8.9	2.2	33
Tin	1.7	41	1.9	17	1.6	24
Molybdenum	1.3	31	1.5	14	1.1	17
Tungsten	1.1	26	0.94	8.4	1.2	18
Mercury	0.089	2.1	0.11	0.98	0.08	1.2
Silver	0.075	1.8	0.091	0.81	0.065	0.98
Platinum	0.046	1.1	0.075	0.67	0.028	0.042
Gold	0.0035	0.084	0.0035	0.31	0.0035	0.053

(1) D.A.Brobst and W.P.Pratt; United States Mineral Resources, Geological Survey Professional Paper 820, (1973)

future. As shown in Figure 2 by a broken line, the ultimate metallic masses are about 5×10^6 times the reserves, on the average. If we can extract useful metals from ordinary rocks, metallic mineral resources will become unlimited. However, at present we can only extract metals from special rocks called ores, which are formed by various natural concentration processes. For example, as shown in Table 1, in the case of abundant metals such as iron and aluminum, we utilize ores whose concentrations are only about 4 times the abundance in the crust. In the case of scarce metals whose crust abundances are below 0.01 percent, much more-concentrated ores are utilized, that is, 100 times more concentrated for copper, 300 times for zinc, and 1,500 times for lead.

Table 1. Continued.

	Continental crust segments (1)				Reserves (2) 10^{12}t	B Minimum grade for profitable recovery(3) %	Concentration 10000B/A
	Shield areas		Folded belts				
	Abundance PPM	Content 10^{12}t	Abundance PPM	Content 10^{12}t			
Al	84000	890000	82000	370000	3240	30	3.6
Fe	49000	520000	4000	18000	88000	25	5.2
Zn	83	880	77	350	(1)235	2.5	310
Ni	64	680	53	240	68	1.0	160
Cu	52	550	46	210	308	0.5	100
Pb	13	140	13	59	93	2.0	1500
U	2.1	22	2.3	10	0.70	0.18	820
Sn	1.5	16	1.7	7.7	4.1	0.20	1300
Mo	1.1	12	1.0	4.5	(1) 4.9	0.25	2300
W	1.2	13	1.2	5.4	(1) 1.3	1.4	12000
Hg	0.078	0.83	0.086	0.39	* 0.18	0.20	25000
Ag	0.067	0.71	0.062	0.28	* 0.16	0.01	1500
Pt	0.031	0.33	0.022	0.10	(1) 0.024	0.0003	110
Au	0.0034	0.06	0.0038	0.017	* 0.011	0.0008	2300

(1) D.A.Brobst and W.P.Pratt; United States Mineral Resources, Geological Survey Professional Paper 820, (1973)

(2) USBM ; Commodity Data Summary, 1972
* USBM ; Mineral Facts and Problems,1970

(3) B.J.Skinner; Earth Resources, Prentice-Hall, 1969

Regional distribution

Ore deposits were formed during geologic time under quite special conditions. Metal-rich districts are limited to those areas where geologic circumstances and conditions for the deposit formation are met. Furthermore, only deposits whose extent and grade exceed certain levels are recoverable with existing technology at present price levels. Therefore, present reserves are very unevenly distributed geographically.

For example, in the case of copper, only 4 countries, the United States, Chile, Canada, and Zambia, have 57 percent of total world reserves. Canada, New Caledonia (France), and Cuba have 60 percent of world nickel reserves. The United States, Canada, and Australia have 61 percent of lead reserves and almost 100

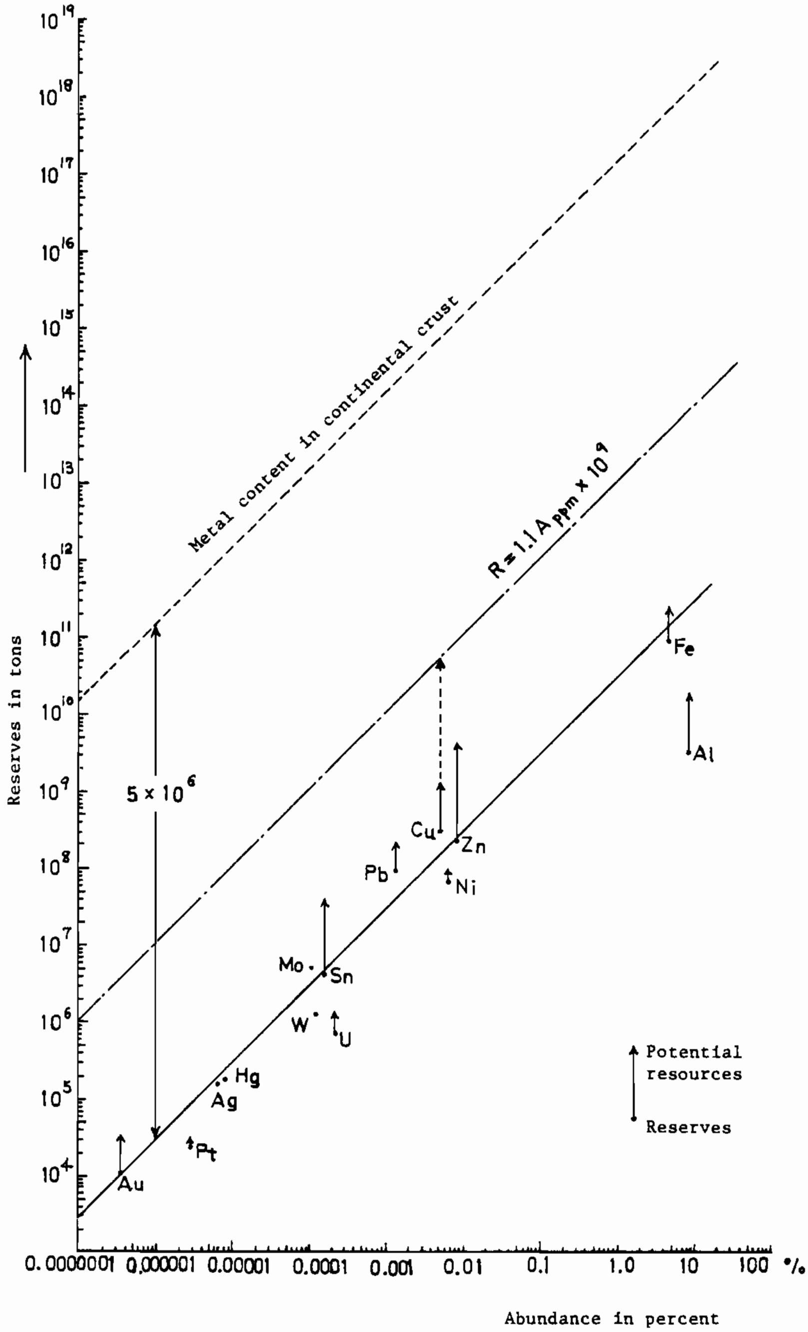


Figure 2. Reserves of elements compared with their abundances.

percent of zinc reserves. Silver reserves in the United States, Mexico, and Peru amount to 59 percent of the world total.

By contrast, reserves of iron, which is one of the abundant metals, are distributed uniformly in the world. However, in the case of more abundant aluminum, reserves are concentrated in tropical and subtropical zones. Jamaica, Australia, and New Guinea have 75 percent of total world reserves. Major aluminum reserves are bauxites, which are formed through so-called chemical weathering under tropical conditions. We have been utilizing ore deposits that are easy to explore, mine, and extract. As demands for metals grow larger, new technologies will be developed. Deeper and less-accessible deposits may be exploited and ores of lower grade may be economically recoverable. For example, clay minerals are considered to be possible sources of aluminum. If we can extract aluminum from these sources, world aluminum resources will be unlimited.

Supply and demand forecasts

Table 2 summarizes supply capacities and demands for metal resources. As for supply capacities, ultimate masses of metals in the continental crust, reserves, potential resources and paramarginal potential resources (whose definition will be given later) are shown. As for demands, metal production in 1970, demand forecasts in the year 2000, and cumulative demands from 1970 to 2000 are shown.

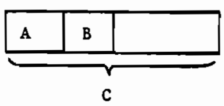
Reserves-production ratios (A/D) are 340 for aluminum, 200 for iron, 185 for platinum, and 110 for nickel. In the case of copper, zinc, and lead, they are 51, 44, and 27. However, metal production grows year by year and these trends will continue in the future. If we take demand growth into account, the reserves index must be decreased considerably.

How much of these resources do we need in the future? The U.S. Bureau of Mines forecasted demands in the year 2000 (see Table 2). Demand in 2000 is 9 times 1970's for aluminum, 6 times for copper, and 2-3 times for other metals. Cumulative demands until 2000 are also shown in Table 2. Ratios of present reserves

Table 2. Supply and demand for metal resources.

	Content in continental crust	A Reserves	Potential resources				B Total	C Paramarginal potential resources (3)
			Conditional		Undiscovered (1)			
			(1)	Mangan nodule (2)	Hypothetical	Speculative		
	10^{12}t	10^6t	10^6t	10^6t	10^6t	10^6t	10^6t	10^9t
Aluminum	1300000	3240	11000 (4)	48000			59000	91000
Iron	720000	88000	158000	232000			390000	53000
Zinc	1200	235	525	780	3575		4880	89
Nickel	920	68	25	16400			16425	67
Copper	760	308	331	8800	363	320	9814	55
Lead	200	93		1500	45	90	1635	14
Uranium	33	(5) 0.70			(5) 0.68		(5) 0.68	2.4
Tin	24	4.1	16.9		9.4	7.6	33.9	1.8
Molybdenum	17.0	4.9		860			860	1.2
Tungsten	18.1	1.3						1.3
Mercury	1.2	0.18						0.088
Silver	0.98	0.16		5			5	0.072
Platinum	0.42	0.024			0.0058		0.0058	0.031
Gold	0.053	0.011			0.024		0.024	0.0039

Resources



See Table 1.

(1) D.A.Brobst and W.P.Pratt; United States Mineral Resources, Geological Survey Professional Paper 820, (1973)

(2) J.L.Mero; The Mineral Resources of the Sea, Elsevier, 1965

(3) Calculated by $R = 1.1$ Appm $\times 10^9$.

(4) Calculated from the value of 5.3×10^9 tons of Kaolinite in the United States, considering that world land area is 16 times as large as that of the United States and Kaolinite has 13 per-cent Aluminum.

(5) Except Eastern Europe and the Soviet Union.

to cumulative demands (A/F) are 2.9 for aluminum, 4.9 for iron, and less than unity for almost all other metals.

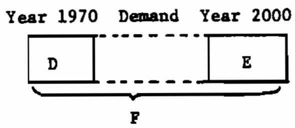
Potential resources

General introduction

Because of growth in demand, many metals may be exhausted within the next 30 yr. In reality, increases in price levels induce saving or substitution of resources, and as a result, demand decreases. Concurrently, exploitation of lower-grade ores and more intense exploration will increase reserves. Both of them effect an increase in A/F. Here we investigate how large we can

Table 2. Continued.

	D	Forecast demand at 2000 (2)		A/D	A/F	(A+B)/F	C/A
	Production at 1970 (1) 10^6t	E 10^6t	F Cumulative demand 1970–2000 10^6t				
Al	9.6	95.1	1135	340	2.9	52	28000
Fe	432 (3)	846	17931	200	4.9	27	602
Zn	5.4	13.8	237	44	0.99	22	379
Ni	0.63	1.04	25.7	110	2.6	640	985
Cu	6.0	38.8	468	51	0.66	22	179
Pb	3.4	7.36	155	27	0.60	11	151
U	0.018	-	-	39	-	-	3430
Sn	0.23	0.496	17.1	18	0.24	2.2	439
Mo	0.081	0.272	4.34	60	1.1	430	245
W	0.034	0.104	1.87	38	0.7	0.7	1000
Hg	0.0098	0.021	0.487	18	0.37	0.37	489
Ag	0.0095	0.032	0.151	17	1.1	34	450
Pt	0.00013	0.00039	0.0066	185	3.6	4.5	1290
Au	0.0015	0.0031	0.052	7	0.21	0.67	355



(1) USBM ; Minerals Year Book 1971

(2) USBM ; Mineral Facts and Problems, (1970)

(3) Iron Ore Statistics Committee, Iron Ore Statistical Handbook 1972, (in Japanese)

expect the increases in reserves to be in the future.

We estimate potential resources by referring to a report of Brobst and Pratt [2] and research by Mero [3], which are also shown in Table 2. It is noticeable that manganese nodules on the sea floor include various metallic resources in abundance. These figures are estimated from the mass of nodules in the Pacific Ocean only. Similar resources also exist in the Atlantic and the Indian oceans.

Accumulation of manganese nodules is in progress continuously. It is estimated that the mass of iron accumulated in nodules reaches 1.4×10^6 metric tons per year in the Pacific Ocean only. Estimates for other metals are 0.055×10^6 for copper, 0.3×10^6

for aluminum, 0.102×10^6 for nickel, 0.0048×10^6 for zinc, 0.00003×10^6 for silver, and 0.009×10^6 for lead. If the conditions for economic recoverability are met, reserves will increase remarkably. It is already confirmed through laboratory experience that existing technologies and equipment are applicable to the processing of manganese nodules.

In Table 2, ratios of supply capacities taking account of potential resources to cumulative demands until the year 2000 ([A + B]/F) are shown.

In Figure 2, potential resources excluding manganese nodules are shown by arrows. We exclude manganese nodules because they are sea sediments and there is no clear correlation between resources included in them and abundances in the continental crust. Figure 3 shows the regional distribution of copper resources, which include both reserves and potential resources.

Estimation of paramarginal potential resources

If we can reasonably estimate increases of potential resources when their grade is lowered, estimation of future supply capacities becomes easier and more reliable. At the beginning, we investigated the relation between reserves and grade for copper resources, for which information is readily available.

Table 3 shows reserves, hypothetical and speculative resources in 1970, cumulative copper production up to 1970, and cumulative resources (including used ones) by grade. Cumulative resources whose grade is above 0.25 percent are estimated by Lowell [4].

Grades and cumulative resources are plotted on a log-log sheet as shown in Figure 4. All points, including Lowell's estimates, are near a line, whose equation is

$$\log R_c = - 1.81 \log \theta + 8.91$$

From this equation, it can be easily seen that the cumulative resources whose grade is above 0.5 percent amount to 2.9×10^9 tons. As for those above 0.1 percent, they amount to 5.3×10^{10} tons. This figure implies that resources increase 65 times when

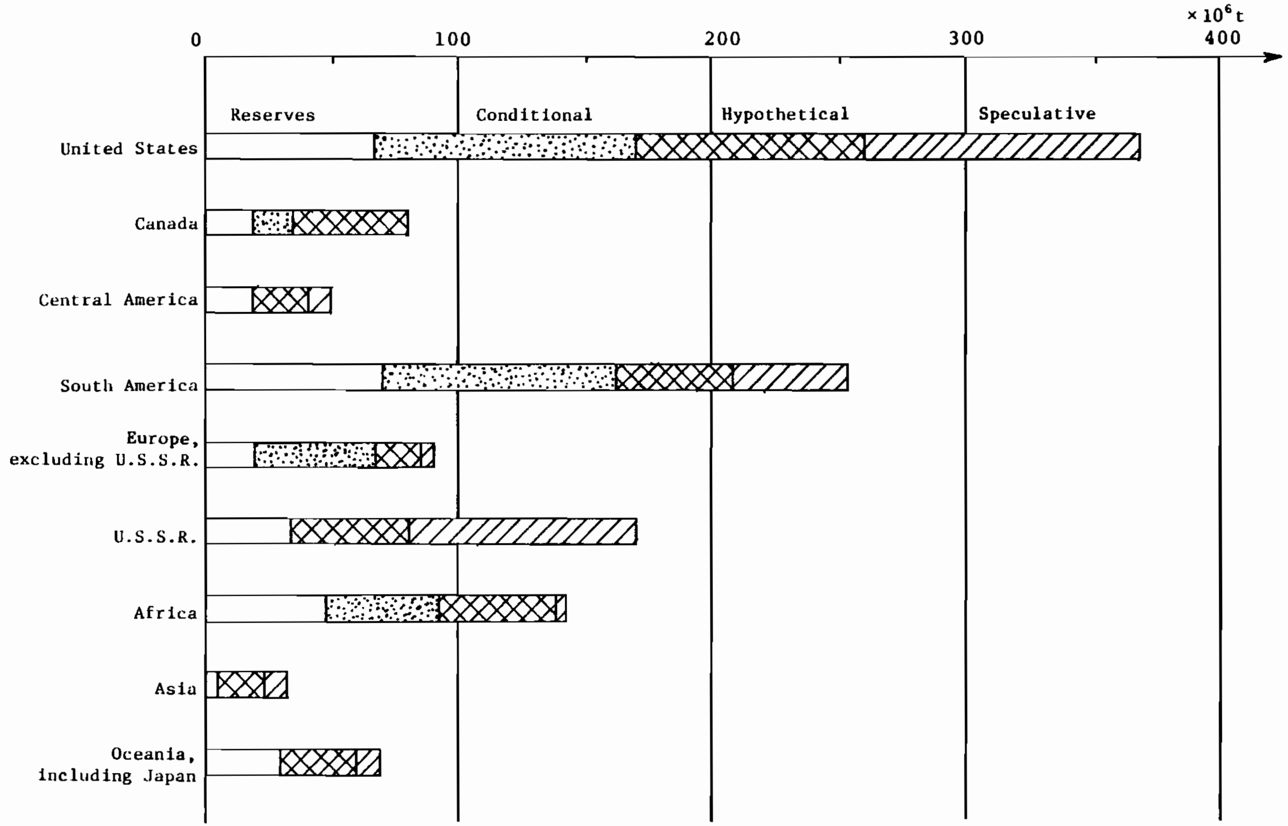


Figure 3. Regional distribution of copper resources.

Table 3. Grade and cumulative copper resources.

Grade θ %	Cumulative mine production up to 1970 by grade (1) 10^6t	(2) Reserves at 1970 10^6t	Hypothetical and Speculative resources at 1970 (3) 10^6t	Cumulative resources by grade 10^6t
3.6	33	43	45	121
1.5	106	38	151	383
1.2	133	71	130	611
1.0	144	56	101	779
0.8	166	101	256	1158
0.25	-	-	-	10000 (4)

Source: (1) U.S.Bureau of Mines data

(2) USBM Commodity data summary, 1972

(3) D.A.Brobst and W.P.Pratt; United States Mineral Resources, Geological Survey Professional Paper 820, 1973

(4) J.D.Lowell; Copper Resources in 1970, Mining Eng., Vol.22, No.4, pp.67-73, 1970

the grade is lowered to one-tenth.

It is expected that the recoverable average grade declines to 0.25 percent in the year 2000 (refer to Figure 5). In this case, the lowest grade recoverable will be around 0.1 percent and corresponding reserves will reach 5.3×10^{10} tons, as shown above.

In the case of other metallic resources, it is impossible to investigate relations between grades and cumulative resources for lack of data. However, if we refer to the figures for copper resources, the potential resources of other metals may be estimated. McKelvey noticed the relation between reserves and abundances which is shown by a solid line in Figure 2, and he estimated potential resources in the United States as

$$R = A \times 10^{9\sim10}$$

where R is the mass of potential resources in short tons and A is the abundance in the continental crust by percent [2].

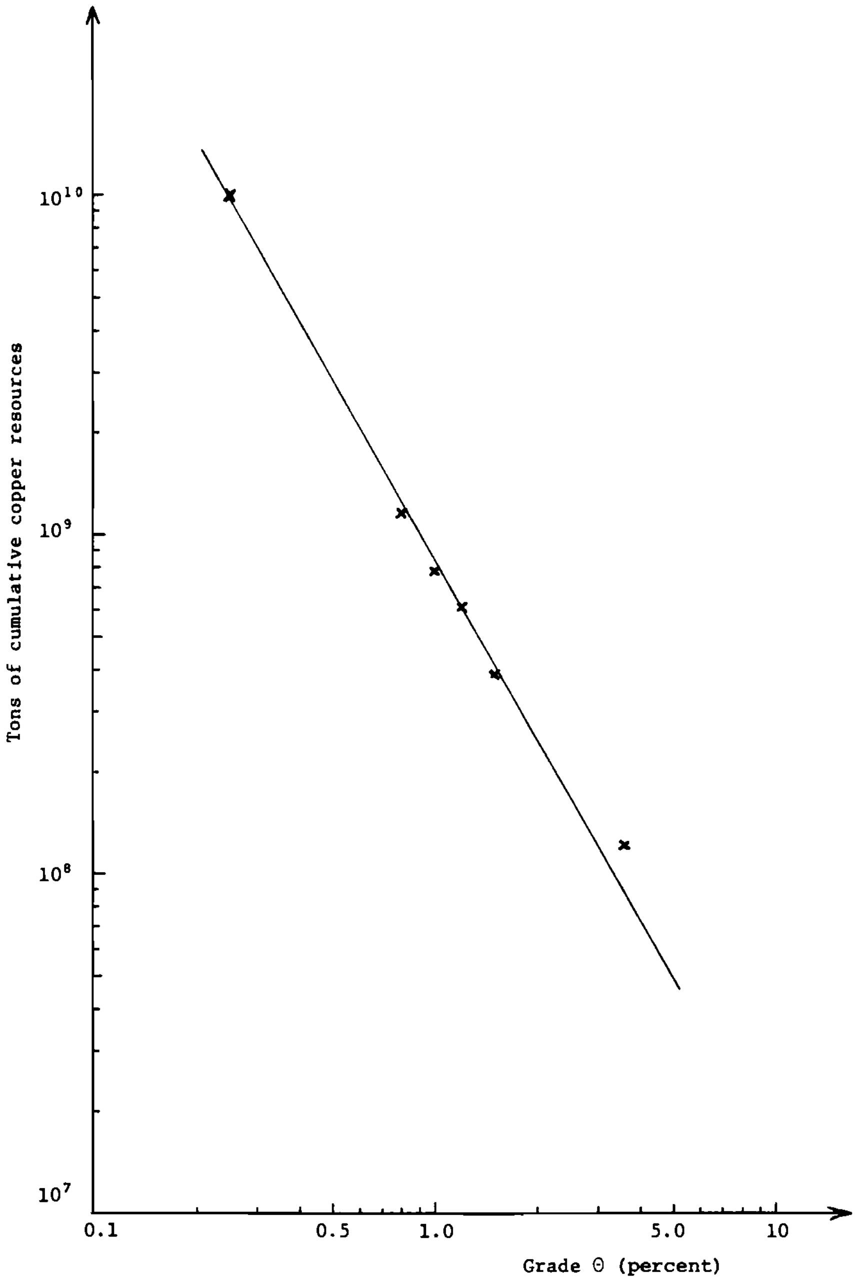


Figure 4. Relation between grade and cumulative copper resources.

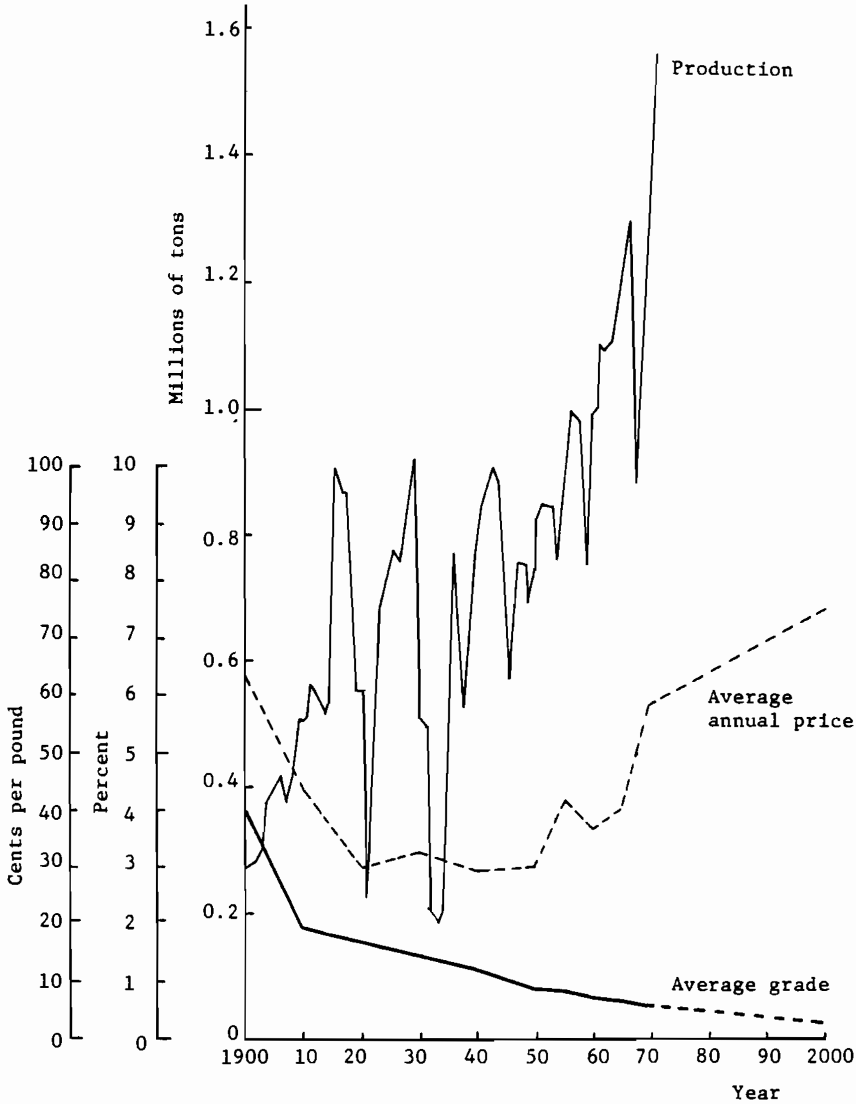


Figure 5. U.S. copper production, average grade, and average annual price. Sources: [2] Production; [1] Average annual price in the year 2000; [4] Average grade in the year 2000.

We adopt a similar equation in order to estimate world paramarginal potential resources. By using the figures for potential copper resources and grade, we obtain the following equation.

$$R \text{ (metric tons)} = 1.1 A \text{ (ppm)} \times 10^9$$

This relation is shown by a broken line in Figure 2. Ratios of paramarginal potential resources estimated by using the above equation to present reserves (C/A) are shown in Table 2.

Relation between grades and prices

As mentioned in the previous section, as the grade of ore becomes lower, the reserves increase, but, concurrently, the extracting cost may also increase. If the decrease in grade induced a disproportionate cost increase, the increase of reserves would become meaningless from the economic viewpoint. The existence of an inversely proportional relation between grade and extracting cost has been investigated [1]. If the grade decreases by one-tenth, the extracting cost increases ten times. In the case of copper resources, the inversely proportional relation between grades and volumes of deposits has been [4] generally investigated.

Figure 5 shows the average grades of copper ores mined and the average annual prices and production in the past 70 years. Forecasts to the year 2000 are also shown. Until the twentieth century, ores whose grade is around 6 percent were mined. In 1960, large-scale open pit mines with porphyrycopper whose grade is 2 percent were exploited. In 1910, extracting cost decreased to 31 cents per pound. Up to 1950, the price was maintained at an almost constant level, although the grade of the ores decreased.

However, as the mines become deeper, the price shows an upward tendency. In the year 2000, the grade will decrease to 0.25 percent and the extracting cost is expected to increase to over 75 cents per pound if there is no remarkable technological progress.

COPPER RESOURCES MODEL

Objectives of the model

The copper resources model was built in order to analyze the changes of various copper resource conditions such as reserves, grade, price, supply, and demand on a regional basis. Through analyses, we expect to clarify the effects of technological progress and changes in resource utilization and resource situation.

Although the model was built with copper in mind, its fundamental structure can be applied to other kinds of mineral resources with minor changes. We are now making an effort to apply the same model to both aluminum and copper resources.

Fundamental structure of the model

An outline of the model structure is shown in Figure 6. The world is disaggregated into nine regions, considering the geography, levels of economic development, types of economy, and abundances of resources. Details of regional disaggregation are shown in Table 4.

Annual resource production and demand are calculated by regions. Resource production depends on regional reserves, grade, production capacity, and operating ratio. The sum of production, stock, and processed scrap yields the regional maximum supply. Actually, nearly half of the copper scrap is used directly by the consumer. This direct scrap is treated separately. The regional potential demand is calculated from the gross regional production taking the level of industrialization and the share of the manufacturing industry into account. These two economic indicators are given exogenously from the global macroeconomic and input-output models.

In almost all regions, considerable supply and demand gaps arise because of the unequal distribution of resources. These gaps are covered by interregional trade. If the world total supply exceeds the world total potential demand, the excess is stored in each region according to the regional stock level. In this case, the potential demand is equal to the actual demand.

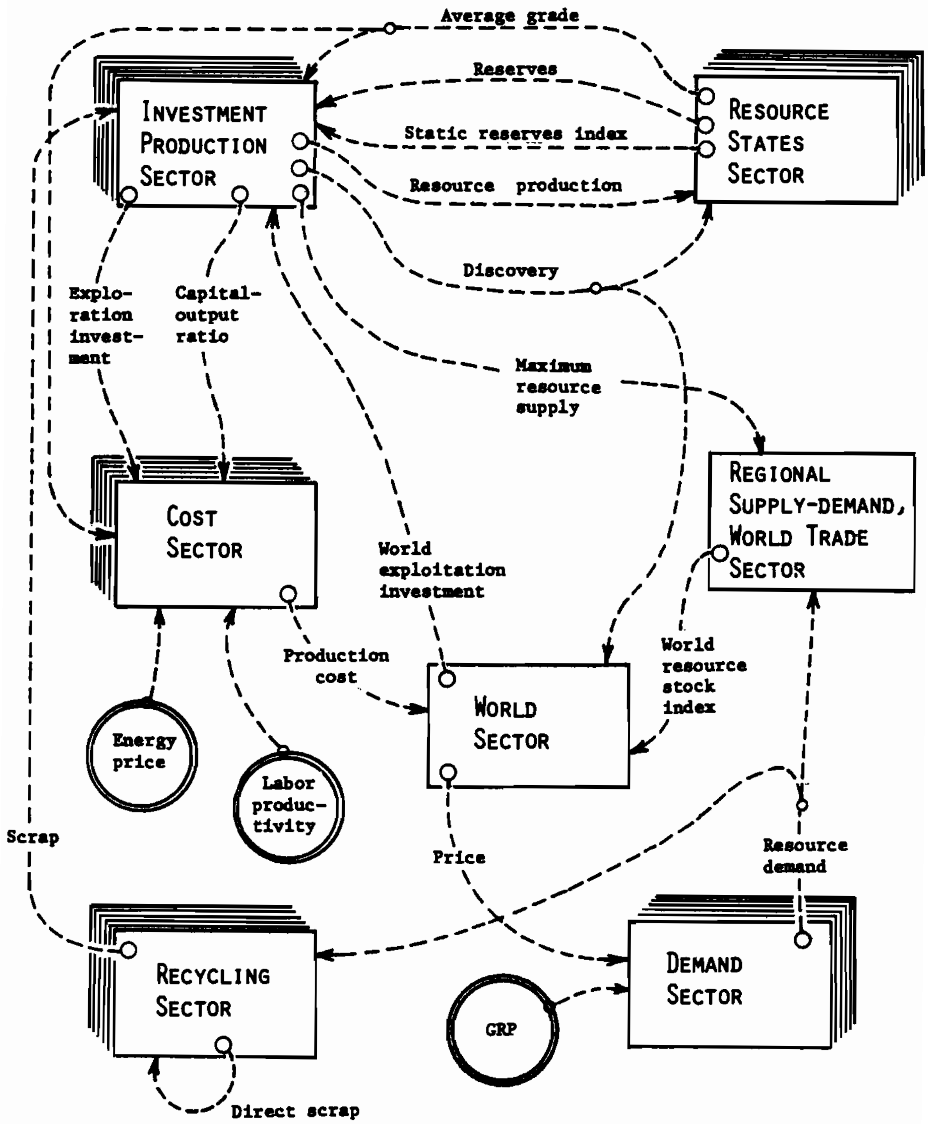


Figure 6. Interactions among the seven sectors of the copper resources model.

Table 4. Details of regional disaggregation.

Region	Country
1	Japan
2	Australia, New Zealand
3	Canada, United States
4	Belgium, Denmark, France, Federal Republic of Germany, Ireland, Italy, Luxembourg, Netherlands, United Kingdom, Austria, Finland, Greece, Iceland, Liechtenstein, Malta, Monaco, Norway, Portugal, San Marino, Spain, Sweden, Switzerland, Vatican, Yugoslavia, Israel, Turkey, Republic of South Africa
5	Hong Kong, Korea, Macao, Taiwan, Indonesia, Malaysia, Philippines, Singapore, Thailand, Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka, Burma, Khmer Republic (Cambodia), Laos, Fiji, Nauru, Tonga, Western Samoa, Bahrain, Cyprus, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen Arab Republic, People's Democratic Republic of Yemen
6	Rhodesia, Algeria, Egypt, Libya, Morocco, Sudan, Tunisia, Dahomey, Gambia, Ghana, Republic of Guinea, Ivory Coast, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, Upper Volta, Burundi, Cameroun, Central African Republic, Chad, Congo, Equatorial Guinea, Gabon, Rwanda, Zaire, Botswana, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Somalia, Swaziland, Tanzania, Uganda, Zambia
7	Bahamas, Barbados, Costa Rica, Dominican Republic, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Trinidad and Tobago, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Uruguay, Venezuela
8	Albania, Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, Romania, USSR, Cuba
9	People's Republic of China, North Korea, Mongolian People's Republic, North Viet Nam, South Viet Nam

If the world total supply cannot satisfy the potential demand, the price feedback loop comes into effect and as a result, demand is regulated to balance with supply. The price follows the full cost principle [5] and is defined as the cost multiplied by the markup ratio. The annual markup ratio is assumed to vary according to the world supply-and-demand gap of the previous year. In the model, various technologies such as resource exploitation, extraction, and utilization are considered implicitly. Their progress is expressed by the form of the multiplier. Price flow diagrams of each sector are shown in Figures 7-13.

Investment production sector

Resource production (RP)

Resource production is assumed to be determined by the capital stock. The labor force is not considered explicitly, and the production capital is not always operated fully. Usually, the operating ratio is within the range of 80 to 90 percent. Considering these conditions, we adopt the following expression for resource production:

RP.K = (OR.K*K)/COR.K

where RP = resource production (metric tons/year), OR = operating ratio, CS = capital stock (U.S. dollars), and COR = capital-output ratio (dollars/ton/year).

Operating ratio (OR)

The operating ratio depends on the world resources stock of the previous year, and we assume the function shown in Figure 14.

OR.K = TABHL(ORT,WRSIX.K,0,10,1)

ORT = 1,0.83,0.6,0.5,0.4,0.3,0.2,0.1,0.05,0,0

where ORT = operating ratio table and WRSIX = world resources stock index.

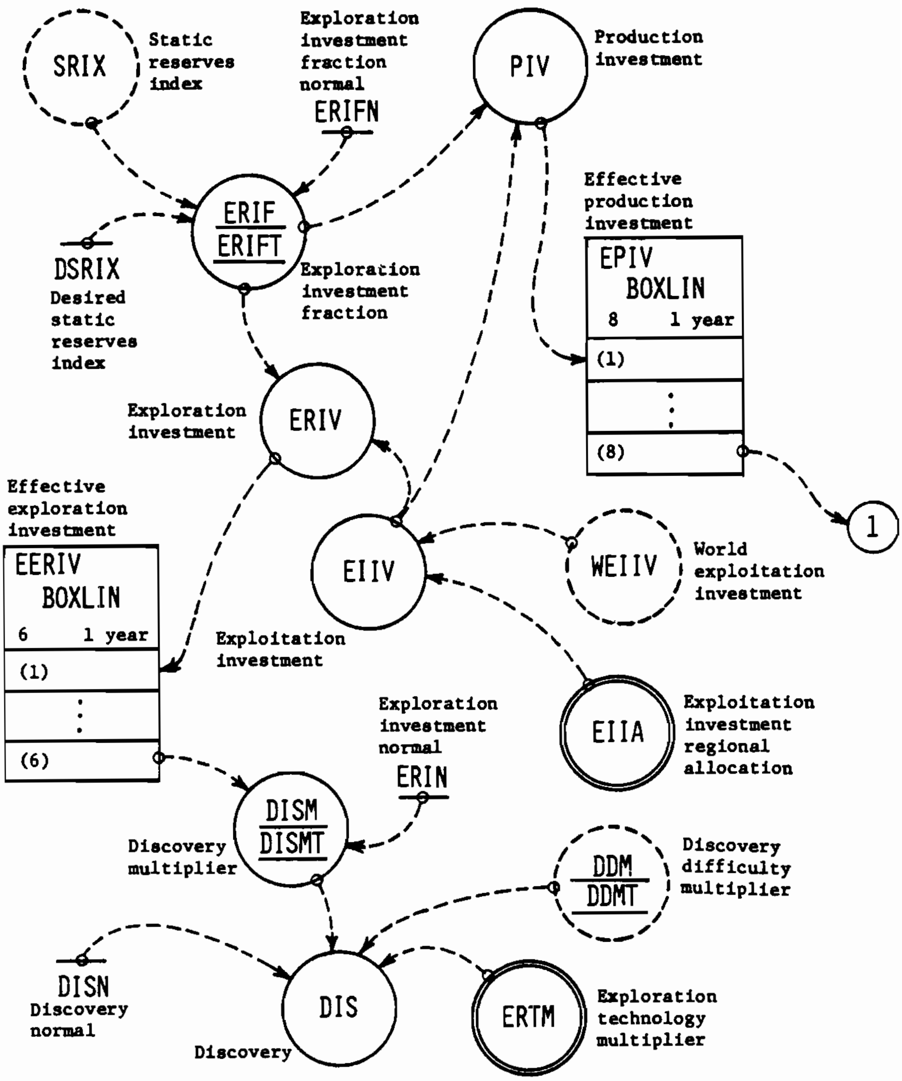


Figure 7a. Investment production sector.

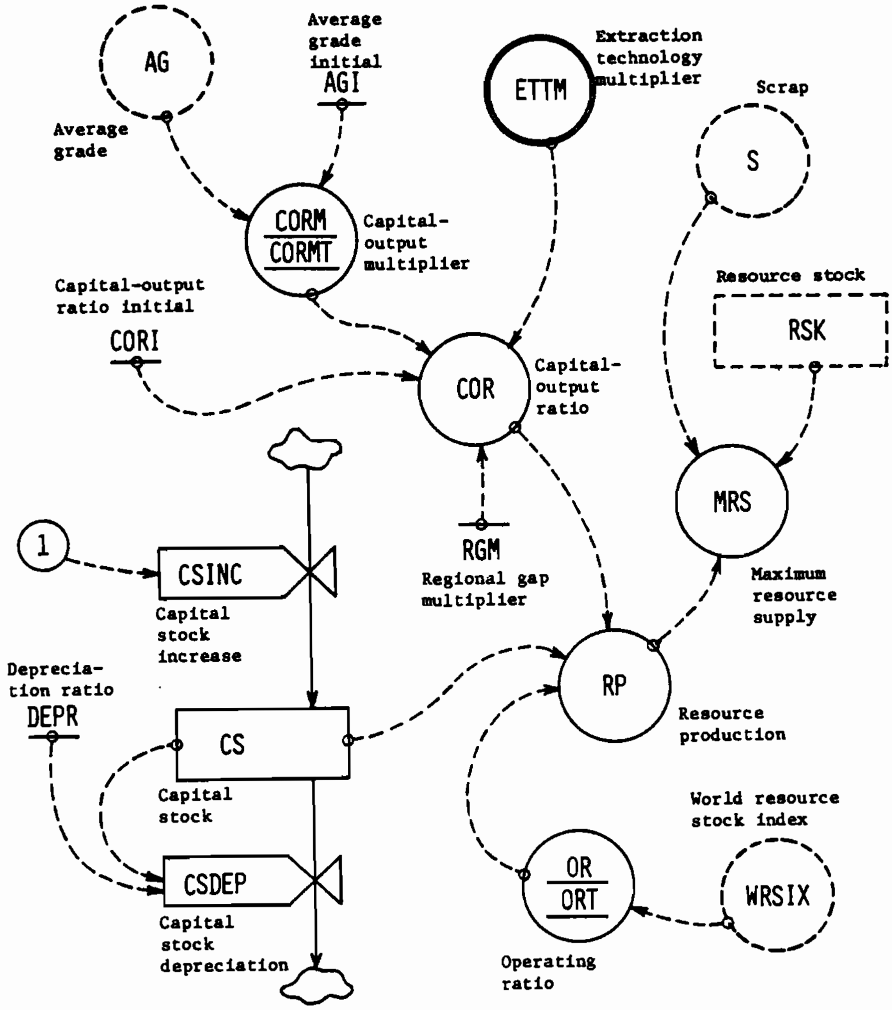


Figure 7b. Investment production sector (continued).

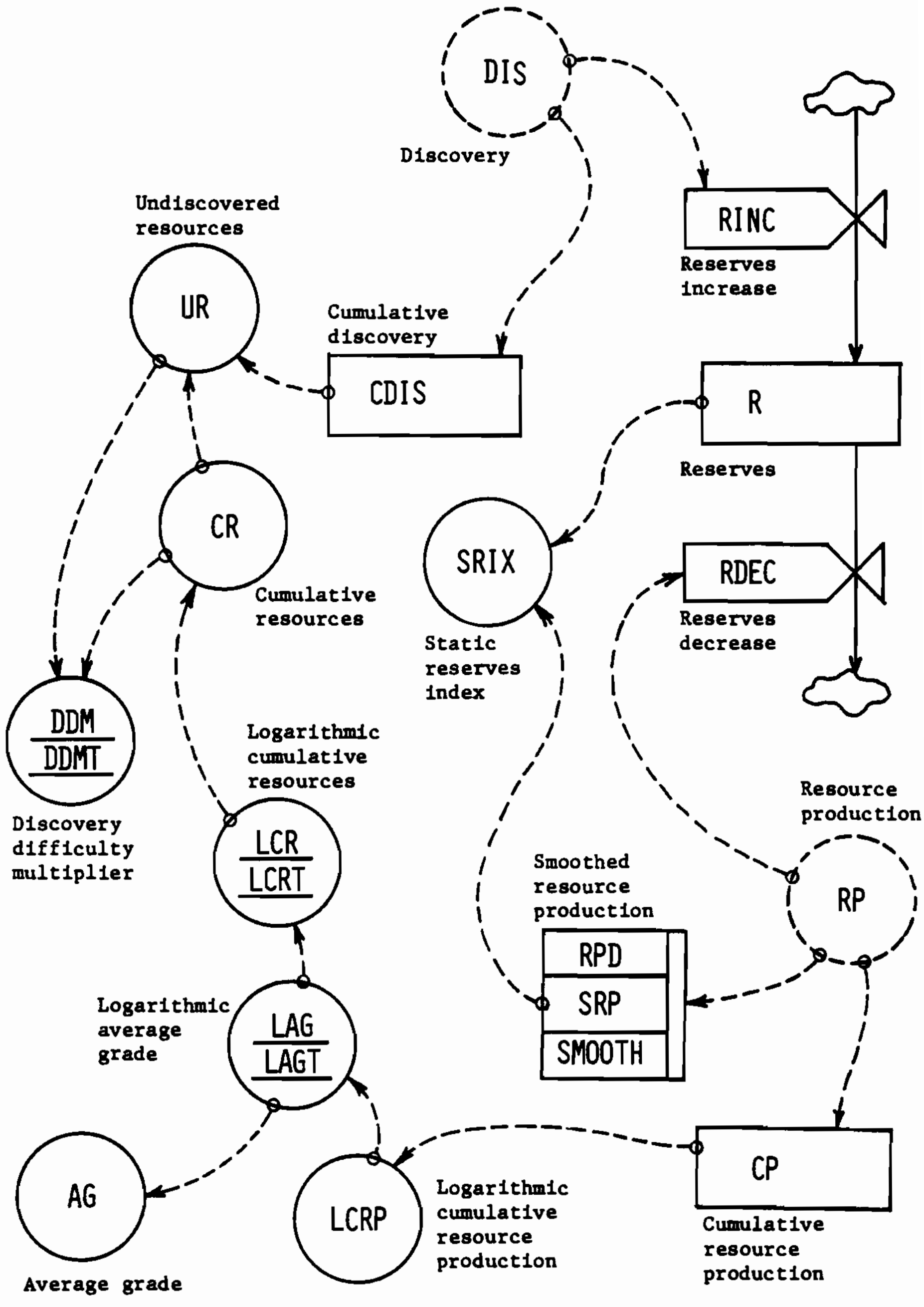


Figure 8. Resource states sector.

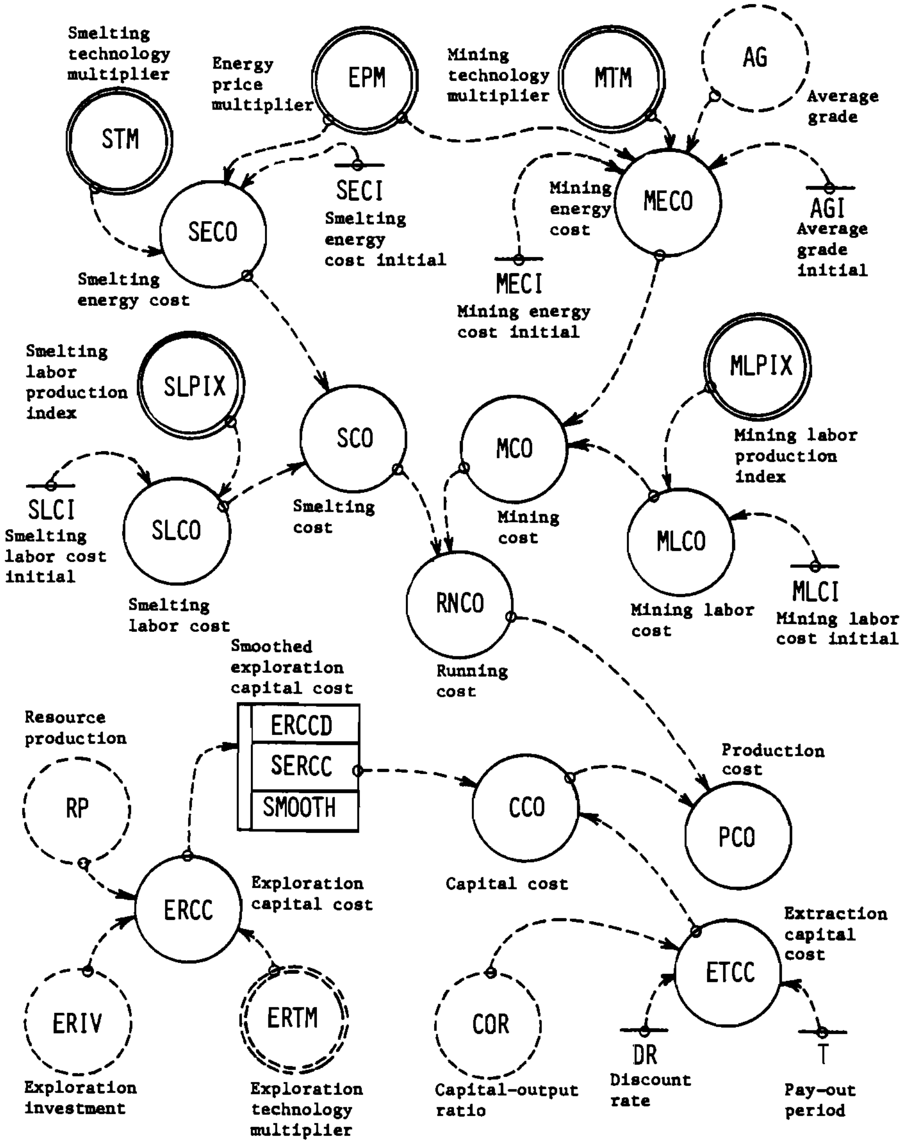


Figure 9. Cost sector.

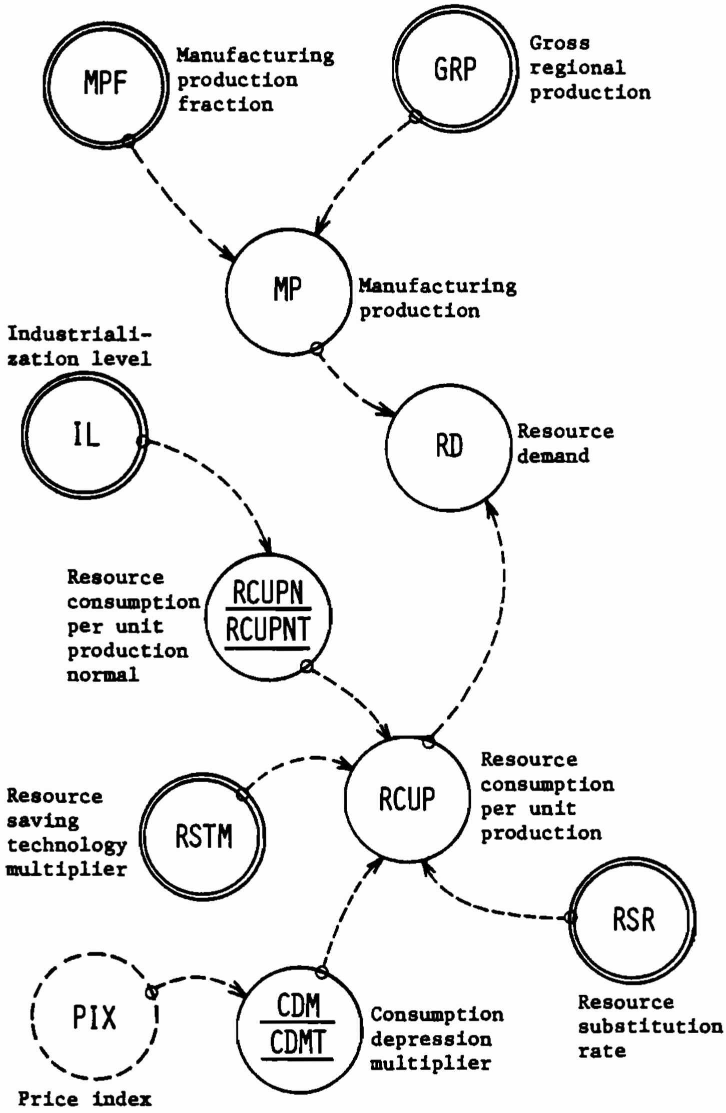


Figure 10. Demand sector.

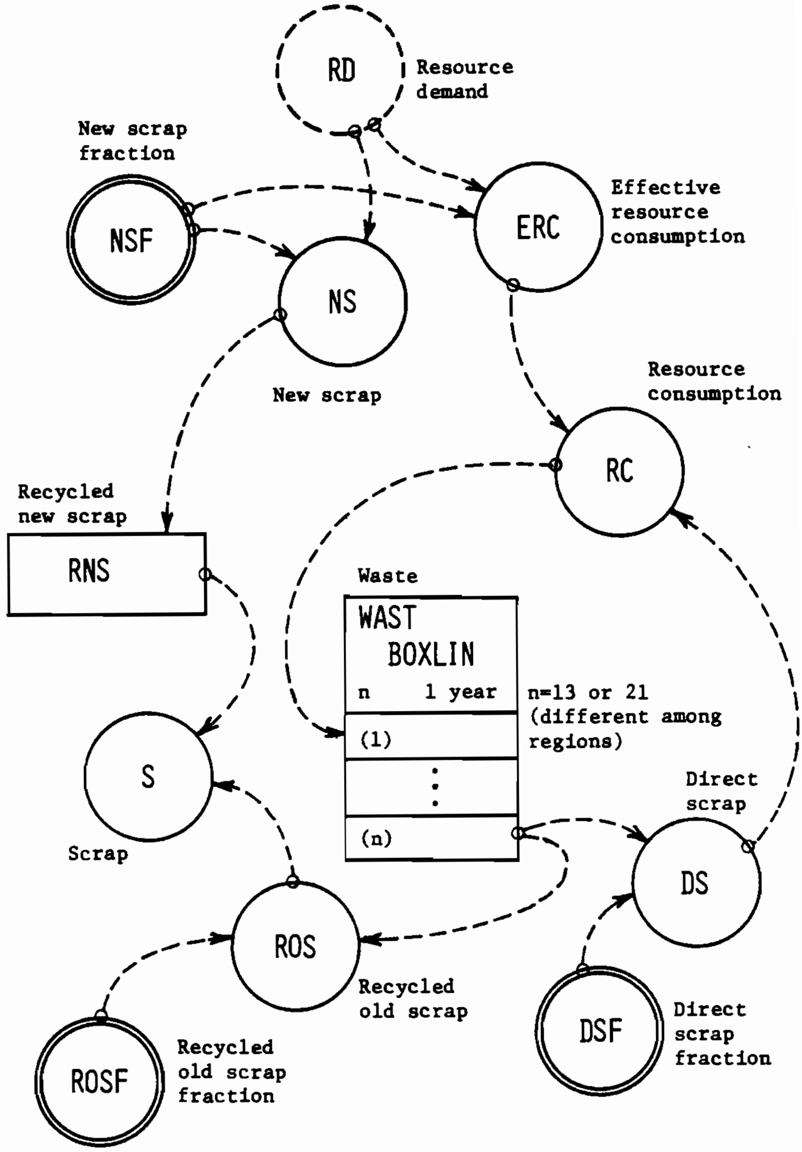


Figure 11. Recycling sector.

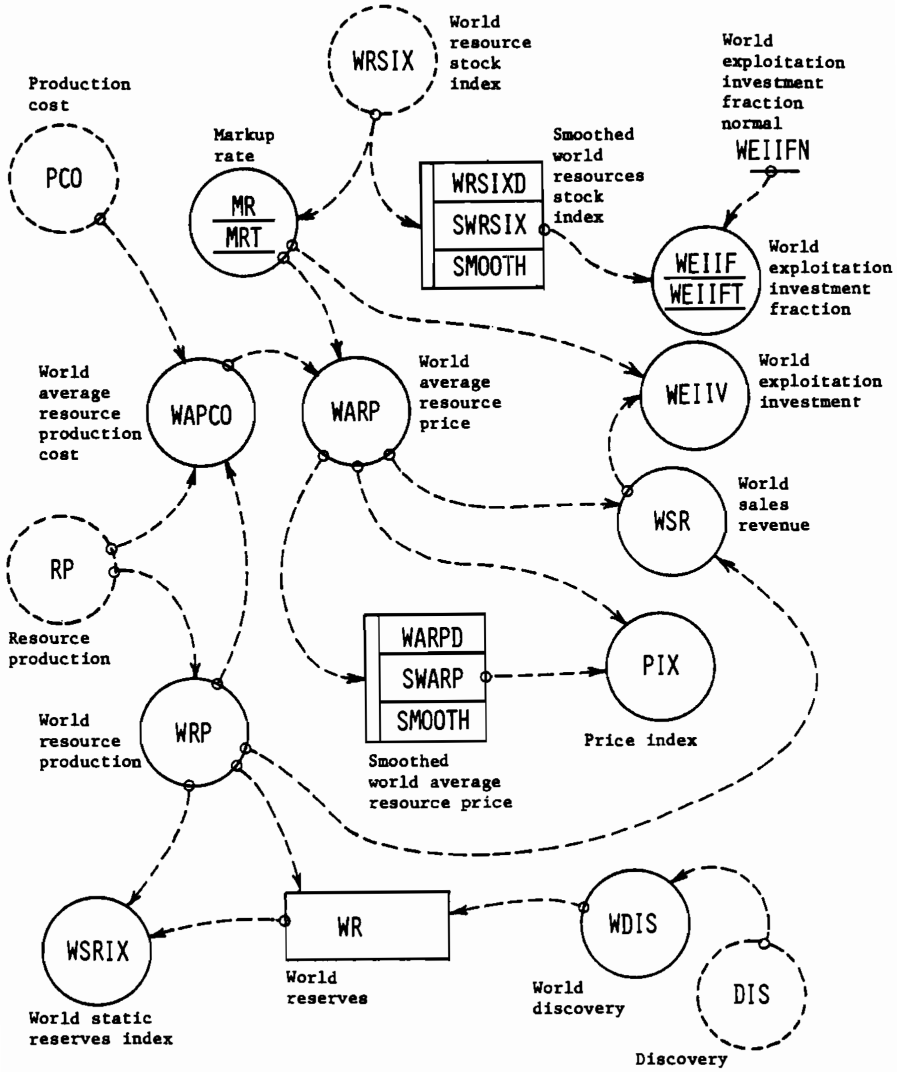


Figure 12. World sector.

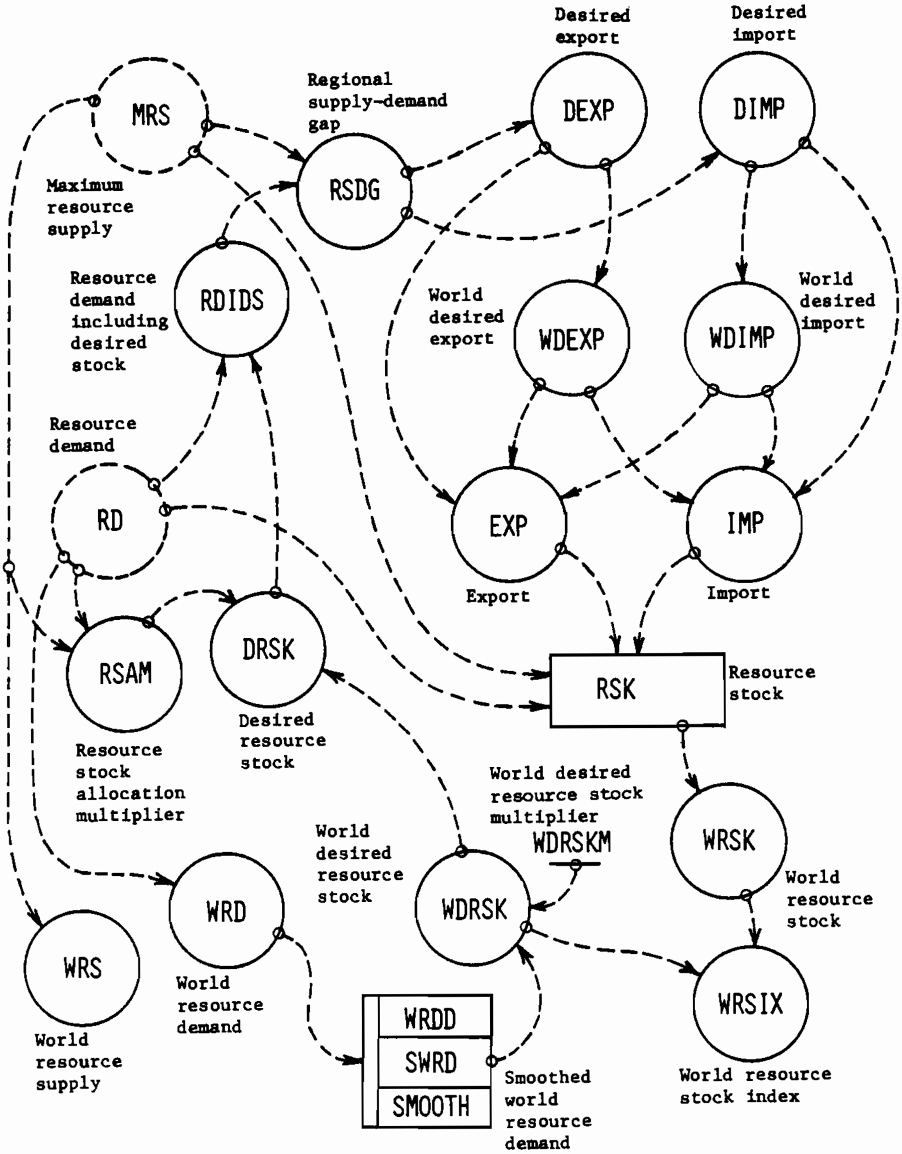


Figure 13. Regional supply-demand and world trade sector.

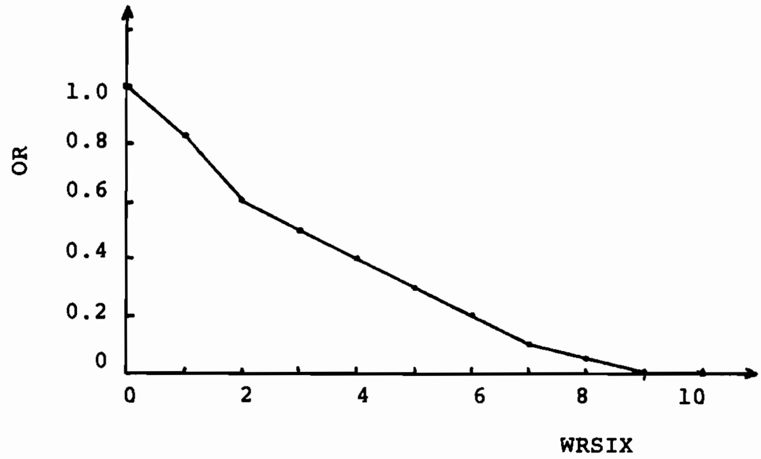


Figure 14. Operating ratio.

Capital-output ratio (COR)

The capital-output ratio is a function of the grade of the ore. Figure 15 shows the relation between the world average capital-output ratio and grade, which was obtained by referring to the data of Japanese overseas mining exploitation. This relation is used commonly in all regions in the form of the following equation (see Table 5):

CORM.K = TABHL(CORMT,AG.K/AGI,0,1,0.1)

where CORM = capital-output ratio multiplier, CORMT = capital-output ratio multiplier table (different among regions), AG = average grade (percent), and AGI = average grade initial (percent)

In overseas mining exploitation it is usually necessary to construct the various infrastructures such as freeways, railroad, harbor, and so on. We introduce a regional gap multiplier, since necessary investments are very different among regions. We also consider the progress of extraction technology. Considering all these factors, the capital-output ratio is calculated as follows.

COR.K = CORM.K*CORI*RGM*ETTM.K

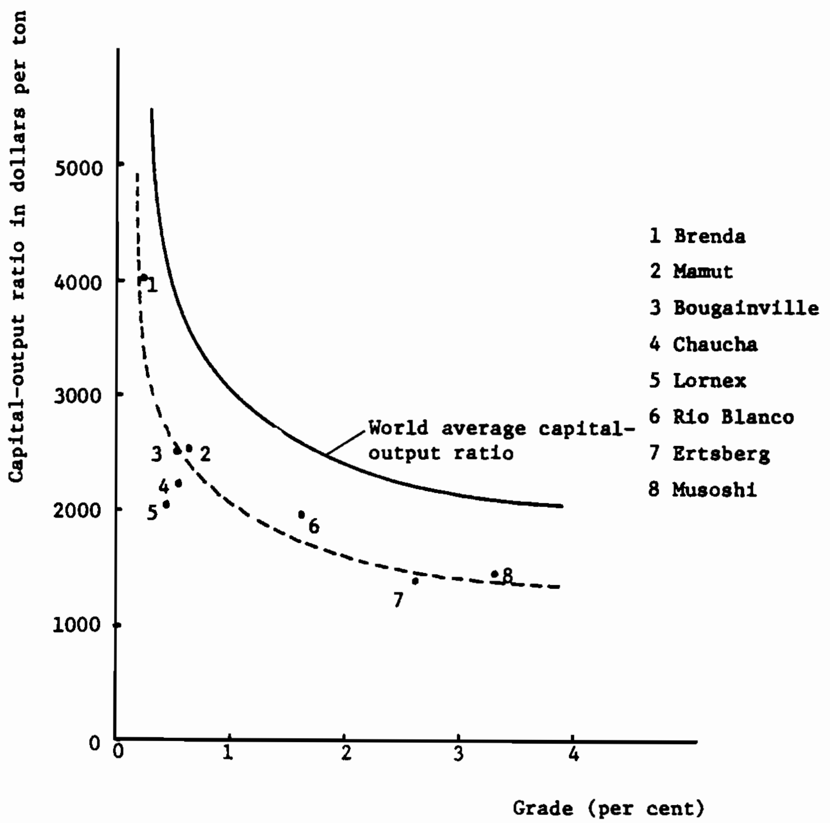


Figure 15. Relation between capital-output ratio and grade for copper.

where COR = capital-output ratio (dollars/ton/year), CORM = capital-output ratio multiplier, CORI = capital-output ratio initial (dollars/ton/year), RGM = regional gap multiplier, and ETTM = extraction technology multiplier.

Exploitation investment(EIIV)

EIIV.K = WEIIV.K*EIIA.K

where EIIV = exploitation investment (dollars/year), WEIIV = world exploitation investment (dollars/year), and EIIA = exploitation investment regional allocation.

Table 5. Japanese overseas copper mining exploitation.

Project	Country	Grade (percent)	Production in thousand tons	Capital investment in 1970 US dollars	Percentage of infrastructure capital to capital investment	Capital-output ratio (except infrastructure capital) in dollars per ton
Rio Blanco	Chile	1.6	67	157000	17	1950
Brenda	Canada	0.2	15.6	606000	3	4020
Musoshi	Zaire	3.3	42	69800	14	1430
Bougainville	Papua New Guinea	0.51	150	443200	15	2500
Lornex	Canada	0.42	55	118400	6	2030
Ertsberg	Indonesia	2.6	60	120000	32	1370
Mamut	Malaysia	0.59	29	84770	10	2540
Chaucha	Ecuador	0.52	31	84300	20	2160

Source: Ministry of International Trade and Industry, Japan.

Exploration investment (ERIV)

ERIV.K = EIIV.K*ERIF.K

where ERIV = exploration investment (dollars), EIIV = exploitation investment (dollars), and ERIF = exploration investment fraction. The fraction of exploration investment depends on the static reserves index.

ERIF.K = TABHL(ERIFT,SRIX.K/DSRIX,0,2.5,0.5)*ERIFN

ERIFT = 3,2,1,0.667,0.333,0

where ERIF = exploration investment fraction, ERIFT = exploration investment fraction table, SRIX = static reserves index (years), DSRIX = desired static reserves index (years), and ERIFN = exploration investment fraction normal.

Production investment (PIV)

PIV.K = EIIV.K*(1 - ERIF.K)

where PIV = production investment (dollars/year), EIIV = exploitation investment (dollars/year), and ERIF = exploration investment fraction.

Discovery (DIS)

Grant [6] pointed out that there exists a relation between annual discoveries and exploration investment as shown in Figure 16. This relation is introduced into the model as a table. Discoveries depend on natural amounts of undiscovered resources, which is included in the discovery difficulty. We also consider the progress of exploration technology.

DIS.K = DISM.K*DISN*DDM.K*ERTM.K

where DIS = discovery (tons/year), DISM = discovery multiplier,

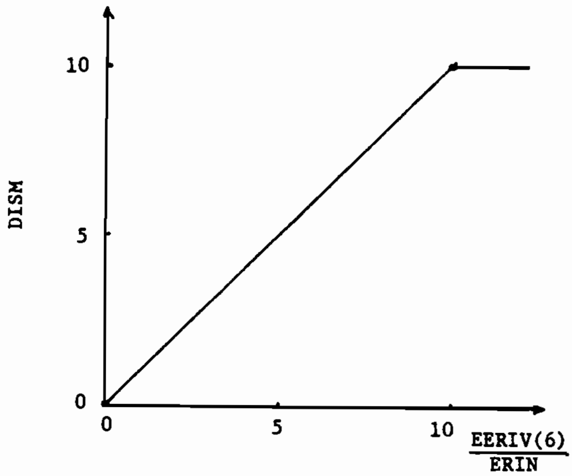


Figure 16. Discovery multiplier.

DISN = discovery normal (tons/year), DDM = discovery difficulty multiplier, and ERTM = exploration technology multiplier.

DISM.K = TABHL(DISMT,EERIV(6).K/ERIN,0,10,10)

DISMT = 0,10

where DISM = discovery multiplier, DISMT = discovery multiplier table, EERIV(6) = effective exploration investment (dollars/year), and ERIN = exploration investment normal (dollars/ year).

Capital stock (CS)

CS.K = CS.J + (DT)(CSINC.JK - CSDEC.JK)

CSINC.KL = EPIV(8).K

CSDEC.KL = CS.K*DEPR

CS = CSI

DEPR = 0.05

where CS = capital stock (dollars), CSINC = capital stock increase (dollars/year), CSDEC = capital stock decrease (dollars/year), EPIV(8) = effective production investment (dollars/year), DEPR = depreciation rate [1/year], and CSI = capital stock initial (dollars).

Maximum resource supply (MRS)

MRS.K = RP.K + RSK.K + S.K

where MRP = maximum resource supply (tons/year), RP = resource production (tons/year), RSK = resource stock (tons/year), and S = scrap (tons/year).

Resource states sector

Cumulative resources (CR)

As already mentioned, there is an approximately linear relation between the logarithm of grades and the logarithm of cumulative resources (including used ones). We assume that a similar relation exists in all regions, that is, all lines denoting this relation by region are almost parallel to the line for the world. The position of each line can be determined by using the figures of average grade and the corresponding cumulative resources in 1970. The slopes of the regional lines are steeper than that for the world because they are adjusted so that the total regional cumulative resources with a grade of 0.25 percent coincide with that for the world. We can estimate the current cumulative resources by using this regional line, if the current average grade is given. This relation is introduced into the model as the table LCRT.

LCR.K = TABHL(LCRT,LAG.K,-2.3,1.3,3.6)

where LCR = logarithmic cumulative resources, LCRT = logarithmic cumulative resources table (different among regions), and LAG = logarithmic average grade.

Average grade (AG)

Figure 17 shows the plots of cumulative production versus average grades in the United States. It is very clear that there exists a similar relation as in the resources case. We assume also that this relation is applicable to all regions, and it is introduced as the table LAGT.

LAG.K = TABHL(LAGT,LCRP.K,14,23,9)

where LAG = logarithmic average grade, LAGT = logarithmic average grade table (different among regions), and LCRP = logarithmic cumulative resources production.

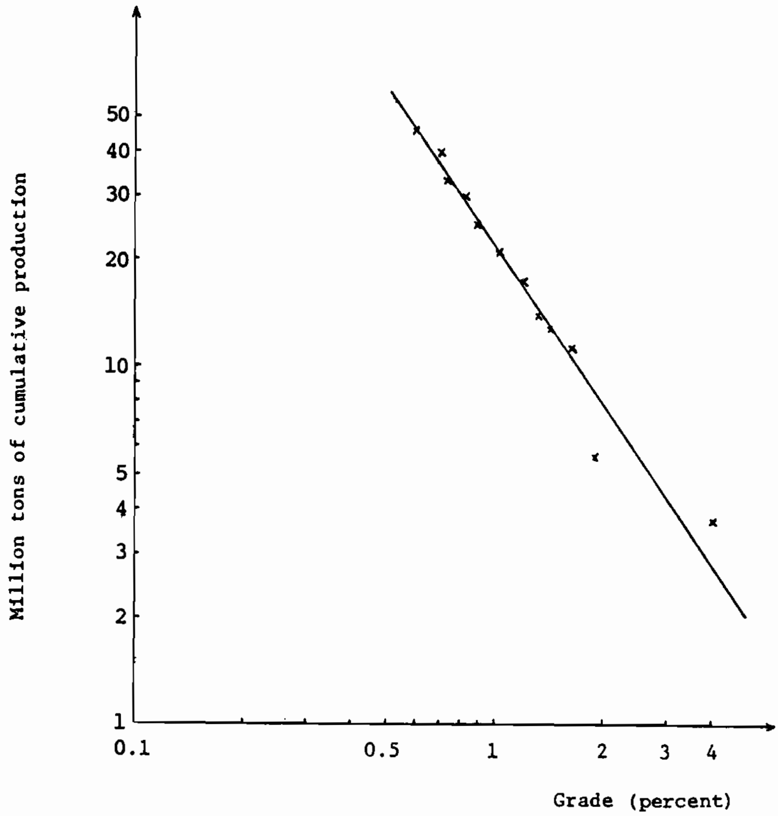


Figure 17. Cumulative production and average grade for copper in the United States.

Reserves (R)

$$R.K = R.J + (DT)(RINC.JK - RDEC.JK)$$

$$RINC.KL = DIS.K$$

$$RDEC.KL = RP.K$$

where R = reserves (tons), RINC = reserves increase (tons/year), RDEC = reserves decrease (tons/year), DIS = discovery (tons/year), and RP = resources production (tons/year).

Undiscovered resources(UR)

$$UR.K = CR.K - CDIS.K$$

where UR = undiscovered resources (tons), CR = cumulative resources (tons), and CDIS = cumulative discovery (tons).

Discovery difficulty multiplier (DDM)

Discovery difficulty is assumed to be a function of the undiscovered ratio (the undiscovered resources-cumulative resources ratio) as shown in Figure 18.

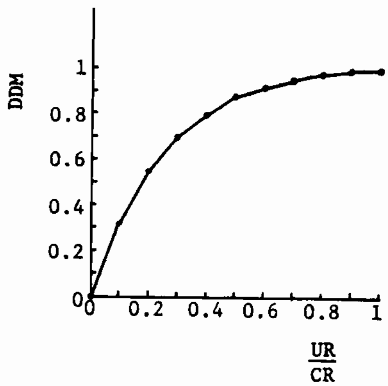


Figure 18. Discovery difficulty multiplier.

DDM.K = TABHL(DDMT,UR.K/CR.K,0,1,0.1)

DDMT = 0,0.32,0.55,0.7,0.8,0.88,0.92,0.96,0.98,0.99,1

where DDM = discovery difficulty multiplier and DDMT = discovery difficulty multiplier table.

Static reserves index (SRIX)

SRIX.K = R.K/SRP.K

where SRIX = static reserves index (years), R = reserves (tons), and SRP = smoothed resources production (tons/year).

Cost sector

Production cost (PCO)

PCO.K = CCO.K + RNCO.K

where PCO = production cost (dollars/ton), CCO = capital cost (dollars/ton), and RNCO = running cost (dollars/ton).

Capital cost (CCO)

CCO.K = SERCC.K + ETCC.K

where CCO = capital cost (dollars/ton), SERCC = smoothed exploration capital cost (dollars/year), and ETCC = extraction capital cost (dollars/ton).

Smoothed exploration capital cost (SERCC)

SERCC.K = SMOOTH(ERCC.K,EPCCD)

SERCC = SERCCI

ERCCD = 5

where SERCC = smoothed exploration capital cost (dollars/ton), ERCC = exploration capital cost (dollars/ton), ERCCD = exploration capital cost smoothing time (years), and SERCCI = smoothed exploration capital cost initial (dollars/ton).

Exploration capital cost (ERCC)

ERCC.K - (ERIV.K/ERTM.K)/RP.K

where ERCC = exploration capital cost (dollars/ton), ERIV = exploration investment (dollars/year), ERTM = exploration technology multiplier, and RP = resources production (tons/year).

Extraction capital cost (ETCC)

The necessary capital per unit production is the capital-output ratio COR. It is assumed that this capital is paid in T years; the following equation must be satisfied:

$$COR = \frac{Q}{1 + DR} + \frac{Q}{(1 + DR)^2} + \cdot \cdot \cdot + \frac{Q}{(1 + DR)^T}$$

where Q is the annual payment and DR is the discount rate. By equating Q to extraction capital cost ETCC and rearranging, we obtain the following equation:

ETCC.K = (COR.K*DR*(1 + DR)**T)/((1 + DR)**T - 1)

where ETCC = extraction capital cost (dollars/ton), COR = capital-output ratio (dollars/ton/year), and DR = discount rate (1/year).

Running cost (RNCO)

RNCO.K = MCO.K + SCO.K

where RNCO = running cost (dollars/ton), MCO = mining cost (dollars/ton), and SCO = smelting cost (dollars/ton).

Mining cost (MCO)

The mining cost includes the transportation and concentration cost. Considering inputs, it can be divided into the energy and labor cost.

MCO.K = MECO.K + MLCO.K

where MCO = mining cost (dollars/ton), MECO = mining energy cost (dollars/ton), and MLCO = mining labor cost (dollars/ton).

Mining energy cost (MECO)

Mining energy cost can be assumed to be inversely proportional to the average grade.

MECO.K = MECI*EPM.K *MTM.K/(AG.K/AGI)

where MECO = mining energy cost (dollars/ton), MECI = mining energy cost initial (dollars/ton), EPM = energy price multiplier, MTM = mining technology multiplier, AG = average grade (percent), and AGI = average grade initial (percent).

Mining labor cost (MLCO)

MLCO.K = MLCI/MLPIX.K

where MLCO = mining labor cost (dollars/ton), MLCI = mining labor cost initial (dollars/ton), and MLPIX = mining labor production index.

Smelting cost (SCO)

The smelting cost includes the refining cost. It can also be divided into the energy and labor cost.

SCO.K = SECO.K + SLCO.K

where SCO = smelting cost (dollars/ton), SECO = smelting energy cost (dollars/ton), and SLCO = smelting labor cost (dollars/ton).

Smelting energy cost (SECO)

SECO.K = SECI*EPM.K*STM.K

where SECI = smelting energy cost initial (dollars/ton), EPM = energy price multiplier, and STM = smelting technology multiplier.

Smelting labor cost (SLCO)

SLCO.K = SLCI/SLPIX.K

where SLCO = smelting labor cost (dollars/ton), SLCI = smelting labor cost initial (dollars/ton), and SLPIX = smelting labor production index.

Demand sector

Resource demand (RD)

RD.K = MP.K*RCUP.K

where RD = resource demand (tons/year), MP = manufacturing production (dollars/year), and RCUP = resource consumption per unit product (tons/dollar).

Manufacturing production is the gross regional production multiplied by the manufacturing production fraction. Both of these economic variables are given exogenously from the world economic model.

Resource consumption per unit product (RCUP)

The resource consumption per unit product largely depends on the level of industrialization. This economic indicator is also given exogenously. If the resource price rises sharply, the consumption will be depressed to some extent. This repercussion is expressed by a consumption depression multiplier. We also consider resource substitution and saving, which are given exogenously.

RCUP.K = RCUPN.K*CDM.K*(1 - RSR.K)*RSTM.K

where RCUP = resource consumption per unit product (tons/dollar), RCUPN = resource consumption per unit product normal(tons/dollar), CDM = consumption depression multiplier, RSR = resource substitution rate, and RSTM = resource saving technology multiplier.

Consumption depression multiplier (CDM)

The consumption depression multiplier is assumed to be a function of price index as shown in Figure 19.

CDM.K = TABHL(CDMT,PIX.K,0,2,1)

CDMT = 1,1,0.9995

where CDM = consumption depression multiplier, CDMT = consumption depression multiplier table, and PIX = price index.

Recycling sector

In the manufacturing process, resources are not used perfectly. The old resources are treated as new scrap for the most part. The resources that are used effectively comprise a part of the manufactured goods. When their lifetime is over, the goods

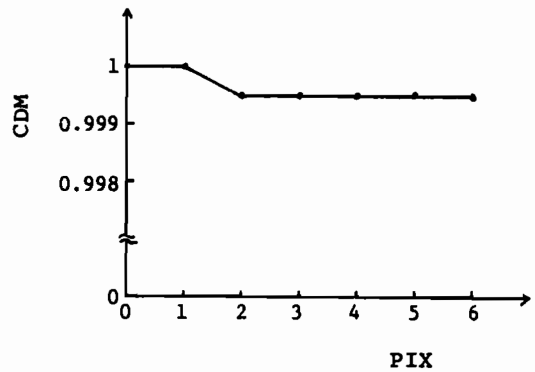


Figure 19. Consumption depression multiplier.

go to waste and the useful parts of the resources in them are recovered. The recovered resources are partly offered for direct use (direct scrap), and partly disposed of as scrap (old scrap).

World sector

World average resource price (WARP)

WARP is defined as the world average production cost multiplied by the markup rate.

WARP.K = WAPCO.K*MR.K

where WARP = world average resource price (dollars/ton), WAPCO = world average production cost (dollars/ton), and MR = markup rate.

Markup rate (MR)

The markup rate is assumed to be a function of world resource stock as shown in Figure 20.

MR.K = TABHL(MRT,WRSIX.K,0,3,1)

MRT = 1.8,1.7,1.6,1.5

where MR = markup rate, MRT = markup rate table, and WRSIX = world resource stock index.

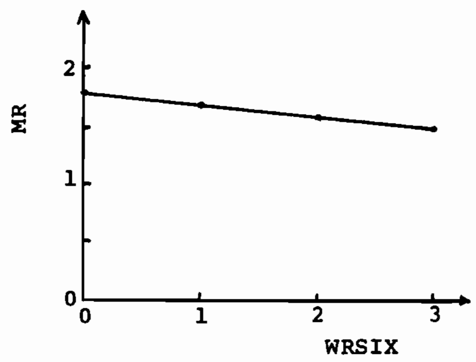


Figure 20. Markup rate.

World average production cost (WAPCO)

WAPCO.K = (RP1.K*PCO1.K + RP2.K*PCO2.K + ...

+ RP8.K*PCO8.K)/WRP.K

where WAPCO = world average production cost (dollars/ton), RP = resource production (tons/year), PCO = resource production cost (dollars/ton), and WRP = world resource production (tons/year).

Price index (PIX)

PIX.K = WARP.K/SWARP.K

where PIX = price index, WARP = world average resource price (dollars/ton), and SWARP = smoothed world average resource price (dollars/ton).

World exploitation investment (WEIIV)

The world exploitation investment occupies a part of the world sales revenue.

WEIIV.K = WSR.K*(MR.K - 1)/MR.K

where WEIIV = world exploitation investment (dollars/year), WSR = world sales revenue (dollars/year), and MR = markup rate.

World exploitation investment fraction (WEIIF)

WEIIF.K = TABHL(WEIIFT,SWRSIX.K,0,2,0.5)*WEIIFN

WEIIFT = 1.5,1.15,1,0.9,0.85

where WEIIF = world exploitation investment fraction, WEIIFT = world exploitation investment fraction table, SWRSIX = smoothed world resources stock index, and WEIIFN = world exploitation investment fraction normal. This relation is shown in Figure 21.

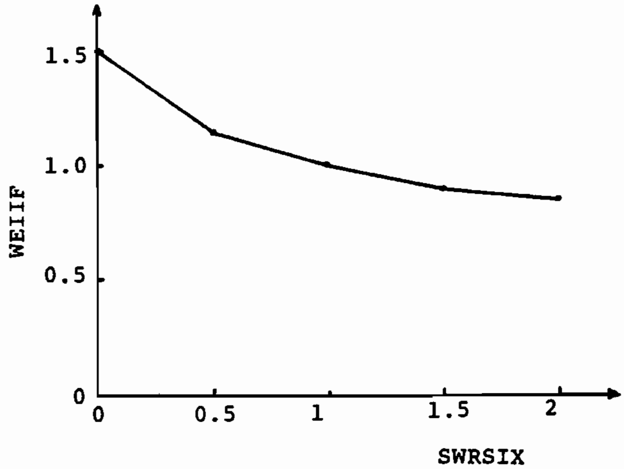


Figure 21. World exploitation investment fraction.

Regional supply-demand; world trade sector

World resource demand (WRD)

World resource demand is the sum of the regional demands.

WRD.K = RD1.K + RD2.K + . . . + RD8.K

where WRD = world resource demand (tons/year) and RD = resource demand (tons/year).

World desired resource stock (WDRSK)

The world desired stock is assumed to be proportional to the world demand.

WDRSK.K = SWRD.K*WDRSKM

where SWRD = smoothed world resource demand (tons/year), WDRSK = world desired resource stock (tons/year), and WDRSKM = world desired resource stock multiplier.

For the resource-importing regions, the regional desired resource stocks are assumed to be proportional to the regional demands. For the exporting regions they are assumed to be proportional to the maximum resource supplies.

Regional supply-demand gap (RSDG)

Regional supply-demand gaps are calculated as follows.

RSDG.K = MRS.K - RDIDS.K

RDIDS.K = RD.K + DRSK.K

where RSDG = regional supply-demand gap (tons/year), MRS = maximum resource supply (tons/year), RDIDS = resource demand including stock (tons/year), RD = resource demand (tons/year), and DRSK = desired resource stock (tons/year). If the regional supply-demand gaps are positive, the gaps themselves mean the desired exports; the negative gaps mean desired imports.

Usually, there is a difference between the world total of desired regional exports and the world total of imports. If the total of desired imports is larger than desired exports, it is physically impossible to satisfy the excess demand with the supply. The desired imports must be depressed so that total actual imports coincide with total desired exports. In this case, the desired exports are equal to the actual exports. That is,

IMP.K = DIMP.K*WDEXP.K/WDIMP.K

WDEXP.K = DEXP1.K + DEXP2.K + ... + DEXP8.K

WDIMP.K = DIMP1.K + DIMP2.K + ... + DIMP8.K

where IMP = import (tons/year), DIMP = desired import (tons/year), WDEXP = world desired export (tons/year), and WDIMP = world desired import (tons/year), for WEXP.K less than WIMP.K. Similar adjustments are necessary for desired exports in the case where WEXP.K is greater than WIMP.K.

Resource stock (RSR)

The actual regional stocks are calculated as follows.

RSK.K = RSK.J + DT*((MRS.K - RSK.J) + IMP.J - RD.J - EXP.J) where RSK = resource stock (tons/year), MRS = maximum resource supply (tons/year), RD = resource demand (tons/year), EXP = export (tons/year), and IMP = import (tons/year).

World resource stock index (WRSIX)

$$WRSIX.K = WRSK.K/WDRSK.K$$

$$WRSK.K = RSK1.K + RSK2.K + \ldots + RSK8.K$$

where WRSIX = world resource stock index, WRSK = world resource stock (tons/year), WDRSK = world desired resource stock (tons/year), and RSK = resource stock (tons/year).

4. COMPUTATIONAL RESULTS

The computational results for the basic run are given in Table 6 and Figure 22.

Table 6. Computational results for the basic run.

Abbreviation	Variable	Result
GRP	Gross regional production	Given
MPF	Manufacturing production fraction	Given
IL	Industrialization level	Given
	Technical progress	None
	Energy price	Fixed to 1970 level
WDRSKM	World desired resource stock multiplier	0.1
ORN	Operating ratio normal	0.83
EIIA	Exploitation investment regional allocation	Proportional to the present resources production
ERIFN	Exploitation investment fraction normal	0.15
DSRIX	Desired static reserves index	50 yr
PID	Production investment delay	7 yr
ERID	Exploration investment	5 yr
DERP	Depreciation ratio	5%/yr
DR	Discount rate	0.1
T	Payout period	20 yr
RSR	Resources substitution rate	1.2%/yr
	Recycling rate	95%
	Goods lifetime	12-20 yr

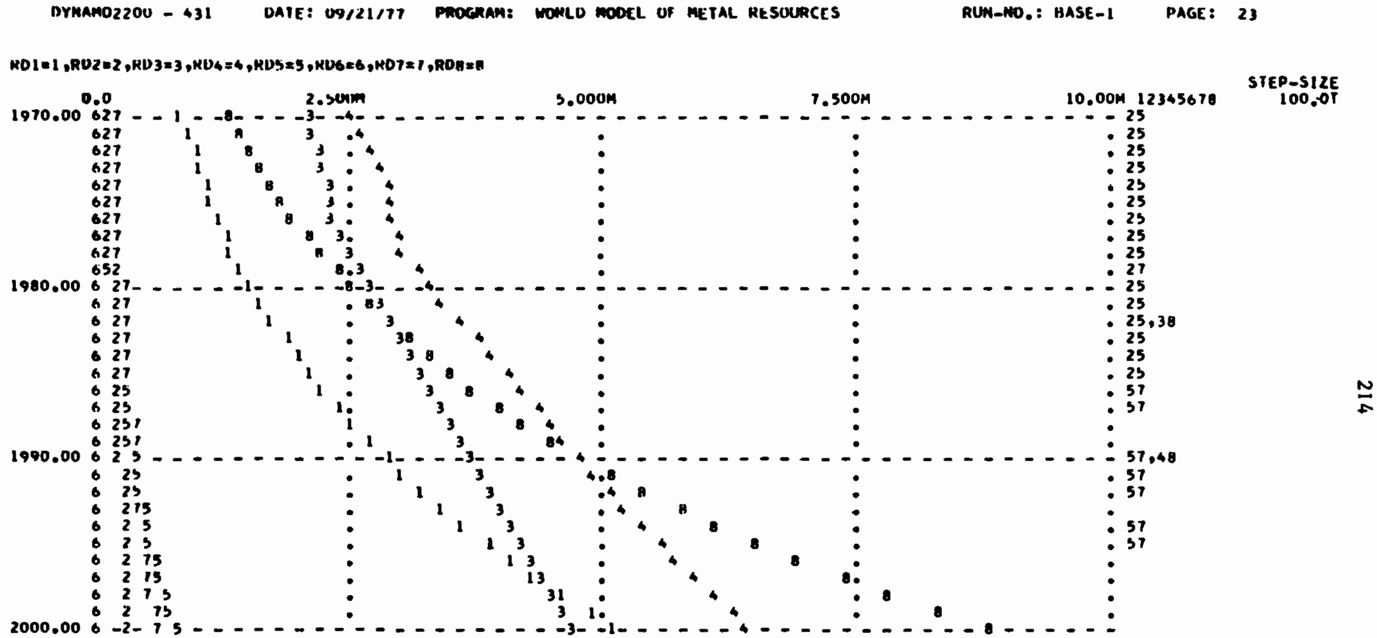


Figure 22. Computational results for the basic run. a. Resource demand in 10^6 ton.

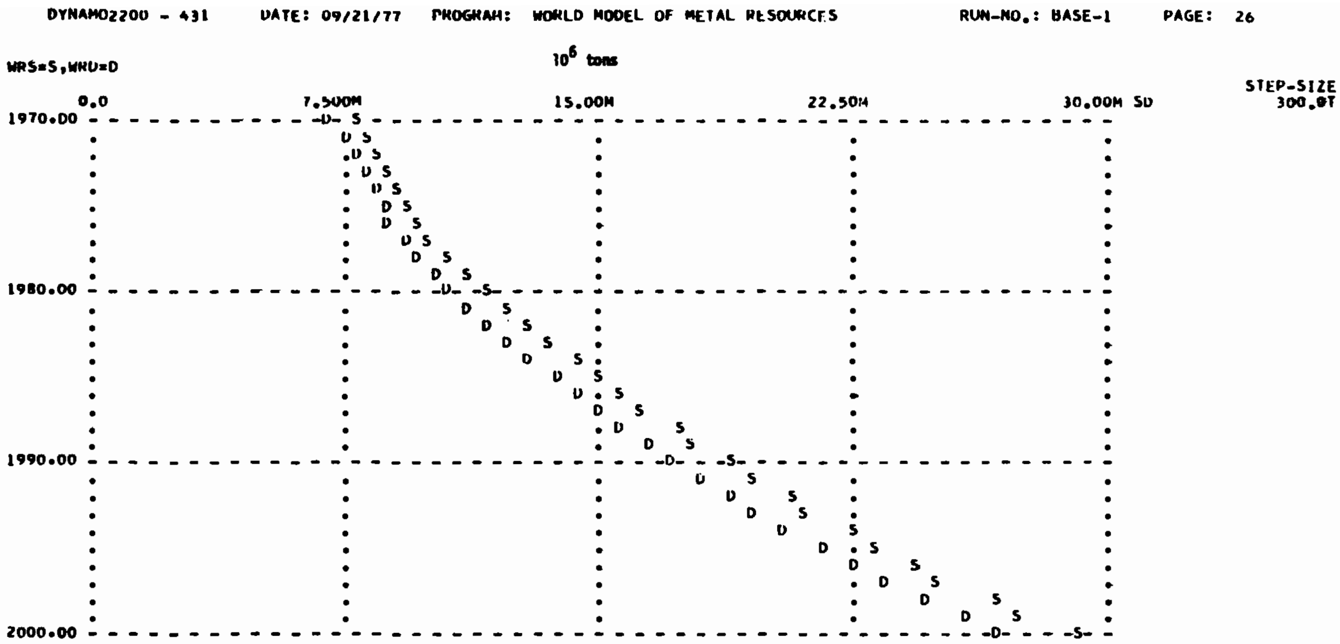


Figure 22b. World resource demand(D) and world resource supply(S) in 10^6 ton.

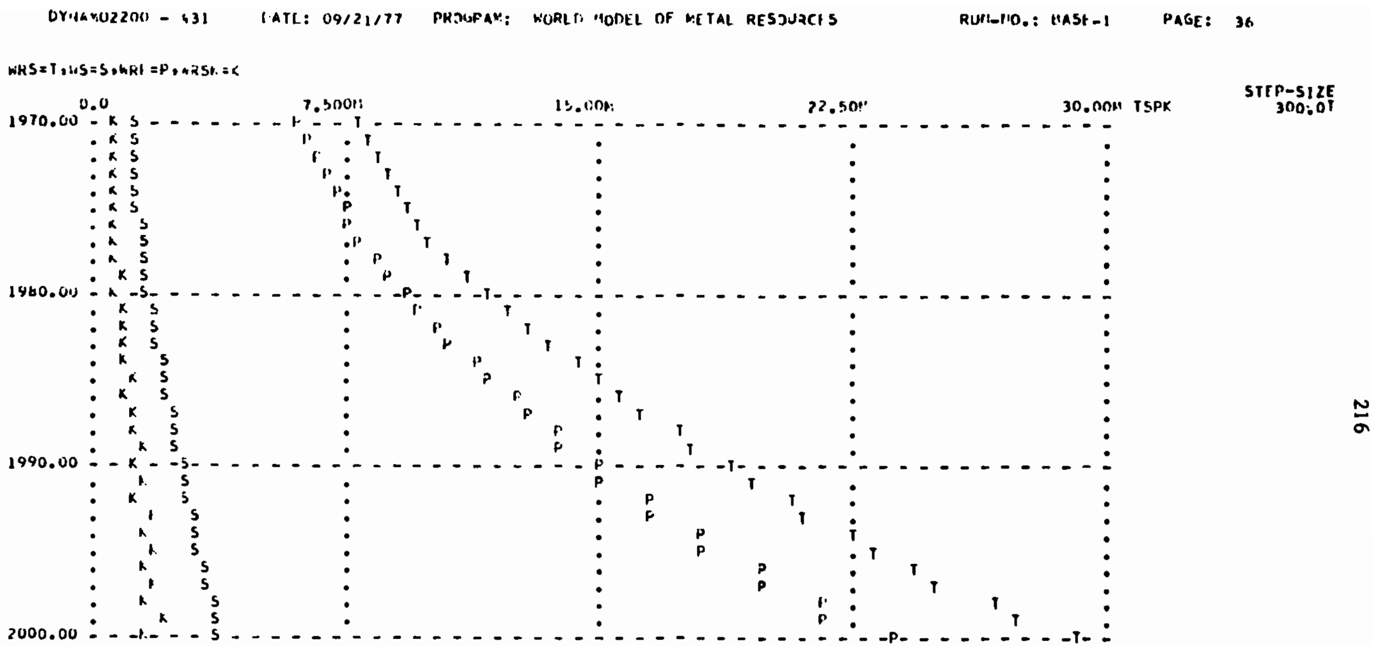


Figure 22c. Stock(K), scrap(S), production(P), and world resource supply(T) in 10^6 ton.

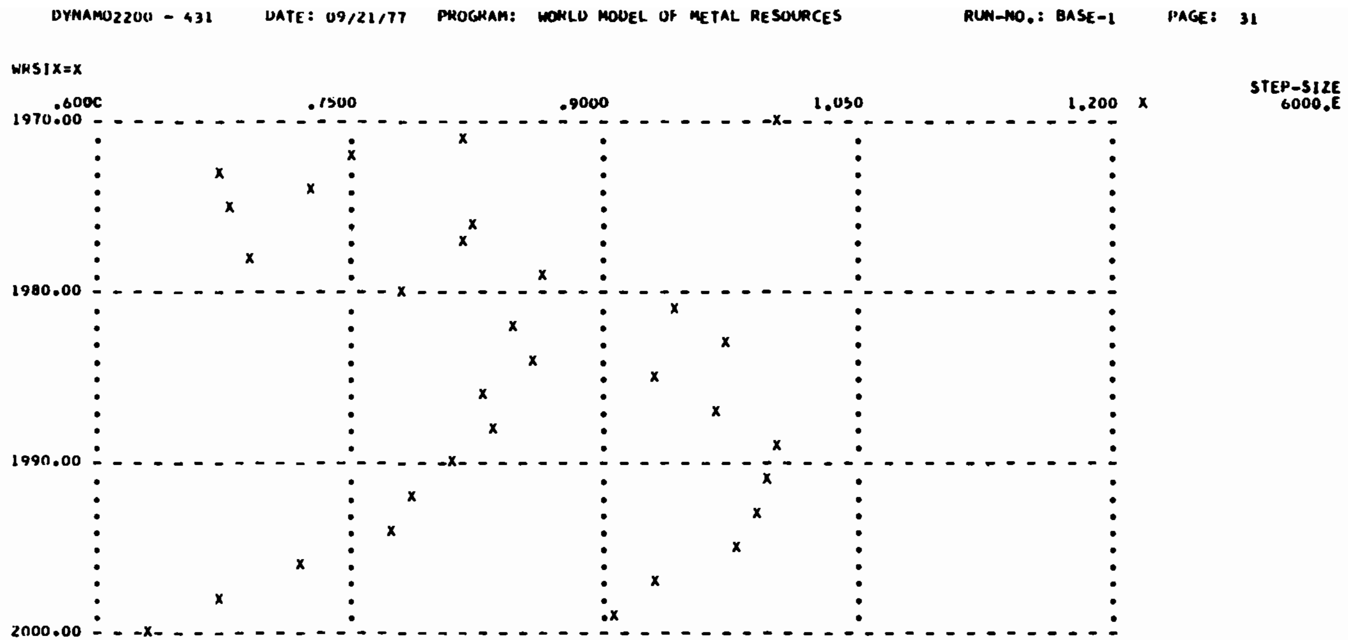


Figure 22d. World resource stock index.

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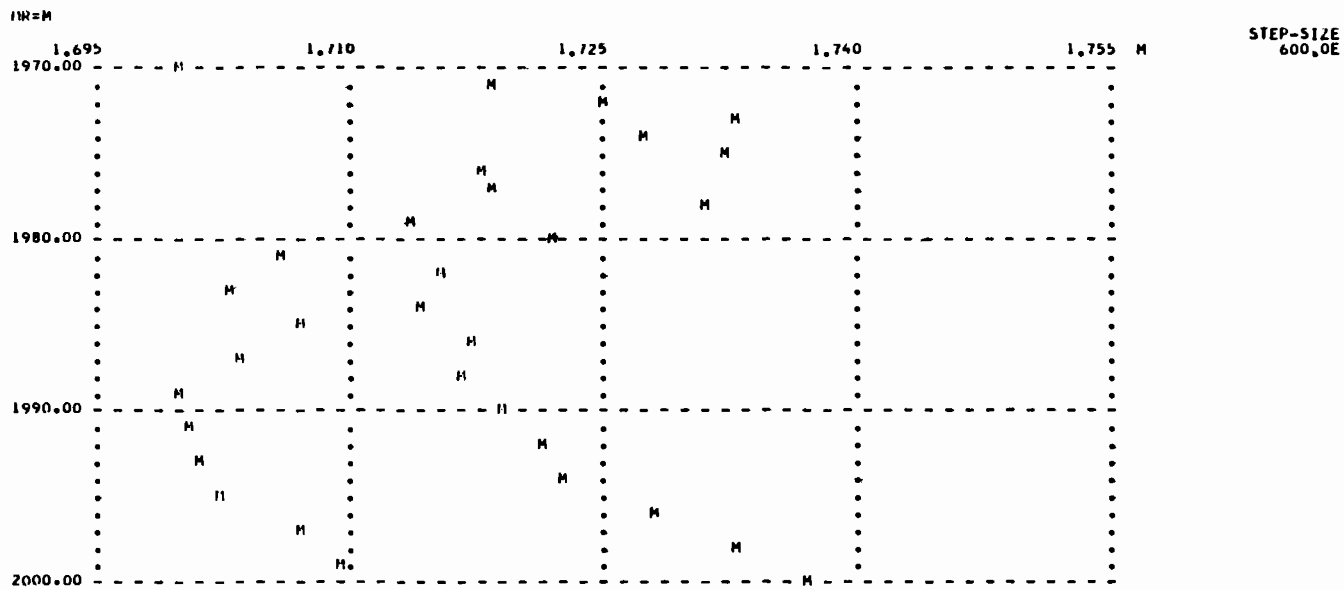

Figure 22e. Markup rate.

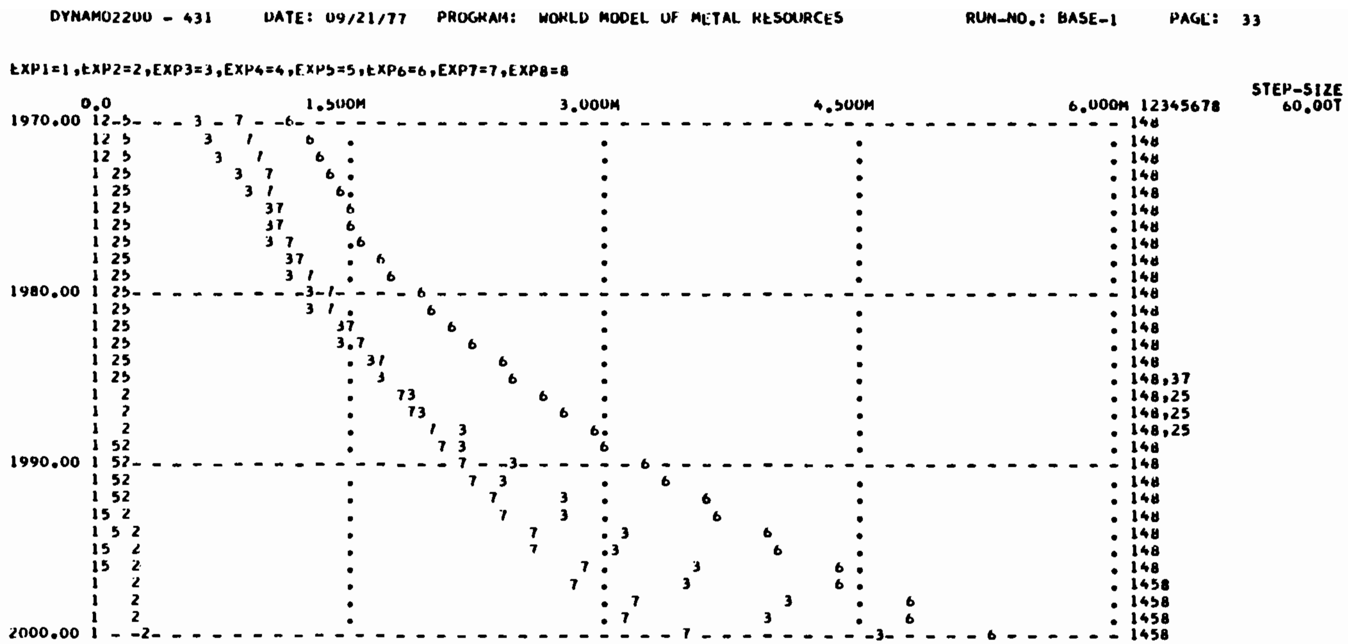

Figure 22f. Export in 10^6 ton.

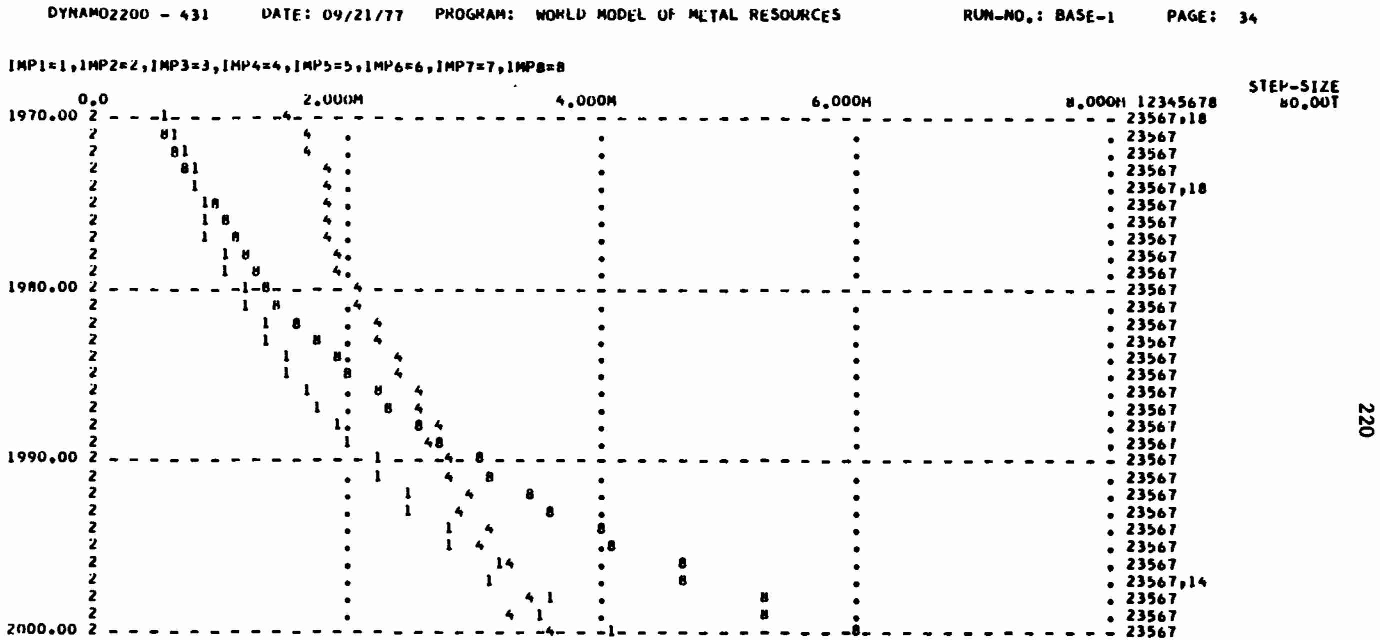

Figure 22g. Import in 10^6 ton.

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AG1=1,AG2=2,AG3=3,AG4=4,AG5=5,AG6=6,AG7=7,AG8=8

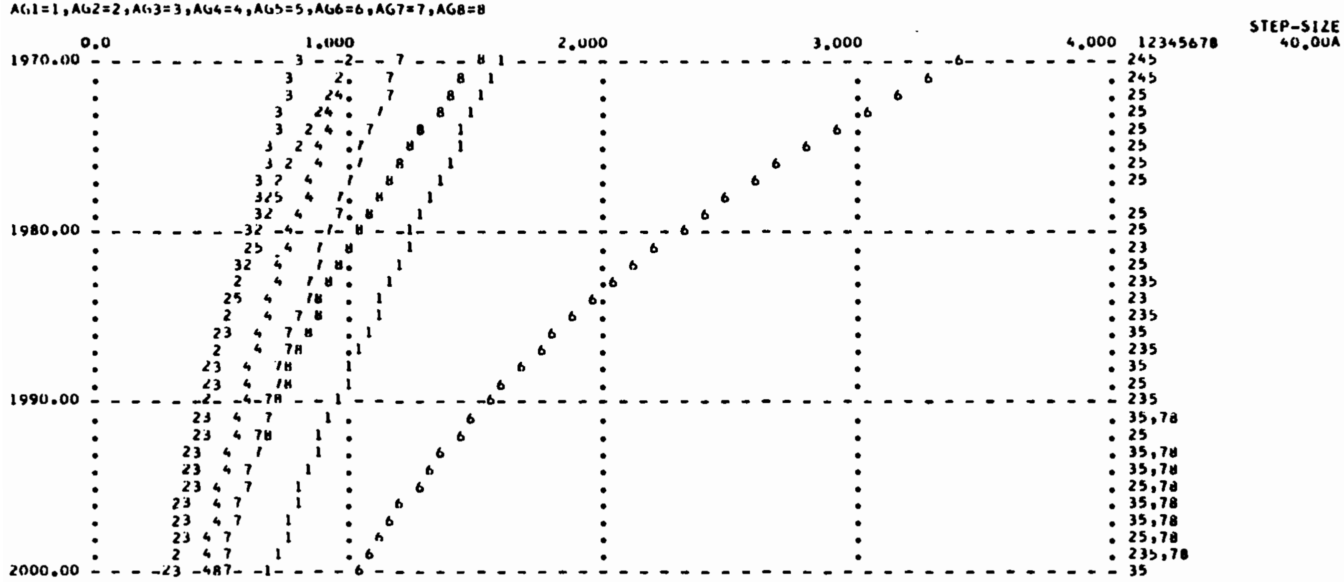

Figure 22h. Average grade in percent.

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WARP=P,WAPCO=C

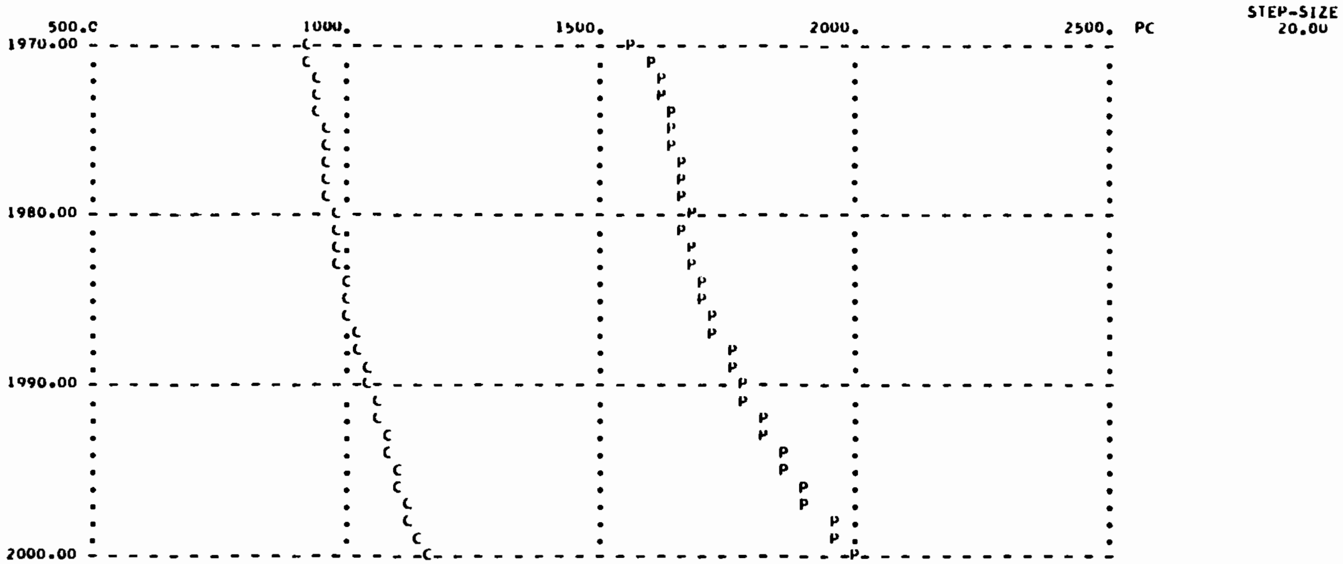

Figure 22i. Cost(C) and world average resource price(P) in dollars per ton.

5. CONCLUSIONS

Our estimations show that the amounts of the metallic mineral resources are sufficient to sustain the necessary world development over many decades. The figures estimated are summarized in Table 2.

However, the rise of resource prices is inevitable because of the declining ore grades. Taking the copper resources as an example, a metallic mineral resources model was developed and used in order to analyze resource situations. The model has the following features.

The model is demand-oriented, and it does not refer to the labor force.

The world is disaggregated into nine regions.

The output capacity is determined by the capital stock available.

The disequilibrium in the product market is adjusted by the stock.

The price follows the full cost principle and is defined as the cost multiplied by the markup ratio. Only the world average resource price is considered in the model.

The markup ratio depends on the world resource stock level.

The annual operating ratio of the capital also depends on the world resource stock level. These two are the principal elements of the error-adjusting mechanism.

The ore grades are functions of the cumulative production.

The scrap including the direct scrap is considered explicitly.

Regional export and import are determined by the supply-demand gap and, accordingly, interregional trade is implicit in the model.

A result of the basic run is summarized in Figure 23. The average grade of ore declines from 3 to about 1 percent of the 1970 level and from 1 to about 0.3 percent in 2000. The price is expected to rise about 33 percent. These results agree with the other estimates shown in Figure 5.

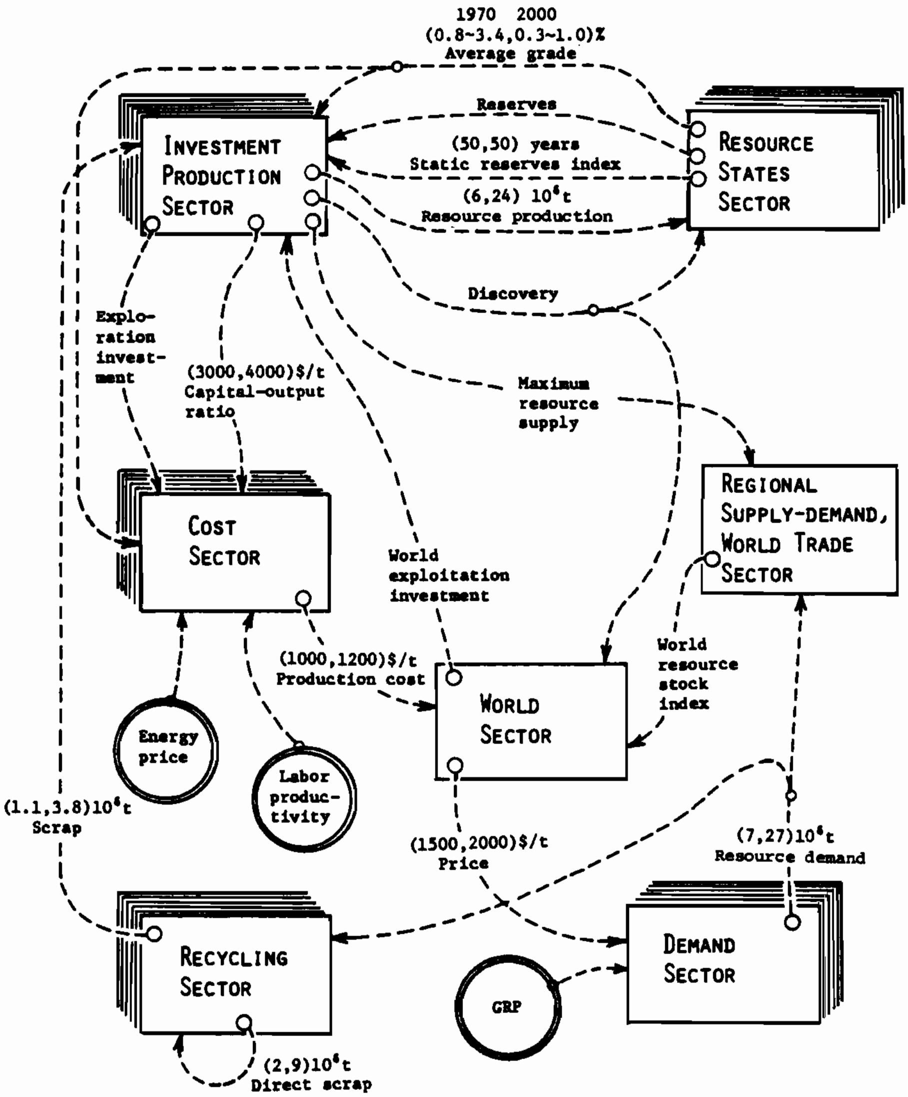

Figure 23. Results for the basic run.

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DISCUSSION

Asked by Richardson how the linkage between the resources model and the world economic model is effectuated, Suzuki referred to Figure 10, adding that the linkage relates mainly to the cost sector.

Petri suggested that the consumption models for particular minerals could be much more accurately predicted if one took the information from the input/output model into account.

Referring to copper resources, Roberts asked how the form of the cost function depending on various grades was determined. Suzuki replied that the form of the function chosen had to rely largely on assumptions and on extrapolation.

Chapter 11
FUGI APPENDIXES

APPENDIX I. TECHNICAL DETAILS OF THE GLOBAL MACRO-ECONOMIC MODEL

I - 1. Research objectives

To forecast long-term trends in the economic development of global society and to provide guidelines for a new world economic order.

I - 2. Research scope

The Global Macro-Economic Model (GMEM) links 15 areas of the world, subdivided as follows;

I. Advanced market economies
1) Japan 2) United States 3) Canada 4) European Economic Community 5) Australia and New Zealand 6) Other areas with advanced market economies

II. Developing market economies
7) East Asia 8) Southeast Asia 9) South Asia 10) Other parts of Asia 11) Middle East 12) Africa 13) Caribbean and Latin America

III. Centrally planned economies
14) Soviet Union and Eastern Europe 15) China and other centrally planned economies in Asia

INPUT CODE OF REGION AND COUNTRY (GEM)

September 27, 1977

Region		Country	
0000	World		
0100	Japan		
		0101	Japan
0200	Australia & New Zealand		
		0201	Australia
		0204	New Zealand
0300	Canada		
		0301	Canada
0400	United States		
		0401	United States
0500	EC		
		0501	Belgium
		0502	Denmark
		0503	France
		0504	West Germany
		0505	Ireland
		0506	Italy
		0507	Luxembourg
		0508	Netherlands
		0509	United Kingdom
0600	Other Advanced Countries		
		0601	Austria
		0602	Finland
		0603	Greece
		0604	Iceland
		0605	Liechtenstein
		0606	Malta
		0607	Monaco
		0608	Norway

Region		Country	
		0609	Portugal
		0610	San Marino
		0611	Spain
		0612	Sweden
		0613	Switzerland
		0614	Vatican
		0615	Yugoslavia
		0651	Israel
		0652	Turkey
		0653	Rhodesia
		0654	South Africa, Republic of
0700	East Asia		
		0701	Hong Kong
		0702	Korea
		0703	Macao
		0704	Taiwan
0800	ASEAN		
		0801	Indonesia
		0802	Malaysia
		0803	Philippines
		0804	Singapore
		0805	Thailand
0900	West Asia		
		0901	Afghanistan
		0902	Bangladesh
		0903	Bhutan
		0904	India
		0905	Maldives
		0906	Nepal
		0907	Pakistan
		0908	Sri Lanka

Region		Country	
1000	Other Asia		
		1001	Burma
		1002	Khmer Republic (Cambodia)
		1003	Laos
		1005	Fiji
		1006	Nauru
		1007	Tonga
		1008	Western Samoa
1100	Middle East		
		1101	Bahrain
		1102	Cyprus
		1103	Iran
		1104	Iraq
		1105	Jordan
		1106	Kuwait
		1107	Lebanon
		1108	Oman
		1109	Qatar
		1110	Saudi Arabia
		1111	Syria
		1113	United Arab Emirates
		1114	Yemen Arab Republic
		1115	Yemen, People's Democratic Republic
1200	Africa		
	North Africa	1201	Algeria
		1202	Egypt
		1203	Libya
		1204	Morocco
		1205	Sudan
		1206	Tunisia
	West Africa	1211	Dahomey
		1212	Gambia

Region		Country	
		1213	Ghana
		1214	Guinea, Republic of
		1215	Ivory Coast
		1216	Liberia
		1217	Mali
		1218	Mauritania
		1219	Niger
		1220	Nigeria
		1221	Senegal
		1222	Sierra Leone
		1223	Togo
		1224	Upper Volta
1200	Africa (contd.)		
	Central Africa	1231	Burundi
		1232	Cameroun
		1233	Central African Republic
		1234	Chad
		1235	Congo
		1236	Equatorial Guinea
		1237	Gabon
		1238	Rwanda
		1239	Zaire
	East Africa	1251	Botswana
		1252	Ethiopia
		1253	Kenya
		1254	Lesotho
		1255	Madagascar
		1256	Malawi
		1257	Mauritius
		1258	Somalia
		1259	Swaziland
		1260	Tanzania
		1261	Uganda
		1262	Zambia

Region		Country	
1300	Caribbean & Latin America		
	Central America		
		1301	Bahamas
		1302	Barbados
		1303	Costa Rica
		1305	Dominican Republic
		1306	El Salvador
		1307	Guatemala
		1308	Haiti
		1309	Honduras
		1310	Jamaica
		1311	Mexico
		1312	Nicaragua
		1313	Panama
		1314	Trinidad and Tobago
	South America	1351	Argentina
		1352	Bolivia
		1353	Brazil
		1354	Chile
		1355	Colombia
		1356	Ecuador
		1357	Guyana
		1358	Paraguay
		1359	Peru
		1360	Uruguay
		1361	Venezuela
1400	USSR & East Europe (including Cuba)		
		1401	Albania
		1402	Bulgaria
		1403	Czechoslovakia
		1404	German Democratic Republic
		1405	Hungary
		1406	Poland
		1407	Romania
		1408	USSR

Region		Country	
		1409	Cuba
1500	China & Other Asian Socialist Countries	1501	People's Republic of China
		1502	North Korea
		1503	Mongolian People's Republic
		1504	Viet Nam

I - 3. Structure of the Global Macro-Economic Model

While the GMEM represents a system linking together "sub-models" which reflect the special characteristics of each of these 15 regions, each sub-model, in turn, is composed of "sub-sectors" as follows ;

i) Production,

ii) Expenditure on gross regional product at constant market prices,

iii) Profit and wages

iV) Prices,

V) Expenditure on gross regional product at current market prices,

Vi) Official development assistance and private overseas investment .

Number of equations:

structural equations	630
definitional equations	270
Total	900

I - 4. Formal equations of the Global Macro-Economic Model

The formal equations of the Global Macro-Economic Model will be given as follows;

I. Production

$$1.\ \log\left(\frac{x^{**}}{1}\right) = \bar{z}_a \left\{ \alpha + \beta \log\left(\frac{\sum_{t}^{t-4} \Delta s^*_p}{1}\right) + \gamma \log\left(\frac{\sum_{t}^{t-4} r^*_d}{1}\right) + \delta \log \bar{q} \right\} + \bar{z}_b \left\{ \alpha + \beta \log\left(\frac{\sum_{t}^{t-4} \Delta s^*_p}{1}\right) + \gamma \log\left(\frac{\sum_{t}^{t-4} r^*_{ed}}{1}\right) \right\} + \bar{z}_c \left\{ \alpha + \beta \log\left(\frac{\sum_{t}^{t-4} \Delta s^*_p}{1}\right) + \gamma \log\left(\frac{\sum_{t}^{t-4} r^*_d}{1}\right) + \delta \log \bar{q} \right\}$$

$$2.\ r^*_d = \alpha + \beta\, x^*_{-1}$$

$$3.\ d^* = \alpha + \beta\, s^*_{p-1}$$

$$4.\ r^*_{ed} = \alpha + \beta\, r^*$$

$$5.\ x^* = \psi \left(\frac{x^{**}}{1}\right) \cdot 1$$ (ψ is endogenously determined for AME.)

$$6.\ s^*_p = s^*_{p-1} + \Delta s^*_p - d^*$$

$$7.\ 1 = (1 - \bar{u})\, \bar{1}_{cs}$$

$\bar{z}_a = 1$, $\bar{z}_b = 0$, $\bar{z}_c = 0$ (for AME) AME: Advanced Market Economies

$\bar{z}_a = 0$, $\bar{z}_b = 1$, $\bar{z}_c = 0$ (for DME) DME: Developing Market Economies

$\bar{z}_a = 0$, $\bar{z}_b = 0$, $\bar{z}_c = 1$ (for CPE) CPE: Centrally Planned Economies

II. Expenditure on GRP (at constant prices)

1. $$e^*_{(i,j)} = \bar{z}_a \{ A + B x^*_{(j)-1} \} + \bar{z}_b \{ A + B [e^*_{(j)-1} + \frac{1}{P_{e(j)-1}} (\Sigma o_{da(i,j)} + \Sigma \Delta s_{op(i,j)} + \bar{a}_m + \bar{a}_c)_{-1}] \cdot [\frac{P_{e(j)}}{P_{m(j)}}]_{-1} + \Gamma x^*_{(j)-1} \} + \bar{z}_c \{ A + B [e^*_{(j)-1} \cdot (\frac{P_{e(j)}}{P_{m(j)}})_{-1}] \}$$

($\bar{z}$ relates to importing region (j).)

2. $$c^* = \bar{z}_a \{ \alpha + \beta x^* + \gamma c^*_{-1} \overset{\ominus}{+} \delta [p_{c-1} / (\Sigma_{-1}^{-2} p_c) / 2] \} + \bar{z}_b [x^* - e^* + m^* - g^* - \Delta s^*_p - \Delta s^*_h - \Delta s^*_i] + \bar{z}_c [x^* - e^* + m^* - g^* - \Delta s^*_p - \Delta s^*_h - \Delta s^*_i]$$

3. $$g^* = \alpha + \beta r^*$$

4. $$r^* = \alpha + \beta x^*_{-1}$$

5. $$\Delta s^*_p = \bar{z}_a \{ \alpha + \beta y^*_{c-1} + \gamma e^*_{-1} \overset{\ominus}{+} \delta \bar{i}_{-1} + \varepsilon [(\frac{1}{\psi})_{-1} / (\Sigma_{-2}^{-1} \frac{1}{\psi}) / 2] \} + \bar{z}_b \{ \alpha + \beta x^*_{-1} + \gamma [e^*_{-1}] \cdot [\frac{P_{e(j)}}{P_{m(j)}}]_{-1} + \delta [\frac{1}{P_{e(j)-1}} (\Sigma_i o_{da(i,j)} + \Sigma_i \Delta s_{op}(i,j) + \bar{a}_m + \bar{a}_c)_{-1}] \cdot [\frac{P_{e(j)}}{P_{m(j)}}]_{-1} \} + \bar{z}_c \{ \alpha + \beta x^*_{-1} \}$$

6. $$\Delta s^*_h = \alpha + \beta x^* \overset{\ominus}{+} \gamma [p_{h-1} / (\Sigma_{-1}^{-2} p_h) / 2] \overset{\ominus}{+} \delta \bar{i}_{-1}$$

7. $$\Delta s^*_i = \alpha + \beta x^* + \gamma (x^*_{-1} - x^*_{-2}) \overset{\ominus}{+} \delta \bar{i}_{-1}$$

8. $$e^* = \beta \Sigma_j e^*_{(i,j)}$$

9. $$m^* = \beta \Sigma_i e^*_{(i,j)}$$

10. $$x^* = e^* - m^* + c^* + g^* + \Delta s^*_p + \Delta s^*_h + \Delta s^*_i \quad \text{(for AME)}$$

III. Profit-Wage

1. $$\left(\frac{y^*_c}{y^*_{co}}\right) = \alpha + \beta \left(\frac{x^*}{x^*_o}\right) \overset{\ominus}{+} \gamma \left(\frac{\bar{i}_{-1}}{\bar{i}_o}\right) + \delta \left[\left(\frac{\Delta s^*_p}{x^*}\right) / \left(\frac{\Delta s^*_{po}}{x^*_o}\right) \right]$$

2. $$\omega = \alpha + \beta\, p_{c-1} + \gamma\, p_y \overset{\ominus}{+} \delta \left(\frac{u}{\bar{u}_o}\right)$$

3. $$p_y = \left(\frac{x^*}{1}\right) / \left(\frac{x^*_o}{1_o}\right)$$

4. $$y_c = p\, y^*_c$$

IV. Prices

1. $$p_w = \alpha + \beta\, p_{m-1} + \gamma \left[\frac{\omega}{p_y}\right] + \delta \left(\frac{x}{x^*}\right)_{-1} + \varepsilon\, i_{v-1} + \xi \left[\left(\frac{y^*_c}{s^*_p}\right) / \left(\frac{y^*_{co}}{s^*_{po}}\right) \right]$$

2. $$p_c = \alpha + \beta\, p_{w-1} + \gamma\, \omega + \delta\, p_{m-1} + \varepsilon\, i_{v-1}$$

3. $$p_{cg} = \alpha + \beta\, p_{w-1} + \gamma\, \omega + \delta\, i_{v-1}$$

4. $$p_i = \alpha + \beta\, p_w + \gamma \left[\left(\frac{\Delta s^*_p}{x^*}\right) / \left(\frac{\Delta s^*_{po}}{x^*_o}\right) \right]$$

5. $$p_h = \alpha + \beta\, p_i + \gamma\, \omega$$

6. $$p_e = \bar{z}_a \{\alpha + \beta\, p_{w-1} + \gamma\, \hat{\bar{i}}_{qw-1} + \delta\, p_{m-1} + \varepsilon \left(\frac{x}{x^*}\right)_{-1} \} / \bar{\rho}$$
$$+ \bar{z}_b \{ \alpha + \beta\, p_{w-1} + \gamma\, \hat{\bar{i}}_{qw-1} + \delta\, p_{m-1} + \varepsilon\, \hat{\bar{p}}_{ec} \} / \bar{\rho} + \bar{z}_c \{ \alpha$$
$$+ \beta\, \hat{\bar{p}}_{ec} + \gamma\, \hat{\bar{p}}_{eE} + \delta\, p_{m-1} \} / \bar{\rho} + \bar{z}_o \{ \hat{\bar{p}}_{eE} \}$$

($\bar{z}$ relates to exporting region (i).)

7. $$p_m = \{ \sum_i [p_{e(i)} \cdot e^*_{(i,j)}] / [\sum_i e^*_{(i,j)}] \}\, \bar{\rho}$$

8. $$p = \frac{x}{x^*}$$

9. $$i_v = \left(\frac{\bar{m}_s}{\bar{m}_{so}}\right) / \left(\frac{x^*}{x^*_o}\right)$$

$\bar{z}_a = 1$, $\bar{z}_b = 0$, $\bar{z}_c = 0$, $\bar{z}_o = 0$ (for AME)

$\bar{z}_a = 0$, $\bar{z}_b = 1$, $\bar{z}_c = 0$, $\bar{z}_o = 0$ (for DME excluding Middle East OPEC)

$\bar{z}_a = 0$, $\bar{z}_b = 0$, $\bar{z}_c = 1$, $\bar{z}_o = 0$ (for CPE)

$\bar{z}_a = 0$, $\bar{z}_b = 0$, $\bar{z}_c = 0$, $\bar{z}_o = 1$ (for OPEC)

V. Expenditure on GRP (at current prices)

1. $e = p_e \cdot e^*$

2. $m = p_m \cdot m^*$

3. $c = p_c \cdot c^*$

4. $g = p_{cg} \cdot g^*$

5. $\Delta s_p = p_i \cdot \Delta s^*_p$

6. $\Delta s_h = p_h \cdot \Delta s^*_h$

7. $\Delta s_i = p_w \cdot \Delta s^*_i$

8. $x = e - m + c + g + \Delta s_p + \Delta s_h + \Delta s_i$

9. $b = \bar{z}_a\ [\ e - m + \bar{j} - \Delta s_{op} - o_{da}\ ] + \bar{z}_b\ [\ e - m + \bar{j} + \sum_i \Delta s_{op} + \sum_i o_{da} + \bar{a}_m$

$+ \bar{a}_c\ ] + \bar{z}_c\ [\ e - m + \bar{j} - \bar{a}_c\ ]$

VI. Official Development Assistance and Private Overseas Investment

1. $o_{da} = \bar{\Pi} \cdot x$

2. $\Delta s_{op} = \bar{\Theta} \cdot x$

3. $\sum_i o_{da(i,j)} = \bar{\Omega} \cdot o_{da}$

4. $\sum_i \Delta s_{op(i,j)} = \bar{K} \cdot \Delta s_{op}$

5. $s_{op} = s_{op-1} + \Delta s_{op} - \bar{f}_d$

Symbol		Unit
x	A column vector of n elements which denotes gross regional product (at current market prices) of n regions in the world.	M$
x^*	" gross regional product at constant prices.	M$70
x^{**}	" potential gross regional product at constant prices.	M$70
$e^*_{(i,j)}$	An element of $e^*_{(i,j)}$ matrix which denotes exports from region i to region j (at constant prices).	M$70
e	A column vector of n elements which denotes exports of goods and services at current prices.	M$
e^*	" exports of goods and services (at constant prices).	M$70
m	" imports of goods and services (at current prices).	M$
m^*	" imports of goods and services (at constant prices).	M$70
c	" private final consumption expenditure (at current prices).	M$
c^*	" " (at constant prices).	M$70
g	" government final consumption expenditure (at current prices).	M$
g^*	" " (at constant prices).	M$70
r^*	" government current revenue (at constant prices).	M$70
Δs_h	" housing investment (at current prices).	M$
Δs^*_h	" " (at constant prices).	M$70
Δs_p	" non-housing investment (at current prices).	M$
Δs^*_p	" " (at constant prices).	M$70
Δs_i	" increase in stocks (at current prices).	M$
Δs^*_i	" " (at constant prices).	M$70

Symbol	Description	Unit
s^*_p	A column vector of n elements which denotes fixed capital stocks (at constant prices).	M$70
d^*_p	" depreciation of fixed capital (at constant prices).	M$70
r^*_d	" research and development expenses (at constant prices).	M$70
y_c	" corporate profit (at current prices).	M$
y^*_c	" corporate profit (at constant prices).	M$70
l	" employment (in terms of man-hours).	TP
$\bar{l}_{cs}$	" civilian labor force (in terms of man-hours).	TP
$\bar{u}$	" unemployment ratio.	%
ω	" average wage and salary per employee (at current prices) index.	1970=1
$\bar{i}$	" average interest rate on loan.	%
ρ	" foreign exchange rate (in terms of dollars).	1970=1
b	" basic balance of payment.	M$
$\bar{j}$	" balance of the capital accounts.	M$
p_y	" labor productivity index.	1970=1
$\bar{q}$	" high-level manpower ratio ($l_{(0,1)} / l_{cs}$)	%
i_v	" money supply/real income index.	1970=1
p	" implicit deflater of GRP.	1970=1
p_c	" implicit deflater of private consumption expenditure (consumer prices index).	"
p_{cg}	" implicit deflater of government consumption.	"
p_i	" implicit deflater of fixed equipment investment.	"
p_h	" implicit deflater of housing investment.	"
p_w	" implicit deflater of increase in stocks (wholesale price index).	"
p_e	" export price index.	"
p_m	" import price index.	"
o_{da}	" each AME region's total official development assistance (net).	M$

Symbol	Definition	Unit
$o_{da(i,j)}$	An element of $o_{da(i,j)}$ matrix which denotes official development assistance from AME region i to DME region j.	M$
Δs_{op}	A column vector of n elements which denotes each AME region's overseas private investment (net) to DME regions.	M$
$\Delta s_{op(i,j)}$	An element of $s_{op(i,j)}$ matrix which denotes overseas private investment from AME region i to DME region j.	M$
$\bar{a}_m$	A column vector of n elements which denotes each DME's official development assistance (net) received from multilateral agencies.	M$
$\bar{a}_c$	" each DME's official development assistance (net) received from centrally planned economy zone.	M$
$\bar{m}_s$	" money supply.	M$
r^*_{ed}	" government education expenditure.	M$
$\hat{\bar{p}}_{eE}$	A scalar of oil export unit price index.	1970=1
$\hat{\bar{i}}_{qw}$	" world liquidity-trade index.	"
$\hat{\bar{p}}_{ec}$	" export price index of primary commodities.	"
t	Denotes time.	
$-$	Denotes the exogenous variables of the model.	
$\bar{z}$	Denotes dummy variables.	
A	An n x n matrix which denotes the constants of export functions from region i to region j within the world.	
B, Γ, Ξ	An n x n matrix which denotes the coefficients of export functions from region i to region j in the world.	
α	A column vector of n elements which denotes the constants of a group of structural equations.	
β, γ, δ θ, λ, π ε, φ, μ, ψ	A diagonal matrix of an n x n order which denotes coefficients of a group of structural equations.	
$\bar{\Pi}$, $\bar{\Theta}$, $\bar{\Omega}$ $\bar{K}$	Development assistance policy parameters.	

Notes :

M$	Million dollars
M$70	Million dollars in 1970 prices
TP	Thousand persons
%	Percentage
*	Constant prices

I - 5. Structural parameters of the Global Macro-Economic Model

Structural parameters of the GMEM are estimated from time-series data covering the period 1960 - 1973 in most regions.

First column EQ. NO. in the listed table denotes the equation number which corresponds to the model.

Second column I, J denotes the region code number in the listed table.

Each column P_1 P_2 ····P_n denotes structural parameters of the corresponding equation (i.e., α, β, γ, ...).
R denotes a coefficient of determinant and S, a standard error of estimate.
T denotes t-value.

EQ.NO.	I	J		P1	P2		
201	1	4	C	-0.1085E 05	0.1799E-01	R	0.9478E 00
			T		0.1076E 02	S	0.8699E 03

Japan's export to the U.S.

$$e^{*}_{J\cdot US} = -\ 10850.0 + 0.01799\ X^{*}_{US-1}$$
$$(\ 10.76\ )$$

$$\bar{R} = 0.9478 \qquad \bar{S} = 869.9$$

I - 5. **Structural Parameters of the Global Macro Economic Model**

$$1.\ \log\left(\frac{x^{**}}{1}\right) = \bar{z}_s \left\{ \alpha + \beta \log\left(\frac{s^{*}p}{1}\right) + \gamma \log\left(\frac{\sum_{}^{t-4} r^{*} d}{1}\right) + \delta \log \bar{q} \right\} + \bar{z}_b \left\{ \alpha + \beta \log\left(\frac{\sum_{t-4}^{t-4} \Delta s^{*} p}{1}\right) + \gamma \log\left(\frac{\sum^{t-4} r^{*} ed}{1}\right) \right\} + \bar{z}_c \left\{ \alpha + \beta \log\left(\frac{\sum^{t-4} \Delta s^{*} p}{1}\right) + \gamma \log\left(\frac{\sum r^{*} d}{1}\right) + \delta \log \bar{q} \right\}$$

EQ.NO.	T	J		P1	P2	P3	P4	P5	P6	P7	P8		
101	1	0	C	0.9936E-01	0.7775E 00	0.	0.	0.	0.	0.	0.	R	0.9941E 00
			T		0.2430E 02	0.	0.	0.	0.	0.	0.	S	0.1018E-01
101	2	0	C	-0.4145E 01	0.6676E 00	0.	0.3721E 01	0.	0.	0.	0.	R	0.9680E 00
			T		0.4973E 01	0.	0.2272E 01	0.	0.	0.	0.	S	0.7454E-02
101	3	0	C	-0.5415E 00	0.	0.	0.1173E 01	0.	0.	0.	0.	R	0.9942E 00
			T		0.	0.	0.2774E 02	0.	0.	0.	0.	S	0.3375E-02
101	4	0	C	0.8042E 00	0.3088E 00	0.2841E 00	0.	0.	0.	0.	0.	R	0.9794E 00
			T		0.1951E 01	0.1095E 01	0.	0.	0.	0.	0.	S	0.5401E-02
101	5	0	C	0.1267E 00	0.9510E 00	0.	0.	0.	0.	0.	0.	R	0.9809E 00
			T		0.1339E 02	0.	0.	0.	0.	0.	0.	S	0.7248E-02
101	6	0	C	0.1587E 00	0.9043E 00	0.	0.	0.	0.	0.	0.	R	0.8572E 00
			T		0.4516E 01	0.	0.	0.	0.	0.	0.	S	0.1422E-01
101	7	0	C	0.4143E-01	0.4428E 00	0.	0.	0.	0.	0.	0.	R	0.9977E 00
			T		0.3931E 02	0.	0.	0.	0.	0.	0.	S	0.4788E-02
101	8	0	C	-0.1735E 00	0.4168E 00	0.	0.	0.	0.	0.	0.	R	0.9893E 00
			T		0.1794E 02	0.	0.	0.	0.	0.	0.	S	0.5967E-02
101	9	0	C	0.1429E 00	0.9560E 00	0.	0.	0.	0.	0.	0.	R	0.9137E 00
			T		0.6030E 01	0.	0.	0.	0.	0.	0.	S	0.1884E-01
101	10	0	C	0.1824E-03	0.6638E 00	0.	0.	0.	0.	0.	0.	R	0.7938E 00
			T		0.3595E 01	0.	0.	0.	0.	0.	0.	S	0.1174E-01
101	11	0	C	0.1368E 00	0.6304E 00	0.	0.	0.	0.	0.	0.	R	0.9893E 00
			T		0.1566E 02	0.	0.	0.	0.	0.	0.	S	0.1086E-01
101	12	0	C	-0.5032E 00	0.1194E 00	0.	0.	0.	0.	0.	0.	R	0.3972E 00
			T		0.4271E 00	0.	0.	0.	0.	0.	0.	S	0.1598E-01
101	13	0	C	0.2628E 00	0.6112E 00	0.	0.	0.	0.	0.	0.	R	0.9702E 00
			T		0.9864E 01	0.	0.	0.	0.	0.	0.	S	0.7498E-02
101	14	0	C	0.3739E-01	0.1164E 01	0.	0.	0.	0.	0.	0.	R	0.9790E 00
			T		0.1180E 02	0.	0.	0.	0.	0.	0.	S	0.1167E-01
101	15	0	C	-0.1151E 00	0.8581E 00	0.	0.	0.	0.	0.	0.	R	0.8668E 00
			T		0.5017E 01	0.	0.	0.	0.	0.	0.	S	0.2374E-01

2. $r^*_d = \alpha + \beta x^*_{-1}$

102	1	0	C	-0.1001E 04	0.2545E-01	0.	0.	0.	0.	0.	0.	R	0.9773E 00
			T		0.1463E 02	0.	0.	0.	0.	0.	0.	S	0.2174E 03
102	2	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
102	3	0	C	-0.4630E 03	0.1033E-01	0.	0.	0.	0.	0.	0.	R	0.9576E 00
			T		0.1154E 02	0.	0.	0.	0.	0.	0.	S	0.7729E 02
102	4	0	C	0.4900E 03	0.2092E-01	0.	0.	0.	0.	0.	0.	R	0.9563E 00
			T		0.1137E 02	0.	0.	0.	0.	0.	0.	S	0.8495E 03
102	5	0	C	-0.1912E 03	0.1958E-01	0.	0.	0.	0.	0.	0.	R	0.8915E 00
			T		0.6304E 01	0.	0.	0.	0.	0.	0.	S	0.7266E 03
102	6	0	C	-0.2625E 04	0.3262E-01	0.	0.	0.	0.	0.	0.	R	0.9844E 00
			T		0.1775E 02	0.	0.	0.	0.	0.	0.	S	0.1916E 03
102	7	0	C	-0.2234E 02	0.4802E-02	0.	0.	0.	0.	0.	0.	R	0.9239E 00
			T		0.7702E 01	0.	0.	0.	0.	0.	0.	S	0.6451E 01
102	8	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
102	9	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
102	10	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
102	11	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
102	12	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
102	13	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
102	14	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
102	15	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

3. $d^{*} = \alpha + \beta s^{*}_{p-1}$

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
103	1	0	C	-0.1782E 05	0.1479E 00	0.	0.	0.	0.	0.	0.	R	0.9935E 00
			T		0.3023E 02	0.	0.	0.	0.	0.	0.	S	0.1307E 04
103	2	0	C	0.6606E 03	0.3193E-01	0.	0.	0.	0.	0.	0.	R	0.9426E 00
			T		0.9827E 01	0.	0.	0.	0.	0.	0.	S	0.2131E 03
103	3	0	C	-0.3149E 04	0.9332E-01	0.	0.	0.	0.	0.	0.	R	0.9954E 00
			T		0.3870E 02	0.	0.	0.	0.	0.	0.	S	0.1651E 03
103	4	0	C	-0.1611E 06	0.1765E 00	0.	0.	0.	0.	0.	0.	R	0.9965E 00
			T		0.4450E 02	0.	0.	0.	0.	0.	0.	S	0.1722E 04
103	5	0	C	-0.2027E 05	0.7658E-01	0.	0.	0.	0.	0.	0.	R	0.9974E 00
			T		0.4582E 02	0.	0.	0.	0.	0.	0.	S	0.7847E 03
103	6	0	C	-0.4778E 04	0.6245E-01	0.	0.	0.	0.	0.	0.	R	0.9979E 00
			T		0.4858E 02	0.	0.	0.	0.	0.	0.	S	0.2329E 03
103	7	0	C	-0.5405E 03	0.6464E-01	0.	0.	0.	0.	0.	0.	R	0.9877E 00
			T		0.2097E 02	0.	0.	0.	0.	0.	0.	S	0.3896E 02
103	8	0	C	-0.1922E 04	0.8206E-01	0.	0.	0.	0.	0.	0.	R	0.9907E 00
			T		0.2307E 02	0.	0.	0.	0.	0.	0.	S	0.5645E 02
103	9	0	C	-0.1120E 04	0.3354E-01	0.	0.	0.	0.	0.	0.	R	0.9559E 00
			T		0.1034E 02	0.	0.	0.	0.	0.	0.	S	0.1961E 03
103	10	0	C	0.1224E 02	0.2793E-01	0.	0.	0.	0.	0.	0.	R	0.8081E 00
			T		0.4452E 01	0.	0.	0.	0.	0.	0.	S	0.6954E 01
103	11	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
103	12	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
103	13	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
103	14	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
103	15	0	C	0.	0.5154E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

6. $r^*_{ed} = \alpha + \beta r^*$

104	1	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	2	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	3	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	4	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	5	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	6	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	7	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	8	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	9	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	10	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	11	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	12	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	13	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	14	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
104	15	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

1. $e^*_{(i,j)} = \bar{x}_a \{ A + B x^*_{(j)-1} \} + \bar{x}_b \{ A + B [e^*_{(j)-1} + \frac{1}{P_{e(j)-1}} (\Sigma o_{da(i,j)} + \Sigma \Delta n_{op(i,j)} + \bar{a}_m + \bar{a}_c)_{-1}] \cdot (\frac{P_{e(j)}}{P_{m(j)}})_{-1} + \Gamma x^*_{(j)-1} \}$

$+ \bar{x}_c \{ A + B [e^*_{(j)-1} \cdot (\frac{P_{e(j)}}{P_{m(j)}})_{-1}] \}$ ($\bar{x}$ relates to importing region (j).)

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
201	1	1	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	1	2	C	-0.1069E 04	0.4664E-01	0.	0.	0.	0.	0.	0.	R	0.9499E 00
			T		0.1059E 02	0.	0.	0.	0.	0.	0.	S	0.1049E 03
201	1	3	C	-0.9302E 03	0.1966E-01	0.	0.	0.	0.	0.	0.	R	0.9193E 00
			T		0.8487E 01	0.	0.	0.	0.	0.	0.	S	0.1280E 03
201	1	4	C	-0.1085E 05	0.1799E-01	0.	0.	0.	0.	0.	0.	R	0.9478E 00
			T		0.1076E 02	0.	0.	0.	0.	0.	0.	S	0.8699E 03
201	1	5	C	-0.4113E 04	0.1103E-01	0.	0.	0.	0.	0.	0.	R	0.9431E 00
			T		0.9876E 01	0.	0.	0.	0.	0.	0.	S	0.3723E 03
201	1	6	C	-0.1739E 04	0.1411E-01	0.	0.	0.	0.	0.	0.	R	0.9711E 00
			T		0.1354E 02	0.	0.	0.	0.	0.	0.	S	0.1268E 03
201	1	7	C	-0.7683E 03	0.1963E 00	0.1377E 00	0.	0.	0.	0.	0.	R	0.9923E 00
			T		0.1502E 01	0.2162E 01	0.	0.	0.	0.	0.	S	0.1091E 03
201	1	8	C	-0.1825E 04	0.1854E 00	0.8849E-01	0.	0.	0.	0.	0.	R	0.9904E 00
			T		0.6578E 00	0.1301E 01	0.	0.	0.	0.	0.	S	0.8791E 02
201	1	9	C	0.7073E 02	0.	0.3877E-02	0.	0.	0.	0.	0.	R	0.6115E 00
			T		0.	0.2752E 01	0.	0.	0.	0.	0.	S	0.4523E 02
201	1	10	C	0.	0.9211E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	1	11	C	-0.2565E 03	0.	0.2904E-01	0.	0.	0.	0.	0.	R	0.9882E 00
			T		0.	0.2046E 02	0.	0.	0.	0.	0.	S	0.2776E 02
201	1	12	C	0.2262E 03	0.4829E-01	0.	0.	0.	0.	0.	0.	R	0.1944E 00
			T		0.7973E 00	0.	0.	0.	0.	0.	0.	S	0.1460E 03
201	1	13	C	-0.8125E 03	0.	0.1044E-01	0.	0.	0.	0.	0.	R	0.9238E 00
			T		0.	0.7694E 01	0.	0.	0.	0.	0.	S	0.1167E 03
201	1	14	C	-0.2807E 03	0.2892E-01	0.	0.	0.	0.	0.	0.	R	0.9496E 00
			T		0.1054E 02	0.	0.	0.	0.	0.	0.	S	0.7189E 02
201	1	15	C	-0.7761E 03	0.5126E 00	0.	0.	0.	0.	0.	0.	R	0.6874E 00
			T		0.3294E 01	0.	0.	0.	0.	0.	0.	S	0.1649E 03
201	2	1	C	0.1820E 03	0.4011E-02	0.	0.	0.	0.	0.	0.	R	0.5146E 00
			T		0.2307E 01	0.	0.	0.	0.	0.	0.	S	0.3783E 03
201	2	2	C	-0.2342E 03	0.1499E-01	0.	0.	0.	0.	0.	0.	R	0.8775E 00
			T		0.6415E 01	0.	0.	0.	0.	0.	0.	S	0.5560E 02
201	2	3	C	-0.1621E 03	0.3874E-02	0.	0.	0.	0.	0.	0.	R	0.9004E 00
			T		0.7531E 01	0.	0.	0.	0.	0.	0.	S	0.2841E 02
201	2	4	C	-0.7473E 03	0.1642E-02	0.	0.	0.	0.	0.	0.	R	0.9378E 00
			T		0.9791E 01	0.	0.	0.	0.	0.	0.	S	0.8728E 02
201	2	5	C	0.4205E 03	0.2068E-02	0.	0.	0.	0.	0.	0.	R	0.8575E 00
			T		0.5860E 01	0.	0.	0.	0.	0.	0.	S	0.1188E 03
201	2	6	C	-0.9634E 02	0.1364E-02	0.	0.	0.	0.	0.	0.	R	0.9436E 00
			T		0.9501E 01	0.	0.	0.	0.	0.	0.	S	0.1748E 02
201	2	7	C	0.7806E 01	0.1420E-01	0.5617E-02	0.	0.	0.	0.	0.	R	0.9920E 00
			T		0.1988E 01	0.1615E 01	0.	0.	0.	0.	0.	S	0.5957E 01
201	2	8	C	-0.2249E 03	0.	0.2073E-01	0.	0.	0.	0.	0.	R	0.9245E 00
			T		0.	0.8108E 01	0.	0.	0.	0.	0.	S	0.3650E 02
201	2	9	C	0.	0.2161E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	2	10	C	-0.5572E 02	0.	0.4707E-01	0.	0.	0.	0.	0.	R	0.8419E 00
			T		0.	0.5270E 01	0.	0.	0.	0.	0.	S	0.8330E 01
201	2	11	C	-0.2746E 02	0.	0.5442E-02	0.	0.	0.	0.	0.	R	0.7743E 00
			T		0.	0.3997E 01	0.	0.	0.	0.	0.	S	0.1981E 02
201	2	12	C	-0.2450E 02	0.1206E-01	0.	0.	0.	0.	0.	0.	R	0.8425E 00
			T		0.5046E 01	0.	0.	0.	0.	0.	0.	S	0.5762E 01
201	2	13	C	-0.3681E 02	0.	0.6069E-03	0.	0.	0.	0.	0.	R	0.8423E 00
			T		0.	0.5042E 01	0.	0.	0.	0.	0.	S	0.1016E 02
201	2	14	C	-0.2799E 02	0.6861E-02	0.	0.	0.	0.	0.	0.	R	0.6937E 00
			T		0.3483E 01	0.	0.	0.	0.	0.	0.	S	0.5161E 02
201	2	15	C	0.	0.1556E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

FD.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
201	3	1	C	-0.2697E 04	0.6380E-02	0.	0.	0.	0.	0.	0.	R	0.9197E 00
			T		0.8175E 01	0.	0.	0.	0.	0.	0.	S	0.1387E 03
201	3	2	C	0.1678E 02	0.4656E-02	0.	0.	0.	0.	0.	0.	R	0.8100E 00
			T		0.4888E 01	0.	0.	0.	0.	0.	0.	S	0.2257E 02
201	3	3	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	3	4	C	-0.1335E 05	0.2553E-01	0.	0.	0.	0.	0.	0.	R	0.9684E 00
			T		0.1403E 02	0.	0.	0.	0.	0.	0.	S	0.9401E 03
201	3	5	C	0.2880E 03	0.3455E-02	0.	0.	0.	0.	0.	0.	R	0.8920E 00
			T		0.6909E 01	0.	0.	0.	0.	0.	0.	S	0.1667E 03
201	3	6	C	-0.1031E 03	0.2408E-02	0.	0.	0.	0.	0.	0.	R	0.7931E 00
			T		0.4433E 01	0.	0.	0.	0.	0.	0.	S	0.6614E 02
201	3	7	C	0.1774E 02	0.8475E-02	0.	0.	0.	0.	0.	0.	R	0.9536E 00
			T		0.1055E 02	0.	0.	0.	0.	0.	0.	S	0.4871E 01
201	3	8	C	-0.3891E 02	0.1509E-01	0.	0.	0.	0.	0.	0.	R	0.9617E 00
			T		0.1169E 02	0.	0.	0.	0.	0.	0.	S	0.5806E 01
201	3	9	C	-0.1030E 03	0.	0.3628E-02	0.	0.	0.	0.	0.	R	0.6927E 00
			T		0.	0.3339E 01	0.	0.	0.	0.	0.	S	0.3488E 02
201	3	10	C	-0.1023E 02	0.	0.5810E-02	0.	0.	0.	0.	0.	R	0.8452E 00
			T		0.	0.5340E 01	0.	0.	0.	0.	0.	S	0.1015E 01
201	3	11	C	-0.2774E 02	0.	0.3572E-02	0.	0.	0.	0.	0.	R	0.7789E 00
			T		0.	0.4053E 01	0.	0.	0.	0.	0.	S	0.1202E 02
201	3	12	C	-0.5505E 02	0.2724E-01	0.	0.	0.	0.	0.	0.	R	0.7861E 00
			T		0.4144E 01	0.	0.	0.	0.	0.	0.	S	0.1585E 02
201	3	13	C	-0.2569E 02	0.3239E-01	0.	0.	0.	0.	0.	0.	R	0.9444E 00
			T		0.9134E 01	0.	0.	0.	0.	0.	0.	S	0.3089E 02
201	3	14	C	0.	0.1069E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	3	15	C	0.3383E 02	0.5495E-01	0.	0.	0.	0.	0.	0.	R	0.2263E 00
			T		0.1263E 01	0.	0.	0.	0.	0.	0.	S	0.4614E 02
201	4	1	C	0.4247E 03	0.2120E-01	0.	0.	0.	0.	0.	0.	R	0.9193E 00
			T		0.8155E 01	0.	0.	0.	0.	0.	0.	S	0.4620E 03
201	4	2	C	0.2395E 03	0.1859E-01	0.	0.	0.	0.	0.	0.	R	0.5325E 00
			T		0.2398E 01	0.	0.	0.	0.	0.	0.	S	0.1844E 03
201	4	3	C	-0.2734E 04	0.1527E 00	0.	0.	0.	0.	0.	0.	R	0.9861E 00
			T		0.2140E 02	0.	0.	0.	0.	0.	0.	S	0.3939E 03
201	4	4	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	4	5	C	-0.9190E 03	0.1968E-01	0.	0.	0.	0.	0.	0.	R	0.9364E 00
			T		0.9294E 01	0.	0.	0.	0.	0.	0.	S	0.7129E 03
201	4	6	C	0.2173E 04	0.2496E-02	0.	0.	0.	0.	0.	0.	R	0.1444E 00
			T		0.8806E 00	0.	0.	0.	0.	0.	0.	S	0.3451E 03
201	4	7	C	-0.7278E 03	0.	0.1128E 00	0.	0.	0.	0.	0.	R	0.9538E 00
			T		0.	0.1058E 02	0.	0.	0.	0.	0.	S	0.1329E 03
201	4	8	C	0.6100E 02	0.1369E 00	0.	0.	0.	0.	0.	0.	R	0.9397E 00
			T		0.9170E 01	0.	0.	0.	0.	0.	0.	S	0.6710E 02
201	4	9	C	0.	0.1944E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	4	10	C	-0.3408E 03	0.	0.2595E 00	0.	0.	0.	0.	0.	R	0.7230E 00
			T		0.	0.3612E 01	0.	0.	0.	0.	0.	S	0.6701E 02
201	4	11	C	0.1480E 03	0.	0.3505E-01	0.	0.	0.	0.	0.	R	0.8990E 00
			T		0.	0.6566E 01	0.	0.	0.	0.	0.	S	0.7966E 02
201	4	12	C	0.4986E 03	0.4760E-01	0.	0.	0.	0.	0.	0.	R	0.3172E 00
			T		0.2028E 00	0.	0.	0.	0.	0.	0.	S	0.3920E 03
201	4	13	C	0.3129E 04	0.4898E-01	0.	0.	0.	0.	0.	0.	R	0.3285E 00
			T		0.1815E 00	0.	0.	0.	0.	0.	0.	S	0.2643E 04
201	4	14	C	-0.4691E 03	0.3500E-01	0.	0.	0.	0.	0.	0.	R	0.6757E 00
			T		0.3329E 01	0.	0.	0.	0.	0.	0.	S	0.2755E 03
201	4	15	C	-0.5089E 02	0.2561E-01	0.	0.	0.	0.	0.	0.	R	0.4243E 00
			T		0.1848E 01	0.	0.	0.	0.	0.	0.	S	0.1469E 02

EQ.NO.	T	J		P1	P2	P3	P4	P5	P6	P7	P8		
201	5	1	C	-0.4494E 03	0.1098E-01	0.	0.	0.	0.	0.	0.	R	0.9083E 00
			T		0.7597E 01	0.	0.	0.	0.	0.	0.	S	0.2572E 03
201	5	2	C	0.4852E 03	0.3133E-01	0.	0.	0.	0.	0.	0.	R	0.4662E 00
			T		0.3252E 01	0.	0.	0.	0.	0.	0.	S	0.2292E 03
201	5	3	C	-0.2789E 03	0.2407E-01	0.	0.	0.	0.	0.	0.	R	0.9156E 00
			T		0.8273E 01	0.	0.	0.	0.	0.	0.	S	0.1607E 03
201	5	4	C	-0.1127E 05	0.2240E-01	0.	0.	0.	0.	0.	0.	R	0.9562E 00
			T		0.1187E 02	0.	0.	0.	0.	0.	0.	S	0.9861E 03
201	5	5	C	-0.7297E 05	0.2349E 00	0.	0.	0.	0.	0.	0.	R	0.9484E 00
			T		0.1041E 02	0.	0.	0.	0.	0.	0.	S	0.7524E 04
201	5	6	C	-0.9226E 04	0.1350E 00	0.	0.	0.	0.	0.	0.	R	0.8648E 00
			T		0.5800E 01	0.	0.	0.	0.	0.	0.	S	0.2835E 04
201	5	7	C	0.4856E 02	0.6480E-01	0.2890E-01	0.	0.	0.	0.	0.	R	0.9887E 00
			T		0.1579E 01	0.1445E 01	0.	0.	0.	0.	0.	S	0.3424E 02
201	5	8	C	-0.7737E 02	0.	0.4978E-01	0.	0.	0.	0.	0.	R	0.9517E 00
			T		0.	0.1033E 02	0.	0.	0.	0.	0.	S	0.6810E 02
201	5	9	C	0.	0.3336E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	5	10	C	0.	0.7048E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	5	11	C	0.9096E 02	0.	0.1049E 00	0.	0.	0.	0.	0.	R	0.9768E 00
			T		0.	0.1446E 02	0.	0.	0.	0.	0.	S	0.1056E 03
201	5	12	C	0.2113E 03	0.7552E 00	0.	0.	0.	0.	0.	0.	R	0.1407E 00
			T		0.8977E 00	0.	0.	0.	0.	0.	0.	S	0.2028E 04
201	5	13	C	0.1373E 04	0.6186E-01	0.	0.	0.	0.	0.	0.	R	0.3114E 00
			T		0.3405E 00	0.	0.	0.	0.	0.	0.	S	0.1583E 04
201	5	14	C	-0.2164E 04	0.2232E 00	0.	0.	0.	0.	0.	0.	R	0.8576E 00
			T		0.5862E 01	0.	0.	0.	0.	0.	0.	S	0.9975E 03
201	5	15	C	-0.4007E 03	0.3908E 00	0.	0.	0.	0.	0.	0.	R	0.7781E 00
			T		0.4228E 01	0.	0.	0.	0.	0.	0.	S	0.8795E 02
201	6	1	C	-0.2832E 03	0.5069E-02	0.	0.	0.	0.	0.	0.	R	0.8985E 00
			T		0.7160E 01	0.	0.	0.	0.	0.	0.	S	0.1258E 03
201	6	2	C	-0.3734E 02	0.7370E-02	0.	0.	0.	0.	0.	0.	R	0.7649E 00
			T		0.4233E 01	0.	0.	0.	0.	0.	0.	S	0.4141E 02
201	6	3	C	-0.3484E 03	0.8840E-02	0.	0.	0.	0.	0.	0.	R	0.9453E 00
			T		0.1049E 02	0.	0.	0.	0.	0.	0.	S	0.4652E 02
201	6	4	C	-0.2088E 04	0.4802E-02	0.	0.	0.	0.	0.	0.	R	0.9077E 00
			T		0.7865E 01	0.	0.	0.	0.	0.	0.	S	0.3178E 03
201	6	5	C	-0.6026E 04	0.3371E-01	0.	0.	0.	0.	0.	0.	R	0.8899E 00
			T		0.6837E 01	0.	0.	0.	0.	0.	0.	S	0.1645E 04
201	6	6	C	-0.3342E 04	0.3912E-01	0.	0.	0.	0.	0.	0.	R	0.8643E 00
			T		0.5787E 01	0.	0.	0.	0.	0.	0.	S	0.8232E 03
201	6	7	C	0.2889E 02	0.4621E-01	0.	0.	0.	0.	0.	0.	R	0.9840E 00
			T		0.1834E 02	0.	0.	0.	0.	0.	0.	S	0.1528E 02
201	6	8	C	0.4021E 01	0.2308E-01	0.	0.	0.	0.	0.	0.	R	0.9200E 00
			T		0.7849E 01	0.	0.	0.	0.	0.	0.	S	0.1322E 02
201	6	9	C	0.2941E 02	0.3805E-01	0.	0.	0.	0.	0.	0.	R	0.1246E 00
			T		0.9120E 00	0.	0.	0.	0.	0.	0.	S	0.2606E 02
201	6	10	C	0.1377E 02	0.1162E-01	0.	0.	0.	0.	0.	0.	R	0.1607E 00
			T		0.1137E 01	0.	0.	0.	0.	0.	0.	S	0.4267E 01
201	6	11	C	0.2980E 02	0.	0.1444E-01	0.	0.	0.	0.	0.	R	0.6478E 00
			T		0.	0.2869E 01	0.	0.	0.	0.	0.	S	0.7322E 02
201	6	12	C	0.1906E 03	0.4972E-01	0.	0.	0.	0.	0.	0.	R	0.2784E 00
			T		0.5297E 00	0.	0.	0.	0.	0.	0.	S	0.2263E 03
201	6	13	C	-0.9464E 02	0.3698E-01	0.	0.	0.	0.	0.	0.	R	0.2039E 00
			T		0.1197E 01	0.	0.	0.	0.	0.	0.	S	0.2691E 03
201	6	14	C	0.3166E 03	0.4147E-01	0.	0.	0.	0.	0.	0.	R	0.4756E 00
			T		0.2123E 01	0.	0.	0.	0.	0.	0.	S	0.5117E 03
201	6	15	C	-0.1028E 03	0.7460E-01	0.	0.	0.	0.	0.	0.	R	0.7023E 00
			T		0.3427E 01	0.	0.	0.	0.	0.	0.	S	0.2311E 02

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
201	7	1	C	-0.3482E 03	0.5900E-02	0.	0.	0.	0.	0.	0.	R	0.9620E 00
			T		0.1224E 02	0.	0.	0.	0.	0.	0.	S	0.8566E 02
201	7	2	C	-0.2394E 03	0.9477E-02	0.	0.	0.	0.	0.	0.	R	0.8902E 00
			T		0.6942E 01	0.	0.	0.	0.	0.	0.	S	0.3295E 02
201	7	3	C	-0.2754E 03	0.5445E-02	0.	0.	0.	0.	0.	0.	R	0.9457E 00
			T		0.1054E 02	0.	0.	0.	0.	0.	0.	S	0.2853E 02
201	7	4	C	-0.4149E 04	0.6329E-02	0.	0.	0.	0.	0.	0.	R	0.9368E 00
			T		0.9703E 01	0.	0.	0.	0.	0.	0.	S	0.3396E 03
201	7	5	C	-0.1877E 04	0.3923E-02	0.	0.	0.	0.	0.	0.	R	0.9544E 00
			T		0.1111E 02	0.	0.	0.	0.	0.	0.	S	0.1177E 03
201	7	6	C	-0.2083E 03	0.1687E-02	0.	0.	0.	0.	0.	0.	R	0.9854E 00
			T		0.1923E 02	0.	0.	0.	0.	0.	0.	S	0.1068E 02
201	7	7	C	0.6334E 01	0.6338E-01	0.	0.	0.	0.	0.	0.	R	0.9860E 00
			T		0.1966E 02	0.	0.	0.	0.	0.	0.	S	0.1955E 02
201	7	8	C	-0.4710E 03	0.	0.3313E-01	0.	0.	0.	0.	0.	R	0.9390E 00
			T		0.	0.9109E 01	0.	0.	0.	0.	0.	S	0.5192E 02
201	7	9	C	0.1108E 02	0.7743E-03	0.	0.	0.	0.	0.	0.	R	0.3115E 00
			T		0.1643E 00	0.	0.	0.	0.	0.	0.	S	0.2944E 01
201	7	10	C	0.	0.4103E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	7	11	C	-0.2687E 02	0.	0.4175E-02	0.	0.	0.	0.	0.	R	0.9188E 00
			T		0.	0.7431E 01	0.	0.	0.	0.	0.	S	0.8175E 01
201	7	12	C	-0.1086E 03	0.	0.7830E-02	0.	0.	0.	0.	0.	R	0.8434E 00
			T		0.	0.9064E 01	0.	0.	0.	0.	0.	S	0.1517E 02
201	7	13	C	-0.3528E 02	0.	0.4856E-03	0.	0.	0.	0.	0.	R	0.7045E 00
			T		0.	0.3295E 01	0.	0.	0.	0.	0.	S	0.1244E 02
201	7	14	C	0.2332E 00	0.1244E-04	0.	0.	0.	0.	0.	0.	R	0.2887E 00
			T		0.2774E 00	0.	0.	0.	0.	0.	0.	S	0.1179E 01
201	7	15	C	0.	0.6714E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	8	1	C	-0.3929E 03	0.1238E-01	0.	0.	0.	0.	0.	0.	R	0.8720E 00
			T		0.6751E 01	0.	0.	0.	0.	0.	0.	S	0.3519E 03
201	8	2	C	0.1350E 03	0.7092E-03	0.	0.	0.	0.	0.	0.	R	0.2523E 00
			T		0.5310E 00	0.	0.	0.	0.	0.	0.	S	0.3177E 02
201	8	3	C	-0.2360E 01	0.8320E-03	0.	0.	0.	0.	0.	0.	R	0.8099E 00
			T		0.5078E 01	0.	0.	0.	0.	0.	0.	S	0.9048E 01
201	8	4	C	-0.4042E 03	0.1733E-02	0.	0.	0.	0.	0.	0.	R	0.8186E 00
			T		0.5235E 01	0.	0.	0.	0.	0.	0.	S	0.1724E 03
201	8	5	C	-0.1865E 03	0.2190E-02	0.	0.	0.	0.	0.	0.	R	0.7818E 00
			T		0.4457E 01	0.	0.	0.	0.	0.	0.	S	0.1638E 03
201	8	6	C	-0.2577E 02	0.7772E-03	0.	0.	0.	0.	0.	0.	R	0.9031E 00
			T		0.7047E 01	0.	0.	0.	0.	0.	0.	S	0.1343E 02
201	8	7	C	-0.1008E 03	0.	0.2913E-01	0.	0.	0.	0.	0.	R	0.9591E 00
			T		0.	0.1129E 02	0.	0.	0.	0.	0.	S	0.3218E 02
201	8	8	C	0.3713E 03	0.4000E-01	0.	0.	0.	0.	0.	0.	R	0.2736E 00
			T		0.4837E 00	0.	0.	0.	0.	0.	0.	S	0.3717E 03
201	8	9	C	0.	0.2626E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	8	10	C	-0.4435E 03	0.2817E 00	0.1031E 00	0.	0.	0.	0.	0.	R	0.6611E 00
			T		0.2169E 01	0.3149E 01	0.	0.	0.	0.	0.	S	0.3030E 02
201	8	11	C	-0.2685E 02	0.	0.4810E-02	0.	0.	0.	0.	0.	R	0.9625E 00
			T		0.	0.1126E 02	0.	0.	0.	0.	0.	S	0.6216E 01
201	8	12	C	0.7769E 01	0.2170E-02	0.	0.	0.	0.	0.	0.	R	0.2827E 00
			T		0.5099E 00	0.	0.	0.	0.	0.	0.	S	0.1026E 02
201	8	13	C	-0.4961E 02	0.	0.6188E-03	0.	0.	0.	0.	0.	R	0.6959E 00
			T		0.	0.3220E 01	0.	0.	0.	0.	0.	S	0.1622E 02
201	8	14	C	0.	0.3768E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	8	15	C	-0.4092E 02	0.2378E-01	0.	0.	0.	0.	0.	0.	R	0.2617E 00
			T		0.1345E 01	0.	0.	0.	0.	0.	0.	S	0.1874E 02

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
201	9	1	C	0.2517E 02	0.1765E-02	0.	0.	0.	0.	0.	0.	R	0.8765E 00
			T		0.6385E 01	0.	0.	0.	0.	0.	0.	S	0.4911E 02
201	9	2	C	0.	0.1868E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	9	3	C	0.	0.5436E-03	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	9	4	C	0.	0.4297E-03	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	9	5	C	0.	0.1298E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	9	6	C	0.	0.5638E-03	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	9	7	C	0.2367E 02	0.1275E-01	0.	0.	0.	0.	0.	0.	R	0.8588E 00
			T		0.5450E 01	0.	0.	0.	0.	0.	0.	S	0.1366E 02
201	9	8	C	0.	0.9471E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	9	9	C	0.	0.3918E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	9	10	C	0.1223E 02	0.7835E-01	0.	0.	0.	0.	0.	0.	R	0.6441E 00
			T		0.2966E 01	0.	0.	0.	0.	0.	0.	S	0.1102E 02
201	9	11	C	0.5236E 02	0.2152E-01	0.	0.	0.	0.	0.	0.	R	0.6778E 00
			T		0.3082E 01	0.	0.	0.	0.	0.	0.	S	0.2889E 02
201	9	12	C	0.	0.1024E-05	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	9	13	C	0.	0.7553E-06	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	9	14	C	0.2126E 03	0.9974E-02	0.	0.	0.	0.	0.	0.	R	0.7789E 00
			T		0.4417E 01	0.	0.	0.	0.	0.	0.	S	0.5916E 02
201	9	15	C	0.	0.1500E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	10	1	C	0.7744E 01	0.1558E-03	0.	0.	0.	0.	0.	0.	R	0.5699E 00
			T		0.2602E 01	0.	0.	0.	0.	0.	0.	S	0.1064E 02
201	10	2	C	-0.3011E 02	0.1453E-02	0.	0.	0.	0.	0.	0.	R	0.7568E 00
			T		0.4133E 01	0.	0.	0.	0.	0.	0.	S	0.8364E 01
201	10	3	C	0.	0.3801E-04	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	10	4	C	0.5930E 01	0.9861E-05	0.	0.	0.	0.	0.	0.	R	0.3958E 00
			T		0.1848E 01	0.	0.	0.	0.	0.	0.	S	0.2770E 01
201	10	5	C	0.	0.1099E-03	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	10	6	C	0.5728E 01	0.1424E-04	0.	0.	0.	0.	0.	0.	R	0.2423E 00
			T		0.6245E 00	0.	0.	0.	0.	0.	0.	S	0.2776E 01
201	10	7	C	0.	0.1776E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	10	8	C	0.	0.3716E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	10	9	C	0.	0.9032E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	10	10	C	0.	0.1506E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	10	11	C	-0.1029E 01	0.5239E-03	0.	0.	0.	0.	0.	0.	R	0.4425E 00
			T		0.1853E 01	0.	0.	0.	0.	0.	0.	S	0.9671E 00
201	10	12	C	0.	0.1275E-05	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	10	13	C	-0.5466E 00	0.5319E-04	0.	0.	0.	0.	0.	0.	R	0.2909E 00
			T		0.1387E 01	0.	0.	0.	0.	0.	0.	S	0.8341E 00
201	10	14	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	10	15	C	0.	0.2539E-03	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
201	11	1	C	-0.8078E 03	0.1427E-01	0.	0.	0.	0.	0.	0.	R	0.9580E 00
			T		0.1162E 02	0.	0.	0.	0.	0.	0.	S	0.2489E 03
201	11	2	C	0.1053E 03	0.1736E-02	0.	0.	0.	0.	0.	0.	R	0.4182E 00
			T		0.1882E 01	0.	0.	0.	0.	0.	0.	S	0.2195E 02
201	11	3	C	0.6253E 01	0.1170E-02	0.	0.	0.	0.	0.	0.	R	0.3831E 00
			T		0.1799E 01	0.	0.	0.	0.	0.	0.	S	0.3592E 02
201	11	4	C	-0.2857E 03	0.6836E-03	0.	0.	0.	0.	0.	0.	R	0.5754E 00
			T		0.2727E 01	0.	0.	0.	0.	0.	0.	S	0.1305E 03
201	11	5	C	-0.5314E 04	0.1958E-01	0.	0.	0.	0.	0.	0.	R	0.9418E 00
			T		0.9754E 01	0.	0.	0.	0.	0.	0.	S	0.6350E 03
201	11	6	C	-0.5387E 03	0.6438E-02	0.	0.	0.	0.	0.	0.	R	0.9049E 00
			T		0.7124E 01	0.	0.	0.	0.	0.	0.	S	0.1101E 03
201	11	7	C	-0.5444E 02	0.5735E-01	0.	0.	0.	0.	0.	0.	R	0.9757E 00
			T		0.1479E 02	0.	0.	0.	0.	0.	0.	S	0.2353E 02
201	11	8	C	-0.5626E 03	0.1245E 00	0.	0.	0.	0.	0.	0.	R	0.9654E 00
			T		0.1231E 02	0.	0.	0.	0.	0.	0.	S	0.4544E 02
201	11	9	C	-0.7402E 02	0.9091E-01	0.	0.	0.	0.	0.	0.	R	0.9086E-01
			T		0.1045E 01	0.	0.	0.	0.	0.	0.	S	0.5435E 02
201	11	10	C	0.	0.2060E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	11	11	C	-0.1138E 03	0.	0.3092E-01	0.	0.	0.	0.	0.	R	0.8240E 00
			T		0.	0.4707E 01	0.	0.	0.	0.	0.	S	0.9559E 02
201	11	12	C	-0.1031E 03	0.	0.9176E-02	0.	0.	0.	0.	0.	R	0.8285E 00
			T		0.	0.4785E 01	0.	0.	0.	0.	0.	S	0.1881E 02
201	11	13	C	-0.2236E 02	0.1399E-01	0.	0.	0.	0.	0.	0.	R	0.4969E 00
			T		0.2068E 01	0.	0.	0.	0.	0.	0.	S	0.9895E 02
201	11	14	C	0.	0.3547E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	11	15	C	0.	0.9033E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	12	1	C	-0.2799E 03	0.4563E-02	0.	0.	0.	0.	0.	0.	R	0.9305E 00
			T		0.8856E 01	0.	0.	0.	0.	0.	0.	S	0.9196E 02
201	12	2	C	0.1901E 02	0.3255E-03	0.	0.	0.	0.	0.	0.	R	0.3213E 00
			T		0.1543E 01	0.	0.	0.	0.	0.	0.	S	0.5018E 01
201	12	3	C	-0.1694E 03	0.3621E-02	0.	0.	0.	0.	0.	0.	R	0.8364E 00
			T		0.5592E 01	0.	0.	0.	0.	0.	0.	S	0.3576E 02
201	12	4	C	-0.2236E 04	0.3504E-02	0.	0.	0.	0.	0.	0.	R	0.8977E 00
			T		0.7414E 01	0.	0.	0.	0.	0.	0.	S	0.2460E 03
201	12	5	C	-0.5680E 04	0.2180E-01	0.	0.	0.	0.	0.	0.	R	0.9535E 00
			T		0.1101E 02	0.	0.	0.	0.	0.	0.	S	0.6600E 03
201	12	6	C	-0.7885E 03	0.6971E-02	0.	0.	0.	0.	0.	0.	R	0.9779E 00
			T		0.1556E 02	0.	0.	0.	0.	0.	0.	S	0.5455E 02
201	12	7	C	0.2514E 02	0.2368E-02	0.	0.	0.	0.	0.	0.	R	0.5251E 00
			T		0.2278E 01	0.	0.	0.	0.	0.	0.	S	0.6307E 01
201	12	8	C	-0.5508E 02	0.1256E-01	0.	0.	0.	0.	0.	0.	R	0.9556E 00
			T		0.1081E 02	0.	0.	0.	0.	0.	0.	S	0.5225E 01
201	12	9	C	-0.2852E 03	0.6113E-01	0.3301E-02	0.	0.	0.	0.	0.	R	0.9191E 00
			T		0.1724E 01	0.4786E 01	0.	0.	0.	0.	0.	S	0.1700E 02
201	12	10	C	-0.4241E 00	0.7746E-02	0.	0.	0.	0.	0.	0.	R	0.2282E 00
			T		0.6751E 00	0.	0.	0.	0.	0.	0.	S	0.4789E 01
201	12	11	C	0.4149E 02	0.7506E-02	0.	0.	0.	0.	0.	0.	R	0.5962E 00
			T		0.2557E 01	0.	0.	0.	0.	0.	0.	S	0.1006E 02
201	12	12	C	-0.3129E 03	0.1960E 00	0.	0.	0.	0.	0.	0.	R	0.8913E 00
			T		0.6297E 01	0.	0.	0.	0.	0.	0.	S	0.7506E 02
201	12	13	C	-0.2484E 03	0.	0.2247E-02	0.	0.	0.	0.	0.	R	0.9017E 00
			T		0.	0.6669E 01	0.	0.	0.	0.	0.	S	0.2845E 02
201	12	14	C	0.2223E 03	0.4642E-02	0.	0.	0.	0.	0.	0.	R	0.2819E 00
			T		0.1427E 01	0.	0.	0.	0.	0.	0.	S	0.5523E 02
201	12	15	C	-0.2214E 02	0.3957E-01	0.	0.	0.	0.	0.	0.	R	0.6652E-01
			T		0.9755E 00	0.	0.	0.	0.	0.	0.	S	0.4300E 02

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
201	13	1	C	0.1571E 03	0.4972E-02	0.	0.	0.	0.	0.	0.	R	0.8801E 00
			T		0.6494E 01	0.	0.	0.	0.	0.	0.	S	0.1086E 03
201	13	2	C	0.	0.8112E-03	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	13	3	C	-0.6234E 02	0.8246E-02	0.	0.	0.	0.	0.	0.	R	0.9371E 00
			T		0.9733E 01	0.	0.	0.	0.	0.	0.	S	0.4679E 02
201	13	4	C	-0.1633E 04	0.7619E-02	0.	0.	0.	0.	0.	0.	R	0.8920E 00
			T		0.7186E 01	0.	0.	0.	0.	0.	0.	S	0.5520E 03
201	13	5	C	0.	0.2732E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	13	6	C	0.6334E 03	0.1532E-02	0.	0.	0.	0.	0.	0.	R	0.3319E 00
			T		0.1537E 01	0.	0.	0.	0.	0.	0.	S	0.1213E 03
201	13	7	C	0.4634E 02	0.3484E-02	0.	0.	0.	0.	0.	0.	R	0.3522E 00
			T		0.1599E 01	0.	0.	0.	0.	0.	0.	S	0.1321E 02
201	13	8	C	0.	0.3186E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	13	9	C	0.	0.1479E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	13	10	C	-0.2361E 02	0.	0.1220E-01	0.	0.	0.	0.	0.	R	0.7475E 00
			T		0.	0.3864E 01	0.	0.	0.	0.	0.	S	0.2945E 01
201	13	11	C	0.2622E 01	0.1842E-02	0.	0.	0.	0.	0.	0.	R	0.2944E 00
			T		0.4507E 00	0.	0.	0.	0.	0.	0.	S	0.1172E 02
201	13	12	C	-0.3584E 02	0.	0.4151E-02	0.	0.	0.	0.	0.	R	0.8231E 00
			T		0.	0.4692E 01	0.	0.	0.	0.	0.	S	0.8679E 01
201	13	13	C	0.	0.4246E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	13	14	C	0.	0.1387E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	13	15	C	0.	0.3027E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	14	1	C	-0.1466E 03	0.4864E-02	0.	0.	0.	0.	0.	0.	R	0.8845E 00
			T		0.6642E 01	0.	0.	0.	0.	0.	0.	S	0.1301E 03
201	14	2	C	-0.1950E 01	0.9841E-03	0.	0.	0.	0.	0.	0.	R	0.2134E 00
			T		0.1254E 01	0.	0.	0.	0.	0.	0.	S	0.1867E 02
201	14	3	C	-0.8974E 02	0.2198E-02	0.	0.	0.	0.	0.	0.	R	0.9361E 00
			T		0.9647E 01	0.	0.	0.	0.	0.	0.	S	0.1298E 02
201	14	4	C	-0.4340E 02	0.3203E-03	0.	0.	0.	0.	0.	0.	R	0.2487E 00
			T		0.1363E 01	0.	0.	0.	0.	0.	0.	S	0.1224E 03
201	14	5	C	-0.8312E 03	0.8304E-02	0.	0.	0.	0.	0.	0.	R	0.8198E 00
			T		0.4988E 01	0.	0.	0.	0.	0.	0.	S	0.5549E 03
201	14	6	C	0.2480E 03	0.8775E-02	0.	0.	0.	0.	0.	0.	R	0.8591E 00
			T		0.5657E 01	0.	0.	0.	0.	0.	0.	S	0.1889E 03
201	14	7	C	0.3826E 01	0.2138E-02	0.	0.	0.	0.	0.	0.	R	0.8402E 00
			T		0.5235E 01	0.	0.	0.	0.	0.	0.	S	0.2477E 01
201	14	8	C	0.	0.6248E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	14	9	C	0.	0.8707E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	14	10	C	0.1370E 02	0.3358E-01	0.	0.	0.	0.	0.	0.	R	0.3116E 00
			T		0.1478E 01	0.	0.	0.	0.	0.	0.	S	0.9486E 01
201	14	11	C	-0.3588E 02	0.	0.1835E-01	0.	0.	0.	0.	0.	R	0.8662E 00
			T		0.	0.5571E 01	0.	0.	0.	0.	0.	S	0.4791E 02
201	14	12	C	-0.2601E 03	0.	0.3048E-01	0.	0.	0.	0.	0.	R	0.8130E 00
			T		0.	0.4527E 01	0.	0.	0.	0.	0.	S	0.6604E 02
201	14	13	C	0.1105E 03	0.1879E-02	0.	0.	0.	0.	0.	0.	R	0.2137E 00
			T		0.7505E 00	0.	0.	0.	0.	0.	0.	S	0.2182E 02
201	14	14	C	0.1210E 03	0.7379E 00	0.	0.	0.	0.	0.	0.	R	0.9631E 00
			T		0.1243E 02	0.	0.	0.	0.	0.	0.	S	0.1595E 04
201	14	15	C	0.	0.2509E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
201	15	1	C	-0.1932E 03	0.3479E-02	0.	0.	0.	0.	0.	0.	R	0.8184E 00
			T		0.5034E 01	0.	0.	0.	0.	0.	0.	S	0.1228E 03
201	15	2	C	-0.5110E 02	0.2379E-02	0.	0.	0.	0.	0.	0.	R	0.9077E 00
			T		0.7559E 01	0.	0.	0.	0.	0.	0.	S	0.7487E 01
201	15	3	C	-0.3819E 02	0.8280E-03	0.	0.	0.	0.	0.	0.	R	0.8941E 00
			T		0.7266E 01	0.	0.	0.	0.	0.	0.	S	0.6294E 01
201	15	4	C	-0.5249E 02	0.7173E-04	0.	0.	0.	0.	0.	0.	R	0.5861E 00
			T		0.2793E 01	0.	0.	0.	0.	0.	0.	S	0.1337E 02
201	15	5	C	-0.2736E 03	0.1150E-02	0.	0.	0.	0.	0.	0.	R	0.9095E 00
			T		0.7647E 01	0.	0.	0.	0.	0.	0.	S	0.5013E 02
201	15	6	C	-0.2438E 02	0.4042E-03	0.	0.	0.	0.	0.	0.	R	0.8204E 00
			T		0.4863E 01	0.	0.	0.	0.	0.	0.	S	0.1012E 02
201	15	7	C	0.8257E 02	0.7030E-01	0.	0.	0.	0.	0.	0.	R	0.5687E 00
			T		0.2501E 01	0.	0.	0.	0.	0.	0.	S	0.1705E 03
201	15	8	C	-0.3298E 03	0.6660E-01	0.	0.	0.	0.	0.	0.	R	0.8287E 00
			T		0.5012E 01	0.	0.	0.	0.	0.	0.	S	0.5972E 02
201	15	9	C	-0.2691E 03	0.9415E-01	0.	0.	0.	0.	0.	0.	R	0.5937E 00
			T		0.2643E 01	0.	0.	0.	0.	0.	0.	S	0.2225E 02
201	15	10	C	-0.7971E 02	0.1407E 00	0.2304E-01	0.	0.	0.	0.	0.	R	0.6861E 00
			T		0.2643E 01	0.9669E 00	0.	0.	0.	0.	0.	S	0.1242E 02
201	15	11	C	-0.5817E 01	0.1779E-01	0.	0.	0.	0.	0.	0.	R	0.5799E 00
			T		0.2463E 01	0.	0.	0.	0.	0.	0.	S	0.2471E 02
201	15	12	C	-0.2425E 03	0.	0.1526E-01	0.	0.	0.	0.	0.	R	0.8307E 00
			T		0.	0.4823E 01	0.	0.	0.	0.	0.	S	0.3103E 02
201	15	13	C	-0.1375E 02	0.	0.1267E-03	0.	0.	0.	0.	0.	R	0.8738E 00
			T		0.	0.5771E 01	0.	0.	0.	0.	0.	S	0.1853E 01
201	15	14	C	0.	0.2693E-01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
201	15	15	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

2. $c^* = \bar{z}_a \{ \alpha + \beta x^* + \gamma c^*_{-1} \overset{\Theta}{} + \delta [p_{c-1} / (\Sigma p_c)^{-2}_{-1} / 2] \} + \bar{z}_b [x^* - e^* + m^* - g^* - \Delta s^*_p - \Delta s^*_h - \Delta s^*_i] + \bar{z}_c [x^* - e^* + m^* - g^* - \Delta s^*_p - \Delta s^*_h - \Delta s^*_i]$

202	1	0	C	0.4249E 04	0.1678E 00	0.7004E 00	0.	0.	0.	0.	0.	0.	R	0.9995E 00
			T		0.1867E 01	0.3487E 01	0.	0.	0.	0.	0.	0.	S	0.8950E 03
202	2	0	C	0.2637E 03	0.1482E 00	0.7855E 00	0.	0.	0.	0.	0.	0.	R	0.9986E 00
			T		0.9045E 00	0.2485E 01	0.	0.	0.	0.	0.	0.	S	0.1799E 03
202	3	0	C	0.3118E 04	0.5503E 00	0.		0.	0.	0.	0.	0.	R	0.9974E 00
			T		0.5013E 02	0.		0.	0.	0.	0.	0.	S	0.6339E 03
202	4	0	C	-0.1789E 05	0.4276E 00	0.3695E 00	0.	0.	0.	0.	0.	0.	R	0.9985E 00
			T		0.3848E 01	0.2077E 01	0.	0.	0.	0.	0.	0.	S	0.5512E 04
202	5	0	C	-0.7279E 04	0.6031E 00	0.		0.	0.	0.	0.	0.	R	0.9988E 00
			T		0.6362E 02	0.		0.	0.	0.	0.	0.	S	0.2617E 04
202	6	0	C	0.4551E 04	0.5960E 00	0.		0.	0.	0.	0.	0.	R	0.9990E 00
			T		0.6752E 02	0.		0.	0.	0.	0.	0.	S	0.8260E 03
202	7	0	C	0.5585E 03	0.2840E 00	0.5965E 00	0.	0.	0.	0.	0.	0.	R	0.9989E 00
			T		0.1712E 01	0.1948E 01	0.	0.	0.	0.	0.	0.	S	0.1072E 03
202	8	0	C	0.1935E 05	0.3434E 00	0.4581E 00	-0.1699E 05	0.	0.	0.	0.	0.	R	0.9932E 00
			T		0.1886E 01	0.1303E 01	-0.1093E 01	0.	0.	0.	0.	0.	S	0.2586E 03
202	9	0	C	0.4680E 04	0.7051E 00	0.		0.	0.	0.	0.	0.	R	0.9934E 00
			T		0.2602E 02	0.		0.	0.	0.	0.	0.	S	0.7084E 03
202	10	0	C	0.1597E 03	0.6914E 00	0.		0.	0.	0.	0.	0.	R	0.8805E 00
			T		0.5662E 01	0.		0.	0.	0.	0.	0.	S	0.9175E 02
202	11	0	C	0.5964E 04	0.1410E 00	0.7864E 00	-0.5547E 04	0.	0.	0.	0.	0.	R	0.9988E 00
			T		0.1781E 01	0.4107E 01	-0.1090E 01	0.	0.	0.	0.	0.	S	0.9743E 02
202	12	0	C	0.1233E 05	0.4539E 00	0.3106E 00	-0.1106E 05	0.	0.	0.	0.	0.	R	0.9787E 00
			T		0.2120E 01	0.8857E 00	-0.1085E 01	0.	0.	0.	0.	0.	S	0.3175E 03
202	13	0	C	0.3305E 04	0.7484E 00	0.		0.	0.	0.	0.	0.	R	0.9991E 00
			T		0.6546E 02	0.		0.	0.	0.	0.	0.	S	0.7832E 03
202	14	0	C	0.4040E 06	0.	0.1101E 01	-0.4165E 06	0.	0.	0.	0.	0.	R	0.9980E 00
			T		0.	0.4486E 02	-0.1135E 01	0.	0.	0.	0.	0.	S	0.3554E 04
202	15	0	C	0.4626E 04	0.6763E 00	0.		0.	0.	0.	0.	0.	R	0.9898E 00
			T		0.2083E 02	0.		0.	0.	0.	0.	0.	S	0.2309E 04

3. $g^* = \alpha + \beta r^*$

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
203	1	0	C	0.6259E 04	0.2805E 00	0.	0.	0.	0.	0.	0.	R	0.7836E 00
			T		0.4656E 01	0.	0.	0.	0.	0.	0.	S	0.2108E 04
203	2	0	C	0.2149E 03	0.4638E 00	0.	0.	0.	0.	0.	0.	R	0.9147E 00
			T		0.7903E 01	0.	0.	0.	0.	0.	0.	S	0.4101E 03
203	3	0	C	0.4473E 04	0.3948E 00	0.	0.	0.	0.	0.	0.	R	0.8025E 00
			T		0.5131E 01	0.	0.	0.	0.	0.	0.	S	0.1890E 04
203	4	0	C	0.6466E 05	0.4297E 00	0.	0.	0.	0.	0.	0.	R	0.7261E 00
			T		0.4210E 01	0.	0.	0.	0.	0.	0.	S	0.2074E 05
203	5	0	C	0.2956E 05	0.2731E 00	0.	0.	0.	0.	0.	0.	R	0.9868E 00
			T		0.2023E 02	0.	0.	0.	0.	0.	0.	S	0.1794E 04
203	6	0	C	0.6739E 04	0.3999E 00	0.	0.	0.	0.	0.	0.	R	0.9929E 00
			T		0.2779E 02	0.	0.	0.	0.	0.	0.	S	0.7181E 03
203	7	0	C	0.5965E 03	0.4513E 00	0.	0.	0.	0.	0.	0.	R	0.9960E 00
			T		0.3678E 02	0.	0.	0.	0.	0.	0.	S	0.3297E 02
203	8	0	C	0.8569E 02	0.9011E 00	0.	0.	0.	0.	0.	0.	R	0.9838E 00
			T		0.1825E 02	0.	0.	0.	0.	0.	0.	S	0.1040E 03
203	9	0	C	-0.9619E 02	0.8802E 00	0.	0.	0.	0.	0.	0.	R	0.9779E 00
			T		0.1554E 02	0.	0.	0.	0.	0.	0.	S	0.2441E 03
203	10	0	C	0.2850E 03	0.2006E 00	0.	0.	0.	0.	0.	0.	R	0.2463E 00
			T		0.1308E 01	0.	0.	0.	0.	0.	0.	S	0.4177E 02
203	11	0	C	-0.1988E 03	0.7342E 00	0.	0.	0.	0.	0.	0.	R	0.9938E 00
			T		0.2817E 02	0.	0.	0.	0.	0.	0.	S	0.1115E 03
203	12	0	C	0.2980E-07	0.1000E 01	0.	0.	0.	0.	0.	0.	R	0.1000E 01
			T		0.1000E 01	0.	0.	0.	0.	0.	0.	S	0.
203	13	0	C	0.	0.1000E 01	0.	0.	0.	0.	0.	0.	R	0.1000E 01
			T		0.1000E 01	0.	0.	0.	0.	0.	0.	S	0..
203	14	0	C	0.2384E-06	0.1000E 01	0.	0.	0.	0.	0.	0.	R	0.1000E 01
			T		0.1000E 01	0.	0.	0.	0.	0.	0.	S	0.
203	15	0	C	0.2980E-07	0.1000E 01	0.	0.	0.	0.	0.	0.	R	0.1000E 01
			T		0.1000E 01	0.	0.	0.	0.	0.	0.	S	0.

4. $r^* = \alpha + \beta x^*_{-1}$

204	1	0	C	0.9159E 04	0.1430E 00	0.	0.	0.	0.	0.	0.	R	0.7638E 00
			T		0.4219E 01	0.	0.	0.	0.	0.	0.	S	0.6024E 04
204	2	0	C	0.1367E 03	0.2757E 00	0.	0.	0.	0.	0.	0.	R	0.8655E 00
			T		0.5817E 01	0.	0.	0.	0.	0.	0.	S	0.9821E 03
204	3	0	C	-0.2721E 04	0.3518E 00	0.	0.	0.	0.	0.	0.	R	0.7808E 00
			T		0.4616E 01	0.	0.	0.	0.	0.	0.	S	0.4012E 04
204	4	0	C	0.7635E 05	0.1943E 00	0.	0.	0.	0.	0.	0.	R	0.5453E 00
			T		0.2631E 01	0.	0.	0.	0.	0.	0.	S	0.4180E 05
204	5	0	C	-0.6297E 05	0.5113E 00	0.	0.	0.	0.	0.	0.	R	0.9908E 00
			T		0.2316E 02	0.	0.	0.	0.	0.	0.	S	0.5164E 04
204	6	0	C	-0.1912E 05	0.4295E 00	0.	0.	0.	0.	0.	0.	R	0.9902E 00
			T		0.2244E 02	0.	0.	0.	0.	0.	0.	S	0.1996E 04
204	7	0	C	-0.3285E 03	0.2424E 00	0.	0.	0.	0.	0.	0.	R	0.9854E 00
			T		0.1833E 02	0.	0.	0.	0.	0.	0.	S	0.1369E 03
204	8	0	C	-0.1142E 04	0.1723E 00	0.	0.	0.	0.	0.	0.	R	0.9882E 00
			T		0.2044E 02	0.	0.	0.	0.	0.	0.	S	0.9629E 02
204	9	0	C	-0.1525E 04	0.1311E 00	0.	0.	0.	0.	0.	0.	R	0.9662E 00
			T		0.1190E 02	0.	0.	0.	0.	0.	0.	S	0.2933E 03
204	10	0	C	0.2459E 03	0.9578E-01	0.	0.	0.	0.	0.	0.	R	0.1860E 00
			T		0.8158E 00	0.	0.	0.	0.	0.	0.	S	0.8733E 02
204	11	0	C	-0.1954E 04	0.3401E 00	0.	0.	0.	0.	0.	0.	R	0.9844E 00
			T		0.1482E 02	0.	0.	0.	0.	0.	0.	S	0.2376E 03
204	12	0	C	-0.2656E 04	0.2966E 00	0.	0.	0.	0.	0.	0.	R	0.9416E 00
			T		0.8450E 01	0.	0.	0.	0.	0.	0.	S	0.2970E 03
204	13	0	C	0.2490E 04	0.8535E-01	0.	0.	0.	0.	0.	0.	R	0.9882E 00
			T		0.1939E 02	0.	0.	0.	0.	0.	0.	S	0.3146E 03
204	14	0	C	-0.1179E 05	0.9110E-01	0.	0.	0.	0.	0.	0.	R	0.9994E 00
			T		0.8852E 02	0.	0.	0.	0.	0.	0.	S	0.2265E 03
204	15	0	C	-0.6791E 03	0.3509E-01	0.	0.	0.	0.	0.	0.	R	0.9249E 00
			T		0.7758E 01	0.	0.	0.	0.	0.	0.	S	0.3098E 03

5. $$\Delta s^*_p = \bar{z}_a\{\alpha + \beta y^*_{c-1} + \gamma e^*_{-1} \overset{\Theta}{+} \delta \bar{i}_{-1} + \varepsilon[(\tfrac{1}{\psi})_{-1} / (\Sigma_{-2}^{-1}\tfrac{1}{\psi}) / 2]\} + \bar{z}_b\{\alpha + \beta x^*_{-1} + \gamma[e^*_{-1}]\cdot[\frac{P_{e(j)}}{P_{m(j)}}]_{-1} + \delta[\frac{1}{P_{e(j)-1}}(\Sigma_i o_{da(i,j)} + \Sigma_i \Delta s_{op}(i,j) + \bar{a}_m + \bar{a}_c)_{-1}]\cdot[\frac{P_{e(j)}}{P_{m(j)}}]_{-1}\} + \bar{z}_c\{\alpha + \beta x^*_{-1}\}$$

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
205	1	0	C	-0.2078E 04	0.2819E 01	0.	0.	0.	0.	0.	0.	R	0.9737E 00
			T		0.1485E 02	0.	0.	0.	0.	0.	0.	S	0.4360E 04
205	2	0	C	0.1016E 04	0.1519E 01	0.	0.	0.	0.	0.	0.	R	0.9773E 00
			T		0.1535E 02	0.	0.	0.	0.	0.	0.	S	0.2909E 03
205	3	0	C	0.3546E 04	0.3146E 00	0.3828E 00	0.	0.	0.	0.	0.	R	0.9360E 00
			T		0.2193E 01	0.4361E 01	0.	0.	0.	0.	0.	S	0.9323E 03
205	4	0	C	0.6756E 04	0.	0.2422E 01	0.	0.	0.	0.	0.	R	0.9740E 00
			T		0.	0.1429E 02	0.	0.	0.	0.	0.	S	0.5102E 04
205	5	0	C	0.2233E 05	0.3562E 00	0.4866E 00	0.	0.	0.	0.	0.	R	0.9909E 00
			T		0.1921E 01	0.1051E 02	0.	0.	0.	0.	0.	S	0.2363E 04
205	6	0	C	0.1022E 05	0.	0.5942E 00	0.	0.	0.	0.	0.	R	0.9814E 00
			T		0.	0.1620E 02	0.	0.	0.	0.	0.	S	0.1313E 04
205	7	0	C	-0.1764E 04	0.3659E 00	0.	0.	0.	0.	0.	0.	R	0.9911E 00
			T		0.2352E 02	0.	0.	0.	0.	0.	0.	S	0.1610E 03
205	8	0	C	-0.3551E 04	0.1253E 00	0.7082E 00	0.	0.	0.	0.	0.	R	0.9941E 00
			T		0.2551E 01	0.4465E 01	0.	0.	0.	0.	0.	S	0.1345E 03
205	9	0	C	-0.3277E 04	0.1571E 00	0.1061E 01	0.	0.	0.	0.	0.	R	0.9785E 00
			T		0.4002E 01	0.1158E 01	0.	0.	0.	0.	0.	S	0.3540E 03
205	10	0	C	-0.1112E 03	0.1632E 00	0.	0.	0.	0.	0.	0.	R	0.9860E 00
			T		0.1965E 02	0.	0.	0.	0.	0.	0.	S	0.7744E 01
205	11	0	C	-0.1544E 04	0.3041E 00	0.	0.	0.	0.	0.	0.	R	0.9867E 00
			T		0.1821E 02	0.	0.	0.	0.	0.	0.	S	0.1962E 03
205	12	0	C	-0.7256E 03	0.2081E 00	0.	0.	0.	0.	0.	0.	R	0.9504E 00
			T		0.9217E 01	0.	0.	0.	0.	0.	0.	S	0.1911E 03
205	13	0	C	-0.7567E 04	0.1980E 00	0.	0.	0.	0.	0.	0.	R	0.9906E 00
			T		0.2173E 02	0.	0.	0.	0.	0.	0.	S	0.6512E 03
205	14	0	C	-0.1902E 05	0.2414E 00	0.	0.	0.	0.	0.	0.	R	0.9746E 00
			T		0.1311E 02	0.	0.	0.	0.	0.	0.	S	0.4054E 04
205	15	0	C	-0.6175E 04	0.3265E 00	0.	0.	0.	0.	0.	0.	R	0.9285E 00
			T		0.7973E 01	0.	0.	0.	0.	0.	0.	S	0.2804E 04

6. $\Delta s^*_h = \alpha + \beta x^{*\ominus} + \gamma [p_{h-1} / (\Sigma p_h)^{-2}_{-1} / 2]^{\ominus} + \delta \bar{i}_{-1}$

206	1	0	C	-0.2177E 04	0.9075E-01	0.	-0.1647E 03	0.	0.	0.	0.	R	0.9980E 00
			T		0.3249E 02	0.	-0.9098E 00	0.	0.	0.	0.	S	0.3414E 03
206	2	0	C	-0.2975E 03	0.7817E-01	-0.1098E 03	-0.1073E 03	0.	0.	0.	0.	R	0.9926E 00
			T		0.1664E 02	-0.1765E 01	-0.2805E 01	0.	0.	0.	0.	S	0.5098E 02
206	3	0	C	0.2428E 02	0.5486E-01	0.	-0.1348E 03	0.	0.	0.	0.	R	0.9577E 00
			T		0.1120E 02	0.	-0.2212E 01	0.	0.	0.	0.	S	0.2384E 03
206	4	0	C	0.1935E 05	0.4009E-01	0.	-0.4439E 04	0.	0.	0.	0.	R	0.7112E 00
			T		0.3904E 01	0.	-0.2743E 01	0.	0.	0.	0.	S	0.3718E 04
206	5	0	C	0.2776E 05	0.5579E-01	-0.1938E 05	-0.1203E 04	0.	0.	0.	0.	R	0.9562E 00
			T		0.6958E 01	-0.2280E 01	-0.1743E 01	0.	0.	0.	0.	S	0.1276E 04
206	6	0	C	0.5227E 03	0.6359E-01	0.	0.	0.	0.	0.	0.	R	0.9837E 00
			T		0.1644E 02	0.	0.	0.	0.	0.	0.	S	0.3620E 03
206	7	0	C	-0.3616E 01	0.2706E-01	-0.1475E 03	-0.1112E 01	0.	0.	0.	0.	R	0.9819E 00
			T		0.1364E 02	-0.1009E 01	-0.7309E 00	0.	0.	0.	0.	S	0.1765E 02
206	8	0	C	0.2446E 03	0.1155E-02	0.	0.	0.	0.	0.	0.	R	0.3291E 00
			T		0.3468E 00	0.	0.	0.	0.	0.	0.	S	0.3911E 02
206	9	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
206	10	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
206	11	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
206	12	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
206	13	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
206	14	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
206	15	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

7. $\Delta s^*_1 = \alpha + \beta x^* + \gamma (x^*_{-1} - x^*_{-2})^{\Theta} + \delta \bar{I}_{-1}$

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
207	1	0	C	-0.4104E 03	0.3335E-01	0.	0.	0.	0.	0.	0.	R	0.7099E 00
			T		0.3489E 01	0.	0.	0.	0.	0.	0.	S	0.1700E 04
207	2	0	C	0.2117E 04	0.	0.3650E 00	-0.4232E 03	0.	0.	0.	0.	R	0.7423E 00
			T		0.	0.1943E 01	-0.3762E 01	0.	0.	0.	0.	S	0.2180E 03
207	3	0	C	0.2701E 04	0.4326E-02	0.	0.	0.	0.	0.	0.	R	0.2866E 00
			T		0.1141E 00	0.	0.	0.	0.	0.	0.	S	0.2189E 04
207	4	0	C	-0.6093E 04	0.1431E-01	0.6435E-01	-0.6833E 03	0.	0.	0.	0.	R	0.8082E 00
			T		0.3113E 01	0.2008E 01	-0.9949E 00	0.	0.	0.	0.	S	0.1546E 04
207	5	0	C	0.3557E 04	0.5682E-02	0.	0.	0.	0.	0.	0.	R	0.2667E 00
			T		0.5797E 00	0.	0.	0.	0.	0.	0.	S	0.2706E 04
207	6	0	C	-0.1708E 04	0.2814E-01	0.	0.	0.	0.	0.	0.	R	0.5300E 00
			T		0.2125E 01	0.	0.	0.	0.	0.	0.	S	0.1239E 04
207	7	0	C	0.1315E 03	0.	0.3124E 00	-0.1029E 02	0.	0.	0.	0.	R	0.8614E 00
			T		0.	0.5157E 01	-0.2113E 01	0.	0.	0.	0.	S	0.5499E 02
207	8	0	C	-0.3735E 02	0.1177E-01	0.	0.	0.	0.	0.	0.	R	0.5992E 00
			T		0.2458E 01	0.	0.	0.	0.	0.	0.	S	0.5625E 02
207	9	0	C	0.	0.4082E-02	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
207	10	0	C	-0.1463E 03	0.7444E-01	0.	0.	0.	0.	0.	0.	R	0.2868E 00
			T		0.5621E 00	0.	0.	0.	0.	0.	0.	S	0.9953E 02
207	11	0	C	0.7149E 00	0.4897E-04	0.	0.	0.	0.	0.	0.	R	0.3418E 00
			T		0.4039E 00	0.	0.	0.	0.	0.	0.	S	0.1495E 01
207	12	0	C	-0.1242E 03	0.1062E-01	0.	0.	0.	0.	0.	0.	R	0.2401E 00
			T		0.7509E 00	0.	0.	0.	0.	0.	0.	S	0.1747E 03
207	13	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
207	14	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
207	15	0	C	-0.5138E 04	0.7543E-01	0.	0.	0.	0.	0.	0.	R	0.6107E 00
			T		0.2521E 01	0.	0.	0.	0.	0.	0.	S	0.2122E 04

8. $e^{*} = \beta \sum_{j} e^{*}(i,j)$

208	1	0	C	0.	0.1014E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	2	0	C	0.	0.1291E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	3	0	C	0.	0.1176E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	4	0	C	0.	0.1401E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	5	0	C	0.	0.1242E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	6	0	C	0.	0.2360E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	7	0	C	0.	0.1164E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	8	0	C	0.	0.1517E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	9	0	C	0.	0.1221E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	10	0	C	0.	0.8547E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	11	0	C	0.	0.5328E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	12	0	C	0.	0.5003E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	13	0	C	0.	0.1615E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	14	0	C	0.	0.1015E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
208	15	0	C	0.	0.8503E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

9. $m^* = \beta \sum_i e^*(i,j)$

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
209	1	0	C	0.	0.1215E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	2	0	C	0.	0.1389E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	3	0	C	0.	0.1364E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	4	0	C	0.	0.1268E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	5	0	C	0.	0.1276E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	6	0	C	0.	0.1740E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	7	0	C	0.	0.1019E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	8	0	C	0.	0.1292E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	9	0	C	0.	0.1071E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	10	0	C	0.	0.2038E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	11	0	C	0.	0.6349E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	12	0	C	0.	0.9200E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	13	0	C	0.	0.1965E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	14	0	C	0.	0.9925E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
209	15	0	C	0.	0.1267E 01	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

1. $\left(\frac{y^*_c}{y^*_{co}}\right) = \alpha + \beta\left(\frac{x^*}{x^*_o}\right)^{\Theta} + \gamma\left(\frac{\bar{I}_{-1}}{\bar{I}_o}\right) + \delta\left[\left(\frac{\Delta s^*_p}{x^*}\right) / \left(\frac{\Delta s^*_p}{x^*}\right)_o\right]$

301	1	0	C	-0.7811E 00	0.5529E 00	0.	0.1139E 01	0.	0.	0.	0.	R	0.9731E 00
			T		0.3071E 01	0.	0.2379E 01	0.	0.	0.	0.	S	0.6150E-01
301	2	0	C	0.2570E 00	0.1313E 01	-0.6568E 00	0.	0.	0.	0.	0.	R	0.9732E 00
			T		0.1170E 02	-0.3375E 01	0.	0.	0.	0.	0.	S	0.3671E-01
301	3	0	C	0.1723E-01	0.1493E 01	-0.3519E 00	0.	0.	0.	0.	0.	R	0.8515E 00
			T		0.4641E 01	-0.1459E 01	0.	0.	0.	0.	0.	S	0.1171E 00
301	4	0	C	-0.5932E 00	0.	0.	0.1469E 01	0.	0.	0.	0.	R	0.8175E 00
			T		0.	0.	0.4813E 01	0.	0.	0.	0.	S	0.5823E-01
301	5	0	C	-0.2012E 01	0.	0.	0.2904E 01	0.	0.	0.	0.	R	0.8628E 00
			T		0.	0.	0.5748E 01	0.	0.	0.	0.	S	0.5890E-01
301	6	0	C	0.6549E 00	0.3027E 00	0.	0.	0.	0.	0.	0.	R	0.8431E 00
			T		0.5294E 01	0.	0.	0.	0.	0.	0.	S	0.3028E-01
301	7	0	C	0.1511E 00	0.8623E 00	0.	0.	0.	0.	0.	0.	R	0.9807E 00
			T		0.1668E 02	0.	0.	0.	0.	0.	0.	S	0.3856E-01
301	8	0	C	-0.2058E-01	0.8266E 00	0.	0.2303E 00	0.	0.	0.	0.	R	0.9828E 00
			T		0.2941E 01	0.	0.8628E 00	0.	0.	0.	0.	S	0.3060E-01
301	9	0	C	0.1957E 00	0.8427E 00	0.	0.	0.	0.	0.	0.	R	0.8935E 00
			T		0.6675E 01	0.	0.	0.	0.	0.	0.	S	0.5324E-01
301	10	0	C	0.3283E 00	0.6603E 00	0.	0.	0.	0.	0.	0.	R	0.8885E 00
			T		0.6498E 01	0.	0.	0.	0.	0.	0.	S	0.3384E-01
301	11	0	C	0.6727E-01	0.9298E 00	0.	0.	0.	0.	0.	0.	R	0.9955E 00
			T		0.3326E 02	0.	0.	0.	0.	0.	0.	S	0.1714E-01
301	12	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
301	13	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
301	14	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
301	15	0	C	0.	0.8769E 00	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

2. $\omega = \alpha + \beta\, p_{c-1} + \gamma\, p_y^{\Theta} + \delta\,(\frac{u}{\bar{u}_o})$

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
302	1	0	C	-0.2601E 00	0.	0.1246E 01	0.	0.	0.	0.	0.	R	0.9962E 00
			T		0.	0.3782E 02	0.	0.	0.	0.	0.	S	0.2384E-01
302	2	0	C	-0.6670E 00	0.1736E 01	0.	0.	0.	0.	0.	0.	R	0.9842E 00
			T		0.1762E 02	0.	0.	0.	0.	0.	0.	S	0.2749E-01
302	3	0	C	-0.1022E 01	0.1617E 01	0.4898E 00	-0.2543E-01	0.	0.	0.	0.	R	0.9990E 00
			T		0.1353E 02	0.4501E 01	-0.1505E 01	0.	0.	0.	0.	S	0.7500E-02
302	4	0	C	-0.8649E 00	0.1829E 01	0.1811E 00	-0.6768E-01	0.	0.	0.	0.	R	0.9995E 00
			T		0.4114E 02	0.5316E 01	-0.7650E 01	0.	0.	0.	0.	S	0.4565E-02
302	5	0	C	-0.1101E 01	0.1058E 01	0.1052E 01	0.	0.	0.	0.	0.	R	0.9871E 00
			T		0.3356E 01	0.3719E 01	0.	0.	0.	0.	0.	S	0.3228E-01
302	6	0	C	-0.7445E 00	0.1705E 01	0.9856E-01	0.	0.	0.	0.	0.	R	0.9929E 00
			T		0.2415E 02	0.7467E 00	0.	0.	0.	0.	0.	S	0.2427E-01
302	7	0	C	-0.5152E 00	0.	0.1488E 01	0.	0.	0.	0.	0.	R	0.9974E 00
			T		0.	0.4617E 02	0.	0.	0.	0.	0.	S	0.1818E-01
302	8	0	C	-0.7935E 00	0.	0.1786E 01	0.	0.	0.	0.	0.	R	0.9977E 00
			T		0.	0.4647E 02	0.	0.	0.	0.	0.	S	0.1182E-01
302	9	0	C	-0.2241E 00	0.3931E 00	0.8305E 00	0.	0.	0.	0.	0.	R	0.8948E 00
			T		0.2652E 01	0.3075E 01	0.	0.	0.	0.	0.	S	0.5655E-01
302	10	0	C	0.8598E 00	0.2396E 00	0.	-0.8920E-01	0.	0.	0.	0.	R	0.7212E 00
			T		0.1614E 01	0.	-0.3572E 01	0.	0.	0.	0.	S	0.3059E-01
302	11	0	C	0.1178E 00	0.	0.8741E 00	0.	0.	0.	0.	0.	R	0.9861E 00
			T		0.	0.1785E 02	0.	0.	0.	0.	0.	S	0.2350E-01
302	12	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
302	13	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
302	14	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
302	15	0	C	-0.3742E 02	0.3797E 02	0.6338E 00	0.	0.	0.	0.	0.	R	0.9830E 00
			T		0.7543E 01	0.1976E 01	0.	0.	0.	0.	0.	S	0.6802E-01

1. $p_w = \alpha + \beta \, p_{m-1} + \gamma \left[\frac{\omega}{p_y} \right] + \delta \left(\frac{\pi}{x^*} \right)_{-1} + \varepsilon \, i_{v-1} + \xi \left[\left(\frac{y^*_c}{s^*_p} \right) / \left(\frac{y^*_{co}}{s^*_{po}} \right) \right]$

401	1	0	C	0.5884E 00	0.	0.3055E 00	0.	0.	0.1002E 00	0.	0.	R	0.9907E 00
			T		0.	0.1259E 02	0.	0.	0.5494E 01	0.	0.	S	0.5974E-02
401	2	0	C	0.2387E 00	0.	0.	0.8002E 00	0.	0.	0.	0.	R	0.9774E 00
			T		0.	0.	0.1466E 02	0.	0.	0.	0.	S	0.1543E-01
401	3	0	C	0.1235E 00	0.4739E 00	0.2852E 00	0.	0.1302E 00	0.	0.	0.	R	0.9952E 00
			T		0.5126E 01	0.3402E 01	0.	0.1985E 01	0.	0.	0.	S	0.7224E-02
401	4	0	C	0.5075E-01	0.3267E 00	0.3100E 00	0.3052E 00	0.	0.4426E-01	0.	0.	R	0.9912E 00
			T		0.1257E 01	0.3232E 01	0.1732E 01	0.	0.1217E 01	0.	0.	S	0.8213E-02
401	5	0	C	-0.3923E 00	0.1403E 01	0.	0.	0.	0.	0.	0.	R	0.9634E 00
			T		0.1141E 02	0.	0.	0.	0.	0.	0.	S	0.1862E-01
401	6	0	C	0.6083E-01	0.6501E 00	0.	0.	0.3318E 00	0.	0.	0.	R	0.9946E 00
			T		0.4677E 01	0.	0.	0.5647E 01	0.	0.	0.	S	0.9576E-02
401	7	0	C	-0.1822E 00	0.	0.7100E 00	0.2942E 00	0.	0.2108E 00	0.	0.	R	0.9970E 00
			T		0.	0.3016E 01	0.1605E 01	0.	0.4109E 01	0.	0.	S	0.1148E-01
401	8	0	C	-0.5316E 00	0.	0.1034E 01	0.3853E 00	0.	0.1319E 00	0.	0.	R	0.9977E 00
			T		0.	0.5242E 01	0.2925E 01	0.	0.1121E 01	0.	0.	S	0.1068E-01
401	9	0	C	-0.5464E 00	0.	0.	0.1606E 01	0.	0.	0.	0.	R	0.9837E 00
			T		0.	0.	0.1732E 02	0.	0.	0.	0.	S	0.4493E-01
401	10	0	C	0.2830E 00	0.7387E 00	0.	0.	0.	0.	0.	0.	R	0.2518E 00
			T		0.1295E 01	0.	0.	0.	0.	0.	0.	S	0.8851E-01
401	11	0	C	-0.1711E 00	0.1009E 01	0.1373E 00	0.	0.6175E-01	0.	0.	0.	R	0.9610E 00
			T		0.5310E 01	0.1123E 01	0.	0.8083E 00	0.	0.	0.	S	0.1113E-01
401	12	0	C	-0.7294E 00	0.1408E 01	0.	0.3892E 00	0.	0.	0.	0.	R	0.9829E 00
			T		0.2049E 01	0.	0.1216E 01	0.	0.	0.	0.	S	0.2045E-01
401	13	0	C	-0.2543E-01	0.	0.	0.1133E 01	0.	0.	0.	0.	R	0.9870E 00
			T		0.	0.	0.1947E 02	0.	0.	0.	0.	S	0.3301E-01
401	14	0	C	0.2673E 00	0.7729E 00	0.	0.	0.	0.	0.	0.	R	0.6208E 00
			T		0.2578E 01	0.	0.	0.	0.	0.	0.	S	0.2270E-01
401	15	0	C	0.7136E 00	0.	0.1358E-01	0.2727E 00	0.	0.1269E-02	0.	0.	R	0.9932E 00
			T		0.	0.4829E 01	0.2033E 01	0.	0.1015E 01	0.	0.	S	0.6524E-03

2. $P_c = \alpha + \beta\, P_{w-1} + \gamma\, \omega + \delta\, P_{m-1} + \epsilon\, i_{v-1}$

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
402	1	0	C	0.3322E 00	0.	0.3639E 00	0.	0.3221E 00	0.	0.	0.	R	0.9968E 00
			T		0.	0.9335E 01	0.	0.4884E 01	0.	0.	0.	S	0.1156E-01
402	2	0	C	0.2631E-01	0.5783E 00	0.4170E 00	0.	0.	0.	0.	0.	R	0.9964E 00
			T		0.4760E 01	0.7505E 01	0.	0.	0.	0.	0.	S	0.8867E-02
402	3	0	C	0.1157E 00	0.5346E 00	0.2232E 00	0.	0.1334E 00	0.	0.	0.	R	0.9965E 00
			T		0.1810E 01	0.1674E 01	0.	0.2267E 01	0.	0.	0.	S	0.7171E-02
402	4	0	C	0.8034E-01	0.3886E 00	0.4381E 00	0.	0.1060E 00	0.	0.	0.	R	0.9990E 00
			T		0.4348E 01	0.1483E 02	0.	0.2916E 01	0.	0.	0.	S	0.3612E-02
402	5	0	C	0.3923E 00	0.	0.1238E 00	0.	0.5306E 00	0.	0.	0.	R	0.9910E 00
			T		0.	0.1476E 01	0.	0.4097E 01	0.	0.	0.	S	0.1268E-01
402	6	0	C	-0.3004E 00	0.1258E 01	0.1004E 00	0.	0.	0.	0.	0.	R	0.9990E 00
			T		0.5908E 01	0.1149E 01	0.	0.	0.	0.	0.	S	0.5780E-02
402	7	0	C	0.1516E 00	0.3078E 00	0.5587E 00	0.	0.	0.	0.	0.	R	0.9956E 00
			T		0.1791E 01	0.5557E 01	0.	0.	0.	0.	0.	S	0.1710E-01
402	8	0	C	0.9997E-02	0.8218E 00	0.2214E 00	0.	0.	0.	0.	0.	R	0.9986E 00
			T		0.6972E 01	0.2266E 01	0.	0.	0.	0.	0.	S	0.8321E-02
402	9	0	C	-0.1666E 00	0.	0.	0.	0.1232E 01	0.	0.	0.	R	0.9889E 00
			T		0.	0.	0.	0.2105E 02	0.	0.	0.	S	0.2306E-01
402	10	0	C	0.2293E-01	0.8205E 00	0.	0.1760E 00	0.	0.	0.	0.	R	0.9767E 00
			T		0.1266E 02	0.	0.1425E 01	0.	0.	0.	0.	S	0.1760E-01
402	11	0	C	0.1037E 00	0.	0.5110E-01	0.8843E 00	0.	0.	0.	0.	R	0.9693E 00
			T		0.	0.9384E 00	0.4315E 01	0.	0.	0.	0.	S	0.1005E-01
402	12	0	C	-0.1168E 01	0.	0.	0.2263E 01	0.	0.	0.	0.	R	0.9755E 00
			T		0.	0.	0.1335E 02	0.	0.	0.	0.	S	0.2497E-01
402	13	0	C	-0.8413E-01	0.1204E 01	0.	0.	0.	0.	0.	0.	R	0.9977E 00
			T		0.4464E 02	0.	0.	0.	0.	0.	0.	S	0.1142E-01
402	14	0	C	0.4327E 00	0.1882E 00	0.	0.3991E 00	0.	0.	0.	0.	R	0.7485E 00
			T		0.1285E 01	0.	0.2576E 01	0.	0.	0.	0.	S	0.1064E-01
402	15	0	C	0.9742E 00	0.	0.2487E-01	0.	0.	0.	0.	0.	R	0.9819E 00
			T		0.	0.1641E 02	0.	0.	0.	0.	0.	S	0.1775E-02

3. $p_{cg} = \alpha + \beta\, p_{w-1} + \gamma\, \omega + \delta\, i_{v-1}$

403	1	0	C	0.1537E 00	0.	0.6867E 00	0.1654E 00	0.	0.	0.	0.	R	0.9996E 00
			T		0.	0.3562E 02	0.5072E 01	0.	0.	0.	0.	S	0.5719E-02
403	2	0	C	-0.6527E 00	0.6937E 00	0.8103E 00	0.1795E 00	0.	0.	0.	0.	R	0.9964E 00
			T		0.2656E 01	0.1020E 02	0.1756E 01	0.	0.	0.	0.	S	0.1265E-01
403	3	0	C	0.1072E-01	0.	0.9438E 00	0.4536E-01	0.	0.	0.	0.	R	0.9996E 00
			T		0.	0.4242E 02	0.1179E 01	0.	0.	0.	0.	S	0.4783E-02
403	4	0	C	-0.3537E-01	0.4815E 00	0.5653E 00	0.	0.	0.	0.	0.	R	0.9775E 00
			T		0.1198E 01	0.4228E 01	0.	0.	0.	0.	0.	S	0.2235E-01
403	5	0	C	0.9089E-01	0.	0.4204E 00	0.5404E 00	0.	0.	0.	0.	R	0.9980E 00
			T		0.	0.6428E 01	0.5351E 01	0.	0.	0.	0.	S	0.9883E-02
403	6	0	C	-0.2134E 00	0.6488E 00	0.6007E 00	0.	0.	0.	0.	0.	R	0.9994E 00
			T		0.2810E 01	0.6340E 01	0.	0.	0.	0.	0.	S	0.6269E-02
403	7	0	C	0.8689E-01	0.5974E-01	0.7752E 00	0.9996E-01	0.	0.	0.	0.	R	0.9998E 00
			T		0.7062E 00	0.1122E 02	0.3019E 01	0.	0.	0.	0.	S	0.4800E-02
403	8	0	C	-0.5780E-01	0.6526E 00	0.1630E 00	0.2865E 00	0.	0.	0.	0.	R	0.9948E 00
			T		0.3221E 01	0.8770E 00	0.1491E 01	0.	0.	0.	0.	S	0.1425E-01
403	9	0	C	-0.4044E-01	0.1024E 00	0.	0.9036E 00	0.	0.	0.	0.	R	0.9891E 00
			T		0.1576E 01	0.	0.7995E 01	0.	0.	0.	0.	S	0.2173E-01
403	10	0	C	0.1960E 00	0.8032E 00	0.	0.	0.	0.	0.	0.	R	0.9879E 00
			T		0.2018E 02	0.	0.	0.	0.	0.	0.	S	0.1177E-01
403	11	0	C	0.6299E 00	0.3847E 00	0.	0.	0.	0.	0.	0.	R	0.4178E 00
			T		0.1704E 01	0.	0.	0.	0.	0.	0.	S	0.2501E-01
403	12	0	C	-0.1037E 00	0.8910E 00	0.	0.2604E 00	0.	0.	0.	0.	R	0.9805E 00
			T		0.2445E 01	0.	0.7846E 00	0.	0.	0.	0.	S	0.2318E-01
403	13	0	C	-0.4909E 00	0.1601E 01	0.	0.	0.	0.	0.	0.	R	0.9909E 00
			T		0.2326E 02	0.	0.	0.	0.	0.	0.	S	0.3192E-01
403	14	0	C	0.2591E 00	0.7150E 00	0.	0.	0.	0.	0.	0.	R	0.4855E 00
			T		0.2021E 01	0.	0.	0.	0.	0.	0.	S	0.2840E-01
403	15	0	C	0.9288E 00	0.	0.6544E-01	0.	0.	0.	0.	0.	R	0.8807E 00
			T		0.	0.6246E 01	0.	0.	0.	0.	0.	S	0.1273E-01

4. $p_1 = \alpha + \beta\, p_w + \gamma \left[\left(\frac{\Delta s^*_p}{x^*}\right) / \left(\frac{\Delta s^*_{po}}{x^*_o}\right) \right]$

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
404	1	0	C	0.8600E-01	0.4151E 00	0.5084E 00	0.	0.	0.	0.	0.	R	0.9463E 00
			T		0.2047E 01	0.3612E 01	0.	0.	0.	0.	0.	S	0.2868E-01
404	2	0	C	-0.3208E 00	0.1335E 01	0.	0.	0.	0.	0.	0.	R	0.9301E 00
			T		0.8825E 01	0.	0.	0.	0.	0.	0.	S	0.4549E-01
404	3	0	C	0.2511E-01	0.9290E 00	0.	0.	0.	0.	0.	0.	R	0.9359E 00
			T		0.1033E 02	0.	0.	0.	0.	0.	0.	S	0.4687E-01
404	4	0	C	-0.3175E 00	0.8630E 00	0.4327E 00	0.	0.	0.	0.	0.	R	0.9665E 00
			T		0.8001E 01	0.2437E 01	0.	0.	0.	0.	0.	S	0.2976E-01
404	5	0	C	-0.6001E 00	0.1456E 01	0.1568E 00	0.	0.	0.	0.	0.	R	0.9918E 00
			T		0.2003E 02	0.8417E 00	0.	0.	0.	0.	0.	S	0.1679E-01
404	6	0	C	-0.1543E 00	0.1142E 01	0.	0.	0.	0.	0.	0.	R	0.9890E 00
			T		0.2224E 02	0.	0.	0.	0.	0.	0.	S	0.1666E-01
404	7	0	C	0.2070E 00	0.7714E 00	0.	0.	0.	0.	0.	0.	R	0.9636E 00
			T		0.1200E 02	0.	0.	0.	0.	0.	0.	S	0.3386E-01
404	8	0	C	0.7276E-11	0.1000E 01	0.	0.	0.	0.	0.	0.	R	0.1000E 01
			T		0.9056E 06	0.	0.	0.	0.	0.	0.	S	0.6032E-06
404	9	0	C	0.2406E 00	0.4723E 00	0.2902E 00	0.	0.	0.	0.	0.	R	0.9492E 00
			T		0.7641E 01	0.1301E 01	0.	0.	0.	0.	0.	S	0.4307E-01
404	10	0	C	0.2330E 00	0.7478E 00	0.	0.	0.	0.	0.	0.	R	0.8849E 00
			T		0.6381E 01	0.	0.	0.	0.	0.	0.	S	0.3602E-01
404	11	0	C	-0.3658E 00	0.1333E 01	0.	0.	0.	0.	0.	0.	R	0.7910E 00
			T		0.4209E 01	0.	0.	0.	0.	0.	0.	S	0.4280E-01
404	12	0	C	0.3188E-01	0.8891E 00	0.6633E-01	0.	0.	0.	0.	0.	R	0.9964E 00
			T		0.2091E 02	0.7869E 00	0.	0.	0.	0.	0.	S	0.8729E-02
404	13	0	C	0.1032E 00	0.9223E 00	0.	0.	0.	0.	0.	0.	R	0.9943E 00
			T		0.2958E 02	0.	0.	0.	0.	0.	0.	S	0.1638E-01
404	14	0	C	0.4668E 00	0.4468E 00	0.6764E-01	0.	0.	0.	0.	0.	R	0.9150E 00
			T		0.5765E 01	0.1208E 01	0.	0.	0.	0.	0.	S	0.6225E-02
404	15	0	C	0.7322E 00	0.2681E 00	0.	0.	0.	0.	0.	0.	R	0.8027E 00
			T		0.4574E 01	0.	0.	0.	0.	0.	0.	S	0.1084E-02

5. $P_h = \alpha + \beta P_1 + \gamma \omega$

405	1	0	C	-0.2551E 00	0.8988E 00	0.3726E 00	0.	0.	0.	0.	0.	R	0.9851E 00
			T		0.4232E 01	0.5156E 01	0.	0.	0.	0.	0.	S	0.3326E-01
405	2	0	C	0.1056E 00	0.8326E 00	0.	0.	0.	0.	0.	0.	R	0.2614E 00
			T		0.1344E 01	0.	0.	0.	0.	0.	0.	S	0.2075E 00
405	3	0	C	-0.1805E-01	0.6968E 00	0.3409E 00	0.	0.	0.	0.	0.	R	0.9938E 00
			T		0.2581E 01	0.2063E 01	0.	0.	0.	0.	0.	S	0.1458E-01
405	4	0	C	0.2253E 00	0.	0.7760E 00	0.	0.	0.	0.	0.	R	0.9788E 00
			T		0.	0.1724E 02	0.	0.	0.	0.	0.	S	0.2424E-01
405	5	0	C	0.1589E 00	0.	0.8509E 00	0.	0.	0.	0.	0.	R	0.9453E 00
			T		0.	0.9667E 01	0.	0.	0.	0.	0.	S	0.6168E-01
405	6	0	C	0.4212E 00	0.	0.5961E 00	0.	0.	0.	0.	0.	R	0.9812E 00
			T		0.	0.1691E 02	0.	0.	0.	0.	0.	S	0.2509E-01
405	7	0	C	-0.3706E 00	0.5053E 00	0.8322E 00	0.	0.	0.	0.	0.	R	0.9915E 00
			T		0.9381E 00	0.3094E 01	0.	0.	0.	0.	0.	S	0.3598E-01
405	8	0	C	0.1818E 00	0.	0.8155E 00	0.	0.	0.	0.	0.	R	0.9866E 00
			T		0.	0.2006E 02	0.	0.	0.	0.	0.	S	0.2450E-01
405	9	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
405	10	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
405	11	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
405	12	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
405	13	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
405	14	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.
405	15	0	C	0.	0.	0.	0.	0.	0.	0.	0.	R	0.
			T		0.	0.	0.	0.	0.	0.	0.	S	0.

6. $p_e = \bar{z}_a \{\alpha + \beta\, p_{w-1} + \gamma\, \hat{\bar{I}}_{qw-1} + \delta\, p_{m-1} + \varepsilon\, (\frac{x}{x^*_{-1}}) \} + \bar{z}_b \{ \alpha + \beta\, p_{w-1} + \gamma\, \hat{\bar{I}}_{qw-1} + \delta\, p_{m-1} + \varepsilon\, \hat{\bar{p}}_{ec} \} + \bar{z}_c \{ \alpha + \beta\, \hat{\bar{p}}_{ec} + \gamma\, \hat{\bar{p}}_{eE} + \delta\, p_{m-1} \} + \bar{z}_o \{ \hat{\bar{p}}_{eE} \}$ ($\bar{z}$ relates to exporting region (1).)

EQ.NO.	I	J		P1	P2	P3	P4	P5	P6	P7	P8		
406	1	0	C	0.4072E-01	0.7441E 00	0.	0.	0.2387E 00	0.	0.	0.	R	0.9640E 00
			T		0.1962E 01	0.	0.	0.2015E 01	0.	0.	0.	S	0.1925E-01
406	2	0	C	-0.3781E 00	0.	0.3049E 00	0.	0.1157E 01	0.	0.	0.	R	0.9590E 00
			T		0.	0.4482E 01	0.	0.1017E 02	0.	0.	0.	S	0.3298E-01
406	3	0	C	-0.1028E 00	0.1141E 01	0.	0.	0.	0.	0.	0.	R	0.9788E 00
			T		0.1791E 02	0.	0.	0.	0.	0.	0.	S	0.2112E-01
406	4	0	C	-0.6665E 00	0.	0.	0.1731E 01	0.	0.	0.	0.	R	0.9891E 00
			T		0.	0.	0.2512E 02	0.	0.	0.	0.	S	0.2282E-01
406	5	0	C	0.1724E 00	0.1405E 00	0.	0.4755E 00	0.2300E 00	0.	0.	0.	R	0.9932E 00
			T		0.1066E 01	0.	0.2603E 01	0.2156E 01	0.	0.	0.	S	0.8360E-02
406	6	0	C	-0.2479E-01	0.6904E 00	0.	0.3754E 00	0.	0.	0.	0.	R	0.9957E 00
			T		0.4936E 01	0.	0.2181E 01	0.	0.	0.	0.	S	0.9017E-02
406	7	0	C	0.2491E 00	0.	0.	0.	0.6967E 00	0.	0.	0.	R	0.9445E 00
			T		0.	0.	0.	0.1001E 02	0.	0.	0.	S	0.2731E-01
406	8	0	C	0.3101E 00	0.	0.	0.	0.5984E 00	0.	0.	0.	R	0.8833E 00
			T		0.	0.	0.	0.6327E 01	0.	0.	0.	S	0.3614E-01
406	9	0	C	-0.5677E 00	0.	0.	0.8648E 00	0.6473E 00	0.	0.	0.	R	0.9198E 00
			T		0.	0.	0.4774E 01	0.3394E 01	0.	0.	0.	S	0.6471E-01
406	10	0	C	0.3195E 00	0.	0.	0.	0.5980E 00	0.	0.	0.	R	0.8833E 00
			T		0.	0.	0.	0.6328E 01	0.	0.	0.	S	0.3611E-01
406	11	0	C	0.3133E 00	0.	0.	0.	0.6551E 00	0.	0.	0.	R	0.9009E 00
			T		0.	0.	0.	0.6640E 01	0.	0.	0.	S	0.2230E-01
406	12	0	C	0.3116E 00	0.	0.	0.	0.6578E 00	0.	0.	0.	R	0.8165E 00
			T		0.	0.	0.	0.4583E 01	0.	0.	0.	S	0.3245E-01
406	13	0	C	0.2150E-01	0.	0.	0.1029E 01	0.	0.	0.	0.	R	0.9813E 00
			T		0.	0.	0.1614E 02	0.	0.	0.	0.	S	0.3058E-01
406	14	0	C	0.1567E 00	0.3157E 00	0.	0.5268E 00	0.	0.	0.	0.	R	0.9014E 00
			T		0.1206E 01	0.	0.1046E 01	0.	0.	0.	0.	S	0.1950E-01
406	15	0	C	0.4994E 00	0.	0.1517E 00	0.3511E 00	0.	0.	0.	0.	R	0.9606E 00
			T		0.	0.2130E 01	0.1895E 01	0.	0.	0.	0.	S	0.1373E-01

I - 6. Forecast scenarios

Scenario A - Indexation of oil price;
To make indexation of oil prices with respect to general price deflaters of the industrially developed regions.

Scenario B - Decreasing the North-South gap;
To decrease growth rates of the advanced market economies* in achieving 0.7% ODA target and to increase exports** from the developing market economies (except oil-exporting Middle East).

Scenario C - Indexation of primary commodities' prices;
To make indexation of commodities' prices with respect to general price deflaters of the industrially developed regions (in addition to indexation of oil prices).

* Decreased growth rates of the advanced market economies from 5% trend to 3% by reducing non-housing investments.

** Modified export coefficients from the developing market economies (15% upward).

I - 7. Results obtained

Forecast of the World Economy 1977 - 1985

Scenario A - Indexation of oil prices

	Annual growth rates * %	
	real	nominal
Developed market economy	5.0	15.3
Developing market economy	6.1	16.2
OPEC (Middle East)	12.0	18.1
Centrally planned economy	5.8	7.4

In this case, the oil price will be increased at an annual rate of 10.3%.

Scenario B - Decreasing the North-South gap

	Annual growth rates * %	
	real	nominal
Developed market economy	3.2	14.2
Developing market economy	6.4	16.6
OPEC (Middle East)	12.0	18.0
Centrally planned economy	5.8	7.5

In this case, the oil price will be increased at an annual rate of 11.0%.

Scenario C - Indexation of primary commodities' prices

	Annual growth rates * %	
	real	nominal
Developed market economy	5.0	15.5
Developing market economy	6.1	16.9
OPEC (Middle East)	12.0	18.5
Centrally planned economy	5.8	7.7

In this case, the oil price will be increased at an annual rate of 10.5%.

* Annual growth rates are based on the period 1975 - 1985.

Scenario A - Indexation of oil price

GPP AT 1970 PRICE — MILLIONS OF U.S. DOLLARS (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85
1	AME	2477600.	2608247.	2726522.	2861102.	3000255.	3155864.	3312479.	3482599.	3663913.	3847040.	4036668.
2	DME	431626.	458334.	485023.	513937.	544926.	578390.	615696.	652645.	691943.	733662.	777613.
3	OPEC	49281.	55885.	63484.	72050.	81595.	91744.	100383.	112049.	124763.	138548.	153430.
4	CPE	981135.	1037756.	1095129.	1159024.	1220233.	1288544.	1362706.	1444242.	1532597.	1624474.	1721382.

GPP GROWTH-RATE AT CONSTANT PRICE — ANNUAL PERCENTAGE CHANGES (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85	75-80	80-85	75-85
1	AME	-1.09	5.27	4.53	4.94	4.86	5.19	4.96	5.14	5.21	5.00	4.93	4.96	5.05	5.00
2	DME	4.95	6.19	5.82	5.96	6.03	6.14	6.45	6.00	6.02	6.03	5.99	6.03	6.10	6.06
3	OPEC	14.80	13.40	13.60	13.49	13.23	12.45	9.42	11.62	11.35	11.05	10.74	13.23	10.83	12.03
4	CPE	4.64	5.77	5.53	5.83	5.28	5.60	5.76	5.98	6.12	5.99	5.97	5.60	5.96	5.78

GRP AT 1970 PRICE — MILLIONS OF U.S. DOLLARS (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85
1	JAPAN	247335.	262910.	280512.	297961.	316617.	336094.	355864.	376900.	400269.	424468.	449709.
2	AUSTRALIA AND N.	50478.	51550.	53358.	55361.	57388.	59879.	62385.	65072.	68161.	71709.	75399.
3	CANADA	104178.	109143.	114776.	120037.	125578.	131956.	138088.	145196.	152662.	160198.	168083.
4	U.S.A.	1080343.	1145163.	1204587.	1270462.	1330633.	1397571.	1464534.	1538494.	1616132.	1689146.	1763328.
5	EC	712370.	740813.	763543.	794456.	831283.	874406.	918019.	964966.	1015184.	1069102.	1125817.
6	OTHER ADVANCED C	282896.	298668.	309753.	322827.	338757.	355959.	373590.	391971.	411506.	432417.	454333.

GRP GROWTH-RATE AT CONSTANT PRICE — ANNUAL PERCENTAGE CHANGES (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85	75-80	80-85	75-85
1	JAPAN	2.07	6.30	6.70	6.22	6.26	6.15	5.88	5.91	6.20	6.05	5.95	6.32	6.00	6.16
2	AUSTRALIA AND N.	0.27	2.12	3.51	3.75	3.66	4.34	4.19	4.31	4.75	5.21	5.15	3.47	4.72	4.09
3	CANADA	0.65	4.77	5.16	4.58	4.62	5.08	4.65	5.15	5.14	4.94	4.92	4.84	4.96	4.90
4	U.S.A.	-1.50	6.09	5.19	5.47	4.74	5.03	4.79	5.05	5.05	4.52	4.39	5.28	4.76	5.02
5	EC	-1.75	3.90	3.07	4.05	4.64	5.10	4.90	5.11	5.20	5.31	5.30	4.18	5.18	4.68
6	OTHER ADVANCED C	-1.30	5.58	3.71	4.22	4.93	5.08	4.95	4.92	4.98	5.08	5.07	4.70	5.00	4.85

GRP AT 1970 PRICE — MILLIONS OF U.S. DOLLARS (1970 DOLLAR)

	75	76	77	78	79	80	81	82	83	84	85
1 EAST ASIA	26602.	29741.	31340.	34227.	37031.	40026.	43019.	46467.	50112.	53936.	57995.
2 ASEAN	39121.	41362.	44109.	46905.	49718.	52819.	56217.	59607.	63301.	67159.	71003.
3 WEST ASIA	85829.	90912.	94206.	98218.	103126.	108740.	114359.	119819.	125826.	132337.	139228.
4 OTHER ASIA	3600.	3791.	4005.	4234.	4478.	4738.	4997.	5262.	5584.	5903.	6239.
5 MIDDLE EAST	49281.	55885.	63484.	72050.	81585.	91744.	100383.	112049.	124763.	138548.	153430.
6 AFRICA	34360.	36086.	37981.	40032.	42266.	44732.	47358.	50170.	53215.	56461.	59916.
7 C. AND LATIN AM.	242114.	257442.	273382.	290320.	308306.	327335.	349747.	371221.	393905.	417867.	443141.

GRP GROWTH-RATE AT CONSTANT PRICE — ANNUAL PERCENTAGE CHANGES (1970 DOLLAR)

	75	76	77	78	79	80	81	82	83	84	85	75-80	80-85	75-85
1 EAST ASIA	7.00	8.04	9.04	9.21	8.19	8.09	7.48	8.01	7.84	7.63	7.53	8.51	7.70	8.11
2 ASEAN	3.20	5.73	6.64	6.34	6.00	6.24	6.43	6.17	6.06	6.09	5.86	6.19	6.12	6.16
3 WEST ASIA	2.00	5.92	3.62	4.26	5.00	5.44	5.17	4.77	5.01	5.17	5.21	4.85	5.07	4.96
4 OTHER ASIA	4.90	5.31	5.64	5.72	5.76	5.80	5.46	5.71	5.71	5.72	5.70	5.65	5.66	5.65
5 MIDDLE EAST	14.80	13.40	13.60	13.49	13.23	12.45	9.42	11.62	11.35	11.05	10.74	13.23	10.83	12.03
6 AFRICA	4.30	5.02	5.25	5.40	5.58	5.83	5.87	5.94	6.07	6.10	6.12	5.42	6.02	5.72
7 C. AND LATIN AM.	6.20	6.33	6.19	6.20	6.19	6.17	6.85	6.14	6.11	6.08	6.05	6.22	6.25	6.23

GPP AT 1970 PRICE — MILLIONS OF U.S. DOLLARS (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85
1	USSR AND EAST E.	765841.	807180.	849013.	895067.	931422.	986377.	1041799.	1100561.	1164350.	1229924.	1298502.
2	CHINA AND OTHER	215294.	230576.	246116.	263958.	281812.	302167.	320907.	343681.	368247.	394480.	422790.

GPP GROWTH-RATE AT CONSTANT PRICE — ANNUAL PERCENTAGE CHANGES (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85	75-80	80-85	75-85
1	USSR AND EAST E.	4.00	5.40	5.18	5.42	4.84	5.11	5.62	5.64	5.80	5.64	5.58	5.19	5.65	5.42
2	CHINA AND OTHER	7.00	7.10	6.74	7.25	6.76	7.22	6.20	7.10	7.15	7.12	7.18	7.01	6.95	6.98

GRP AT CURRENT MARKET PRICE MILLIONS OF U.S. DOLLARS (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85
1	AME	3543040.	4205933.	4852618.	5644946.	6540904.	7558055.	8678922.	9956807.	11394708.	12991417.	14755691.
2	DME	973866.	1255085.	1539504.	1837277.	2059523.	2486066.	2811006.	3156112.	3542432.	3943135.	4383176.
3	OPEC	120415.	143397.	173728.	204199.	248343.	295358.	343870.	403720.	471723.	549092.	636980.
4	CPE	999217.	1069202.	1145992.	1232504.	1319306.	1414696.	1523058.	1635270.	1761280.	1894831.	2038129.

GRP GROWTH-RATE AT CURRENT PRICE ANNUAL PERCENTAGE CHANGES (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85	75-80	80-85	75-85
1	AME	8.83	18.71	15.39	16.33	15.87	15.55	14.83	14.72	14.44	14.01	13.58	16.36	14.32	15.33
2	DME	29.42	28.88	22.66	19.34	13.89	18.81	13.07	12.28	12.24	11.31	11.16	20.62	12.01	16.23
3	OPEC	15.23	19.09	21.15	17.54	21.62	18.93	16.42	17.40	16.84	16.40	16.01	19.66	16.62	18.13
4	CPE	4.11	7.00	7.18	7.55	7.05	7.22	7.66	7.37	7.71	7.58	7.56	7.20	7.58	7.39

GDP AT CURRENT MARKET PRICE   MILLIONS OF U.S. DOLLARS (1970 DOLLAR)

	75	76	77	78	79	80	81	82	83	84	85
1 JAPAN	356648.	409226.	471048.	525715.	572855.	626458.	683950.	749338.	825039.	907636.	999768.
2 AUSTRALIA AND N.	84535.	103288.	118463.	130697.	154903.	192037.	219975.	249430.	280867.	315075.	351319.
3 CANADA	157532.	178592.	202515.	224406.	256055.	301674.	341685.	386787.	434121.	480835.	529872.
4 U.S.A.	1520199.	1872465.	2289619.	2707910.	3227267.	3832997.	4539915.	5356903.	6282128.	7333584.	8494373.
5 EC	974053.	1121361.	1245041.	1385502.	1542303.	1714992.	1890536.	2088301.	2304978.	2545620.	2809889.
6 OTHER ADVANCED C	450073.	521000.	575930.	661715.	777432.	889908.	1002860.	1125957.	1260575.	1408667.	1570470.

GDP GROWTH-RATE AT CURRENT PRICE   ANNUAL PERCENTAGE CHANGES (1970 DOLLAR)

	75	76	77	78	79	80	81	82	83	84	85	75-80	80-85	75-85
1 JAPAN	14.06	14.74	15.11	11.61	8.97	9.36	9.18	9.56	10.10	10.01	10.15	11.93	9.80	10.86
2 AUSTRALIA AND N.	18.30	22.18	14.69	17.92	18.04	15.45	14.55	13.39	12.60	12.18	11.50	17.83	12.84	15.31
3 CANADA	9.39	13.37	13.40	10.81	14.10	17.82	13.26	13.20	12.24	10.76	10.20	13.88	11.92	12.90
4 U.S.A.	8.52	23.17	19.61	20.91	19.18	18.77	18.44	18.00	17.40	16.61	15.83	20.32	17.25	18.77
5 EC	5.62	15.12	11.03	11.28	11.32	11.19	10.24	10.47	10.37	10.44	10.38	11.98	10.38	11.18
6 OTHER ADVANCED C	11.33	15.76	10.54	14.90	17.49	14.47	12.69	12.27	11.96	11.75	11.49	14.61	12.03	13.31

GDP AT CURRENT MARKET PRICE MILLIONS OF U.S. DOLLARS (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85
1	EAST ASIA	52073.	59884.	78130.	108558.	132611.	159551.	184316.	213205.	244471.	278677.	316843.
2	ASEAN	70166.	80690.	94731.	111591.	131891.	157149.	176793.	198486.	226857.	258217.	293057.
3	WEST ASIA	157333.	184473.	203900.	234514.	266003.	298499.	330693.	363692.	401232.	442952.	488390.
4	OTHER ASIA	6538.	7453.	8459.	9419.	10365.	11890.	12988.	14263.	15647.	17050.	18572.
5	MIDDLE EAST	120415.	143397.	173728.	204199.	248343.	295358.	343870.	403720.	471723.	549092.	636980.
6	AFRICA	52061.	64129.	71677.	86630.	102103.	118597.	136740.	156597.	177847.	201252.	227048.
7	C. AND LATIN AM.	635694.	859456.	1082606.	1286564.	1449550.	1740379.	1969477.	2209880.	2476378.	2744986.	3039269.

GDP GROWTH-RATE AT CURRENT PRICE ANNUAL PERCENTAGE CHANGES (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85	75-80	80-85	75-85
1	EAST ASIA	17.60	15.00	30.47	38.95	22.16	20.32	15.52	15.67	14.66	13.99	13.70	25.10	14.71	19.79
2	ASEAN	15.00	15.00	17.40	17.80	18.19	19.15	12.50	12.27	14.29	13.82	13.49	17.50	13.27	15.37
3	WEST ASIA	16.00	17.25	10.53	15.01	13.43	12.22	10.79	9.98	10.33	10.40	10.26	13.66	10.35	11.99
4	OTHER ASIA	14.00	13.99	13.49	11.35	10.05	14.72	9.23	9.82	9.71	8.97	8.92	12.71	9.33	11.00
5	MIDDLE EAST	15.23	19.09	21.15	17.54	21.62	18.93	16.42	17.40	16.84	16.40	16.01	19.66	16.62	18.13
6	AFRICA	16.00	23.18	11.77	20.86	17.86	16.15	15.30	14.52	13.57	13.16	12.82	17.90	13.87	15.87
7	C. AND LATIN AM.	37.91	35.04	26.11	18.84	12.67	20.06	13.16	12.21	12.06	10.85	10.72	22.31	11.80	16.94

GDP AT CURRENT MARKET PRICE — BILLIONS OF U.S. DOLLARS (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85
1	USSR AND EAST E.	772984.	836948.	899096.	968126.	1037535.	1112812.	1202506.	1291361.	1391887.	1497641.	1610371.
2	CHINA AND OTHER	219233.	232254.	246896.	264376.	281840.	301684.	320552.	343909.	369393.	397190.	427757.

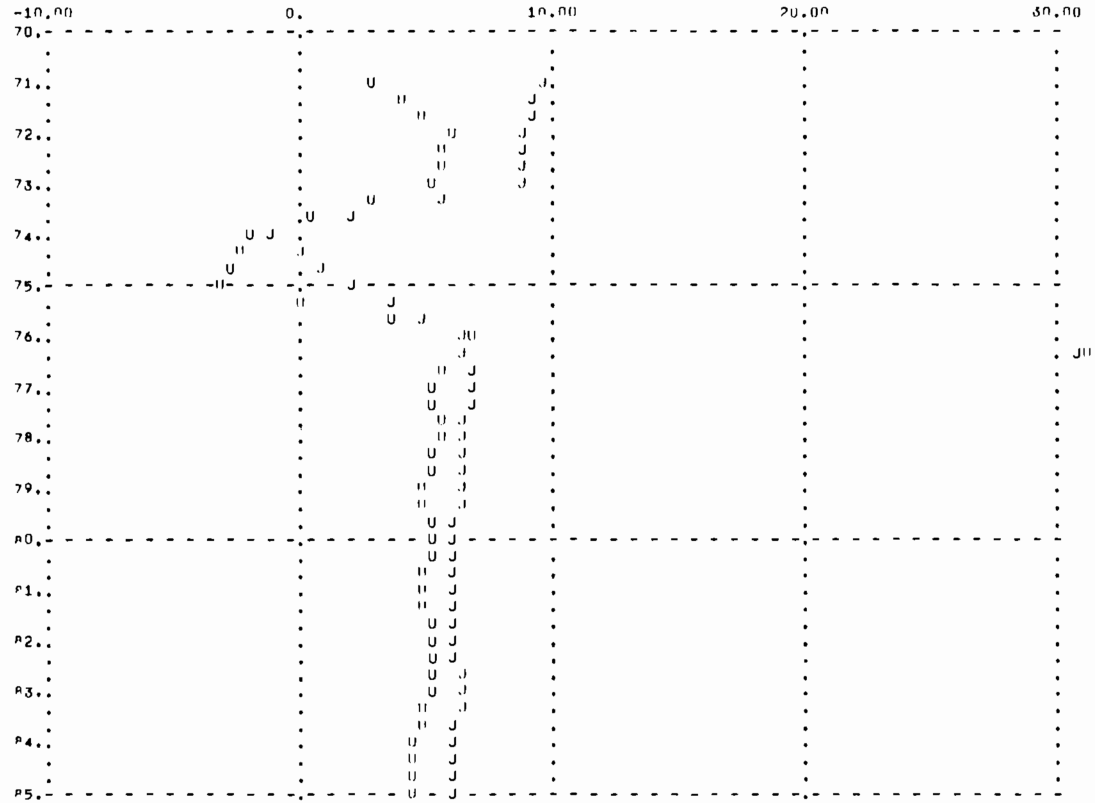
GDP GROWTH-RATE AT CURRENT PRICE — ANNUAL PERCENTAGE CHANGES (1970 DOLLAR)

		75	76	77	78	79	80	81	82	83	84	85	75-80	80-85	75-85
1	USSR AND EAST E.	3.34	7.30	7.43	7.68	7.17	7.26	8.06	7.39	7.78	7.60	7.53	7.37	7.67	7.52
2	CHINA AND OTHER	6.97	5.94	6.30	7.08	6.61	7.10	6.18	7.29	7.41	7.52	7.70	6.61	7.22	6.91

Scenario A - Indexation of oil price

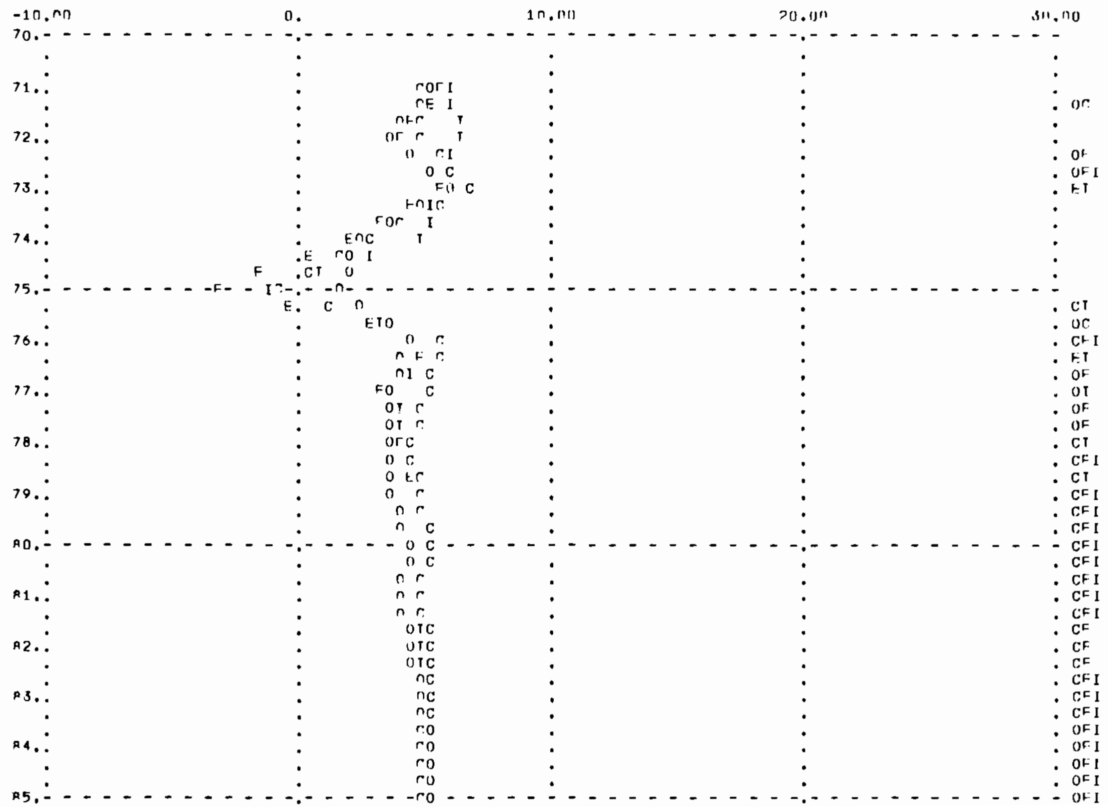
A-1 GDP GROWTH-RATE AT CONSTANT PRICE ANNUAL PERCENTAGE CHANGES (1970 DOLLARS)

JAPAN=J, UNITED STATES=U,



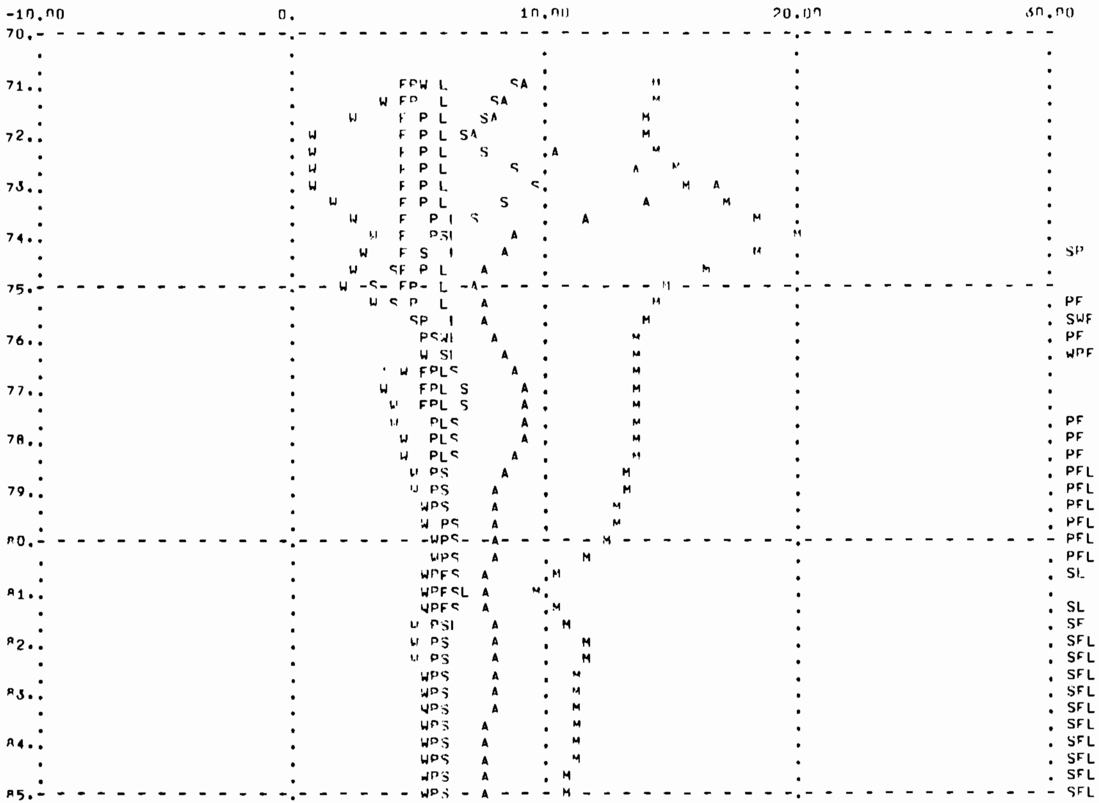
A-2 GDP GROWTH-RATE AT CONSTANT PRICE ANNUAL PERCENTAGE CHANGES (1970 DOLLAR)

AUSTRALIA AND NEW ZEALAND=O, CANADA=C, ECE=E, OTHER ADVANCED COUNTRIES=I,



GDP GROWTH-RATE AT CONSTANT PRICE ANNUAL PERCENTAGE CHANGES (1970 DOLLARS)

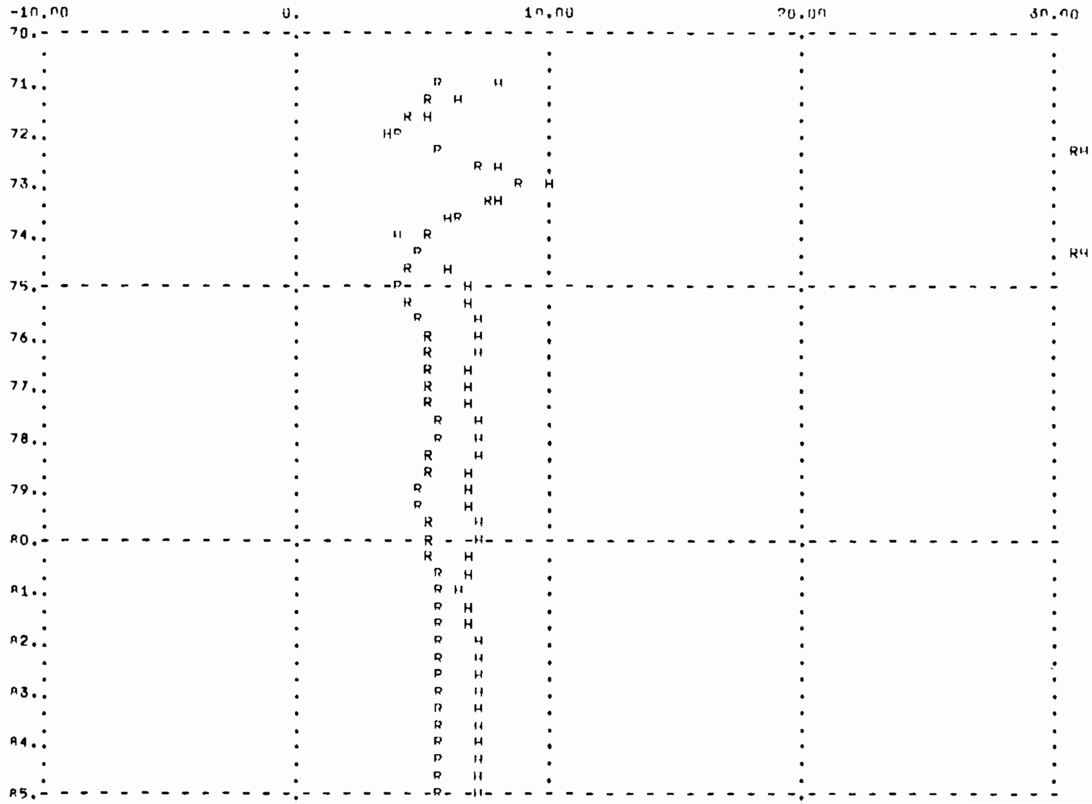
EAST ASIA=A, ASEAN=S, WEST ASIA=W, OTHER ASIA=P, MIDDLE EAST=M, AFRICA=F, CARIBBEAN AND LATIN AMERICA=L.



A-4 27

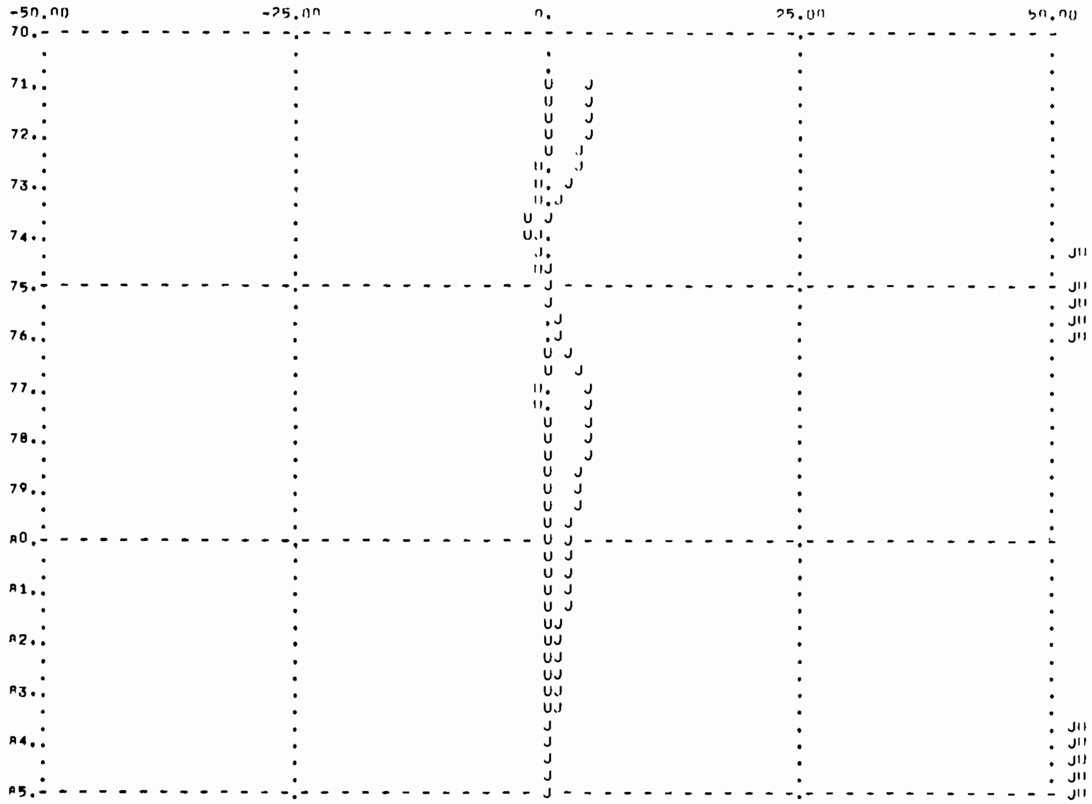
GRP GROWTH-RATE AT CONSTANT PRICE ANNUAL PERCENTAGE CHANGES (1970 DOLLARS)

USSR AND EAST EUROPE (INCLUDING CUBA)=R, CHINA AND OTHER ASIAN SOCIALIST COUNTRIES=H,



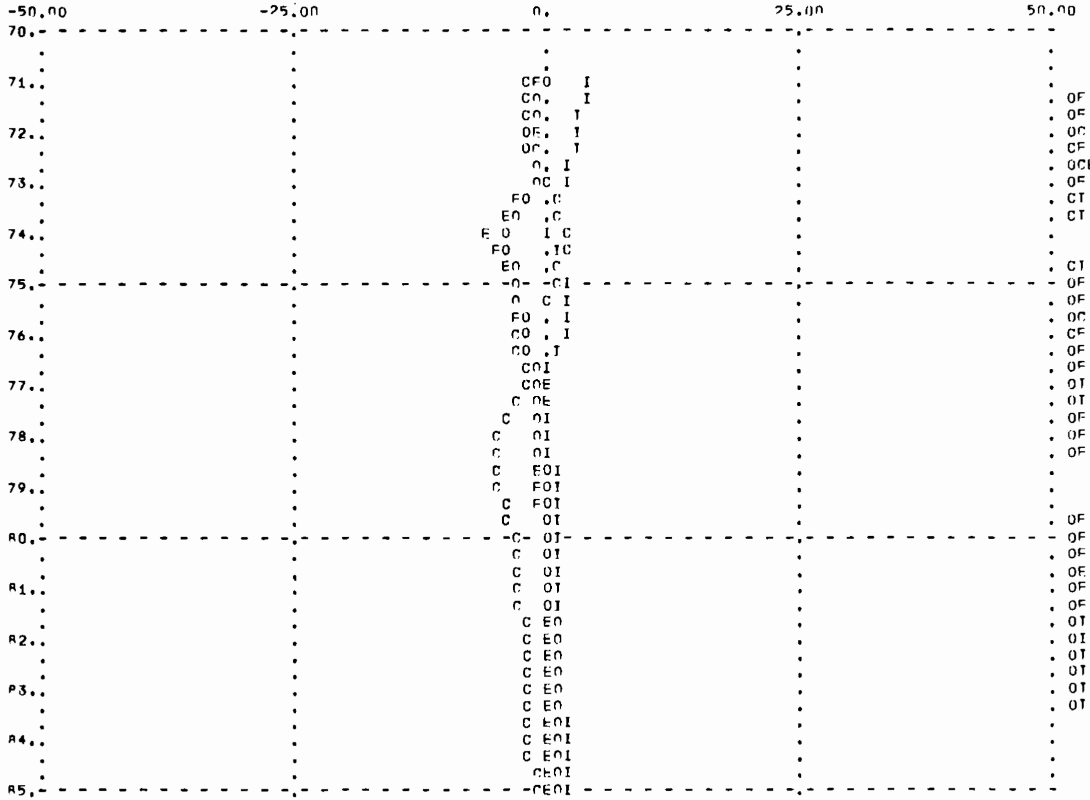
BALANCE OF PAYMENT / X

JAPAN=J, UNITED STATES=U,



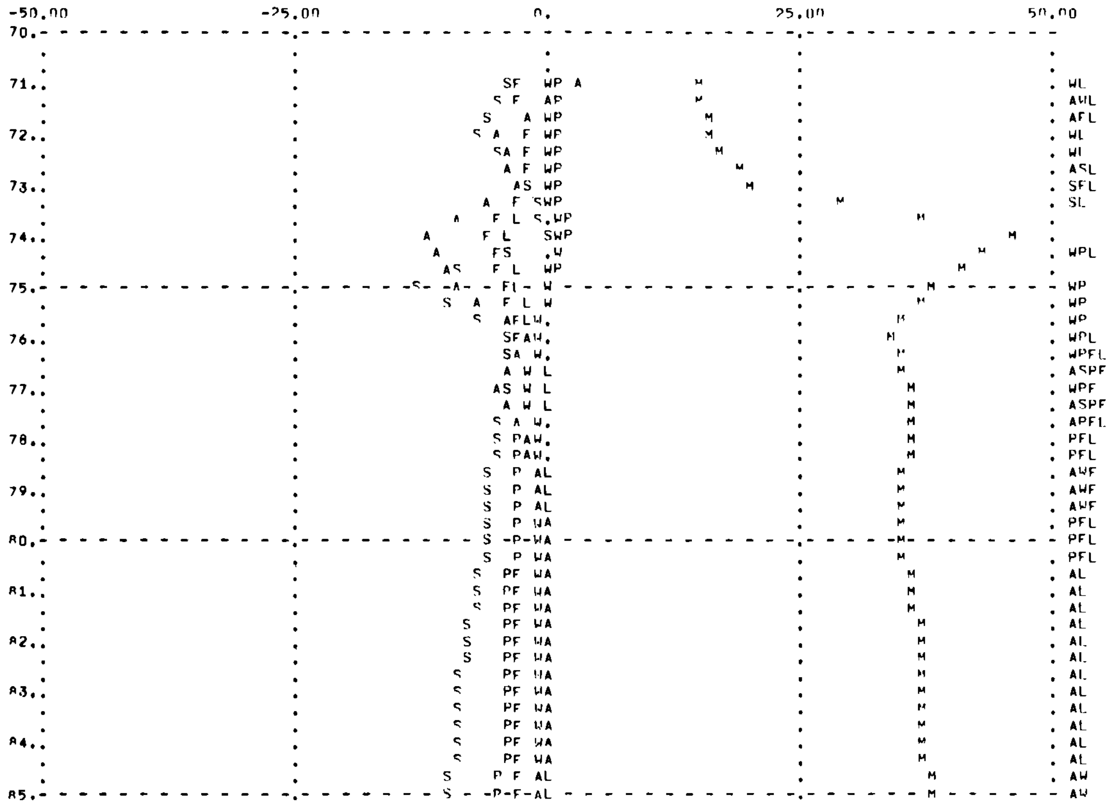
BALANCE OF PAYMENT / X

AUSTRALIA AND NEW ZEALAND=O, CANADA=C, EC=E, OTHER ADVANCED COUNTRIES=I,



BALANCE OF PAYMENT / X

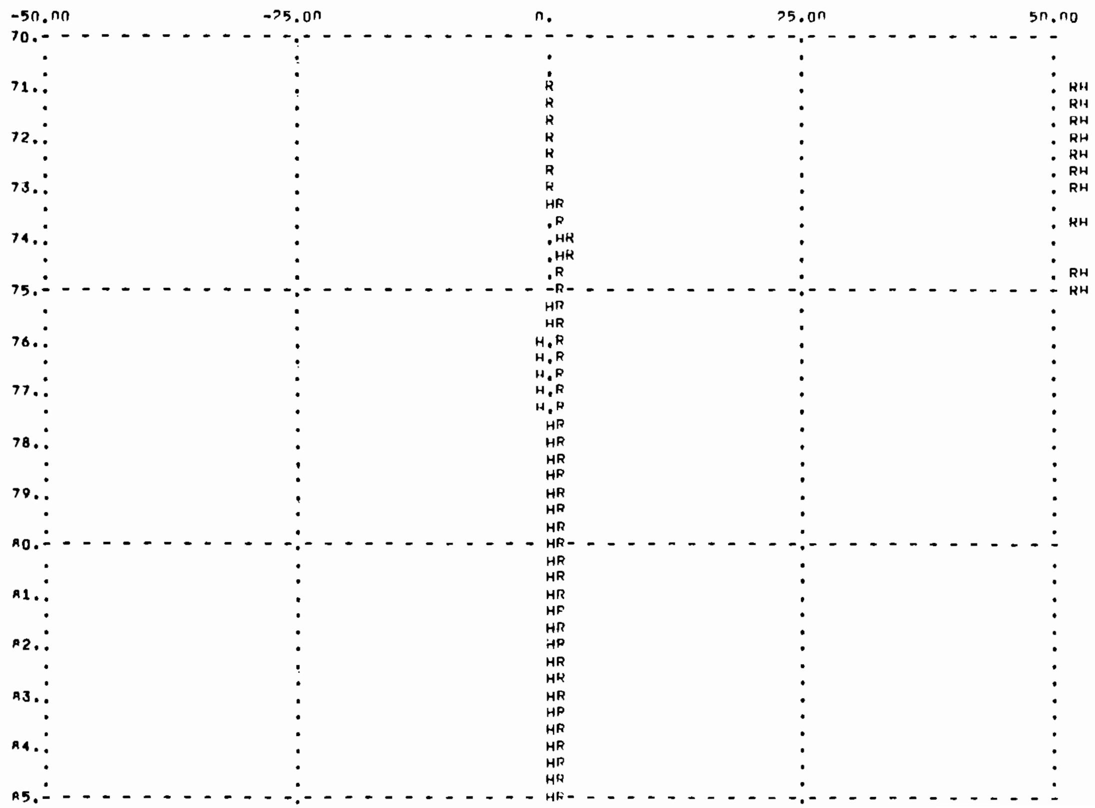
EAST ASIA=A, ASEAN=S, WEST ASIA=W, OTHER ASIA=P, MIDDLE EAST=M, AFRICA=F, CARIBBEAN AND LATIN AMERICA=L.



A-8

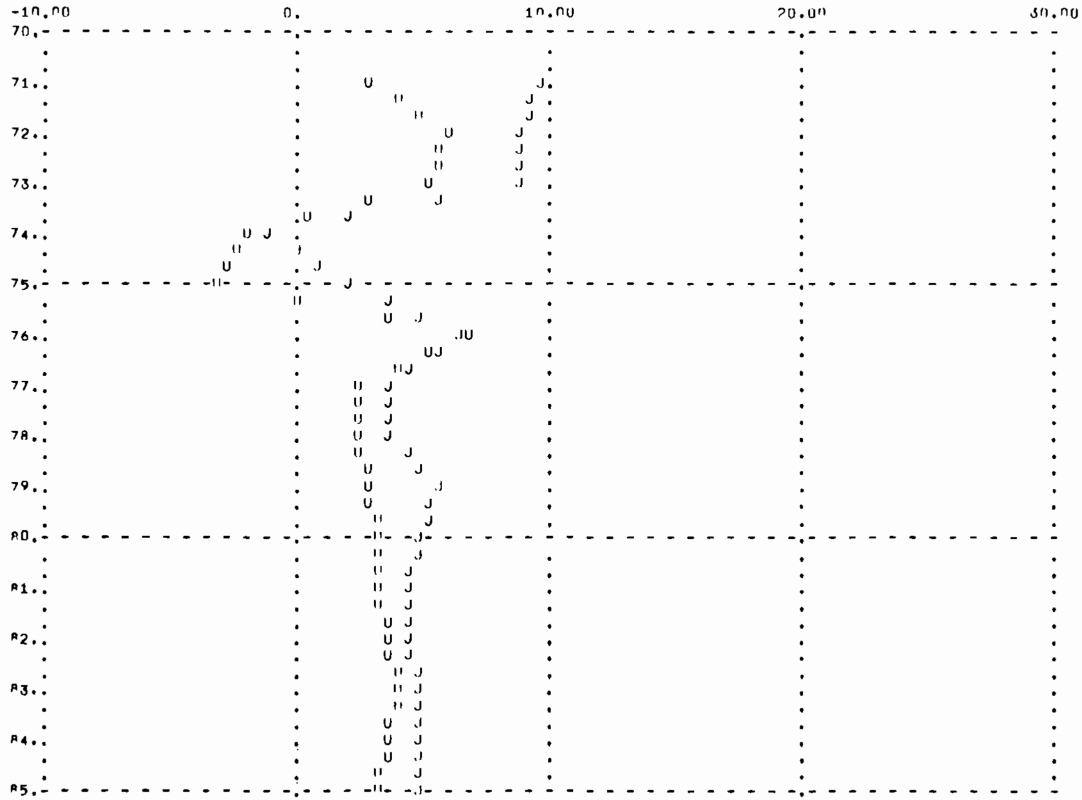
BALANCE OF PAYMENT / X

USSR AND EAST EUROPE (INCLUDING CUBA)ER, CHINA AND OTHER ASIAN SOCIALIST COUNTRIES=H,



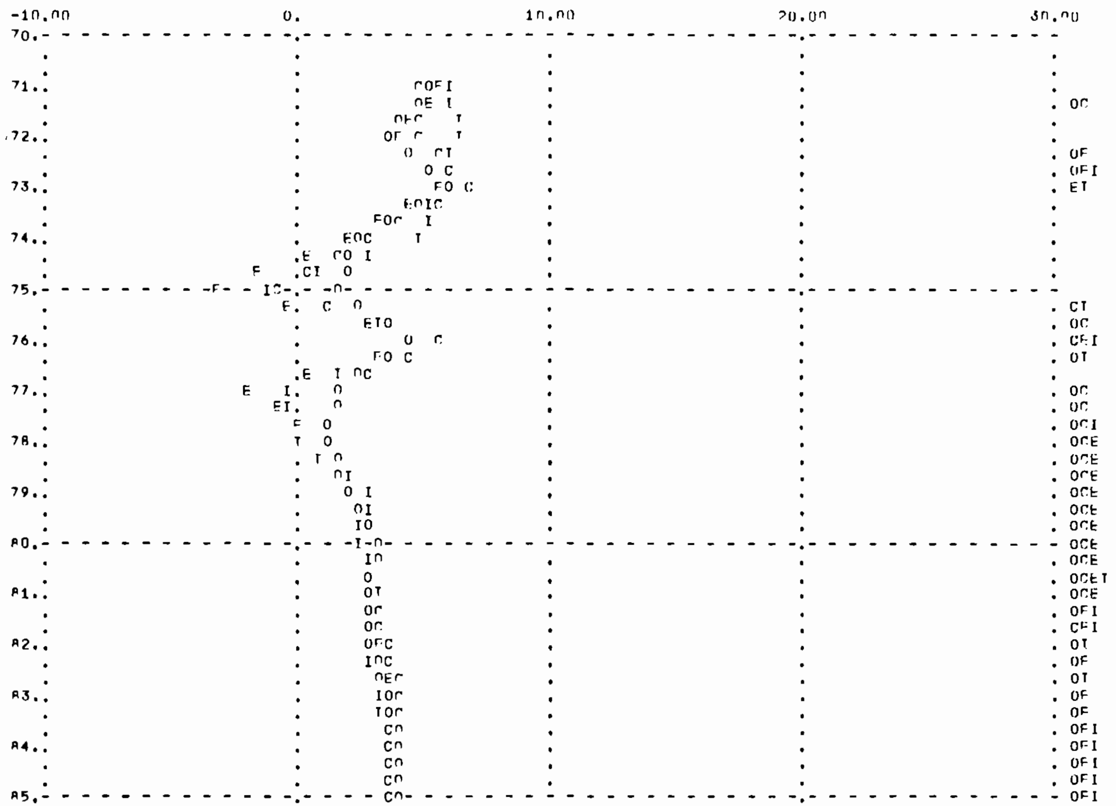
B-1 GDP GROWTH-RATE AT CONSTANT PRICE ANNUAL PERCENTAGE CHANGES (1970 DOLLAR)

JAPAN=J, UNITED STATES=U,



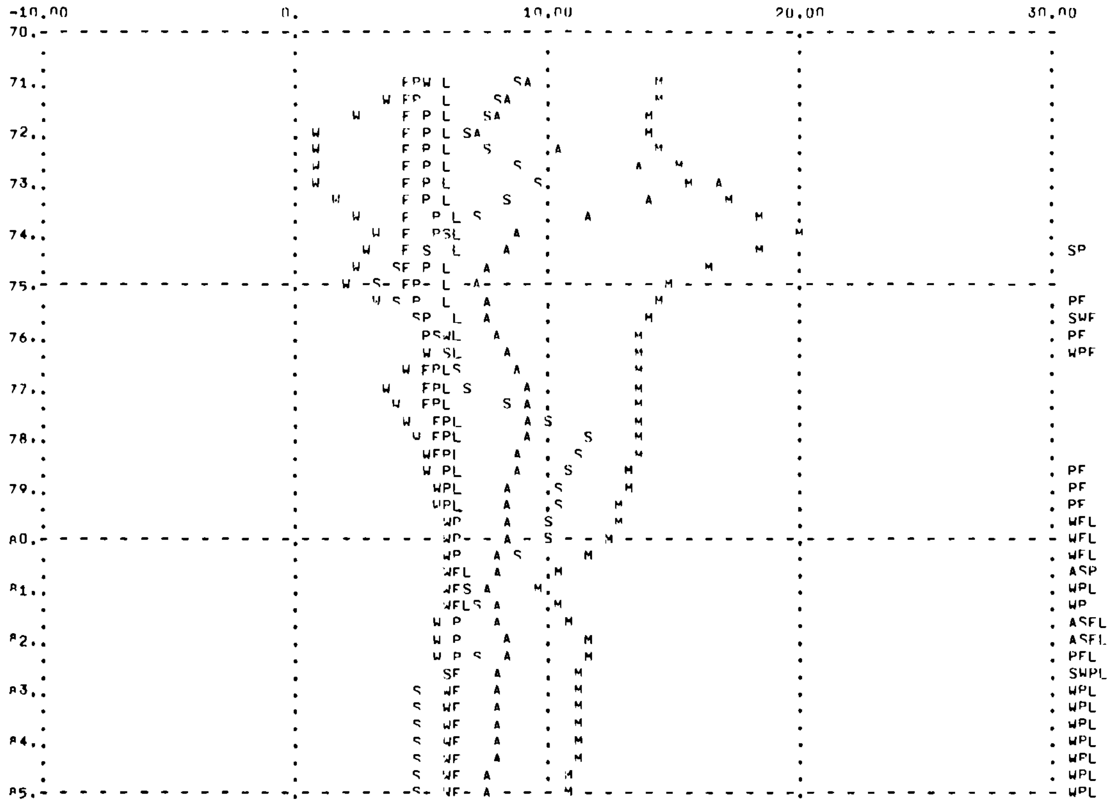
GRP GROWTH-RATE AT CONSTANT PRICE   ANNUAL PERCENTAGE CHANGES   (1970 DOLLAR)

AUSTRALIA AND NEW ZEALAND=O, CANADA=C, EC=E, OTHER ADVANCED COUNTRIES=I,



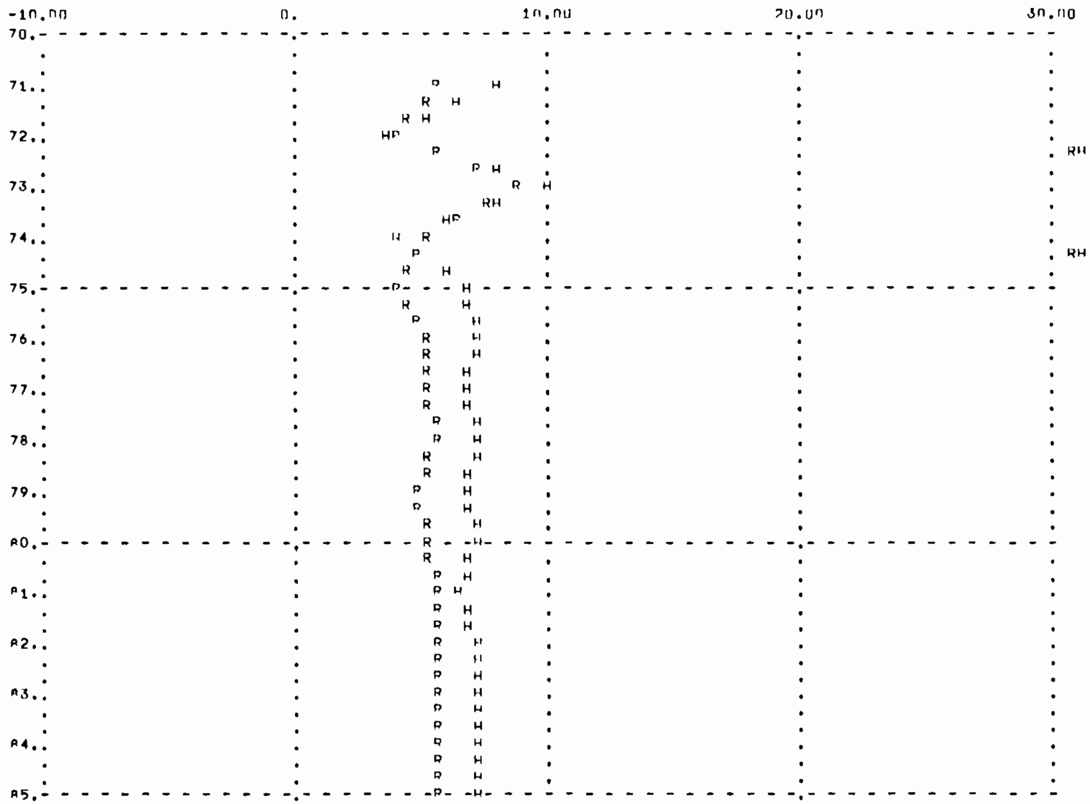
GDP GROWTH-RATE AT CONSTANT PRICE   ANNUAL PERCENTAGE CHANGES   (1970 DOLLAR)

EAST ASIA=A, ASEAN=S, WEST ASIA=W, OTHER ASIA=P, MIDDLE EAST=M, AFRICA=F, CARIBBEAN AND LATIN AMERICA=L.



GDP GROWTH-RATE AT CONSTANT PRICE ANNUAL PERCENTAGE CHANGES (1970 DOLLAR)

USSR AND EAST EUROPE (INCLUDING CUBA)=R, CHINA AND OTHER ASIAN SOCIALIST COUNTRIES=H,



B-5

BALANCE OF PAYMENT / X

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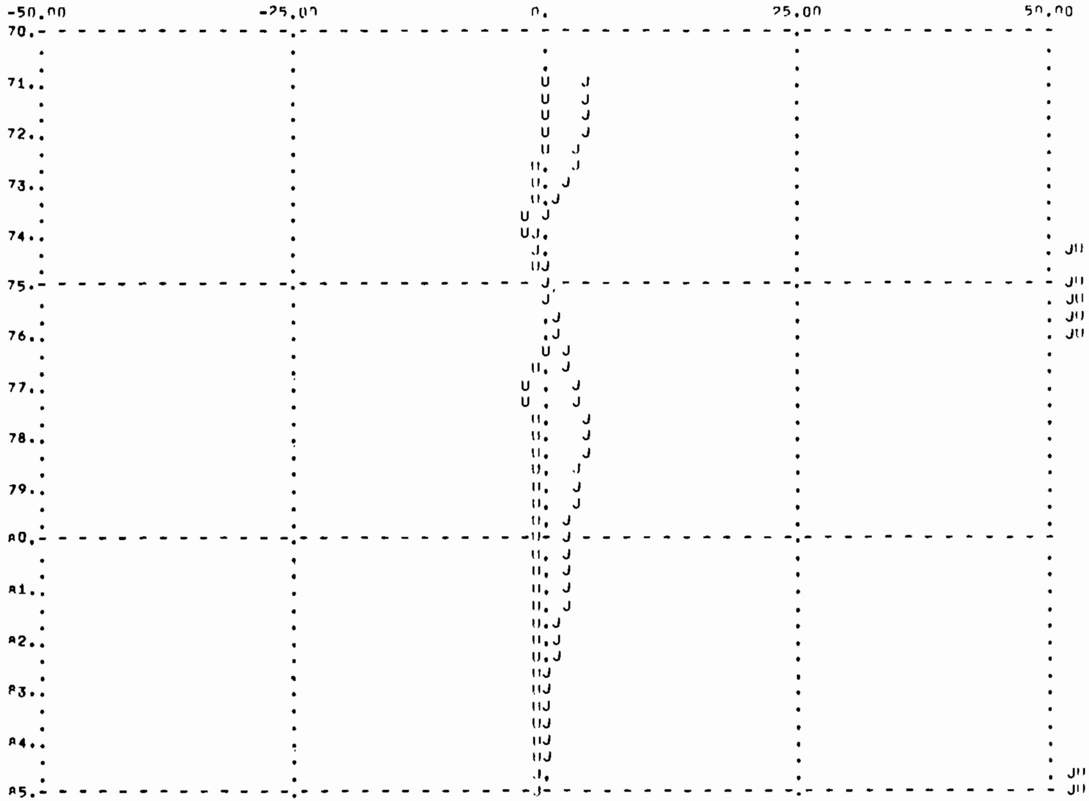
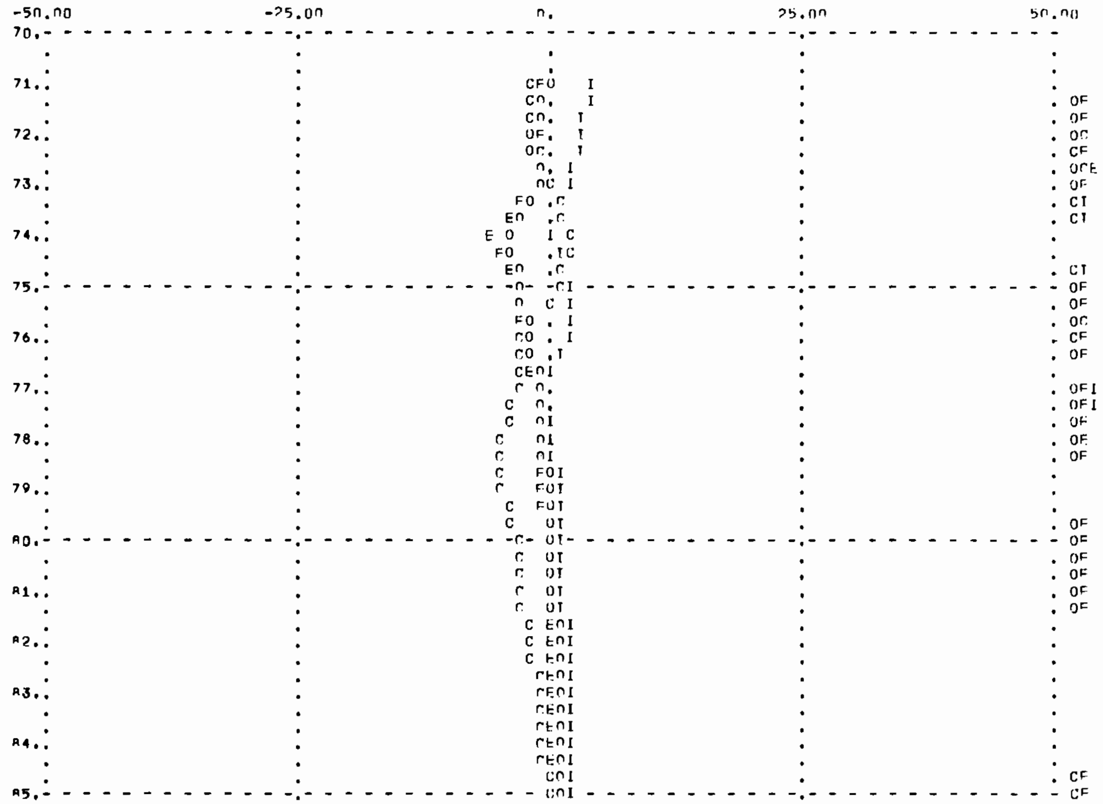


B-6

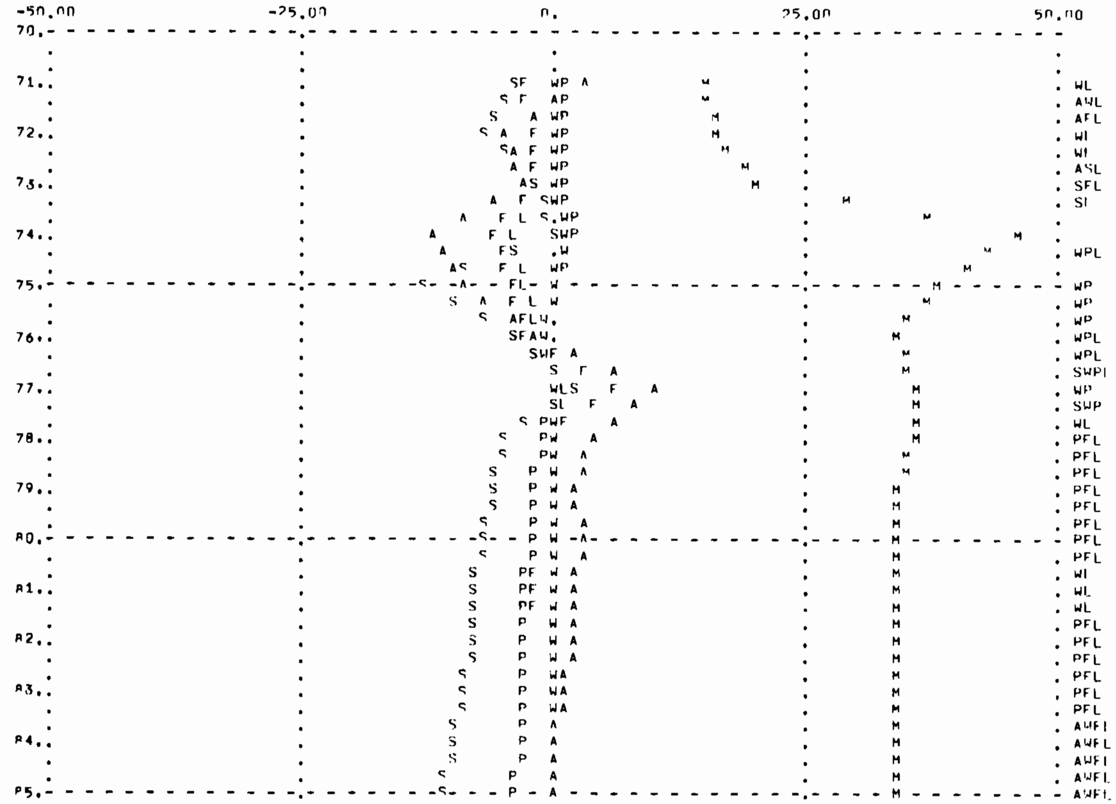
BALANCE OF PAYMENT / X

AUSTRALIA AND NEW ZEALAND=O, CANADA=C, EC=E, OTHER ADVANCED COUNTRIES=I.



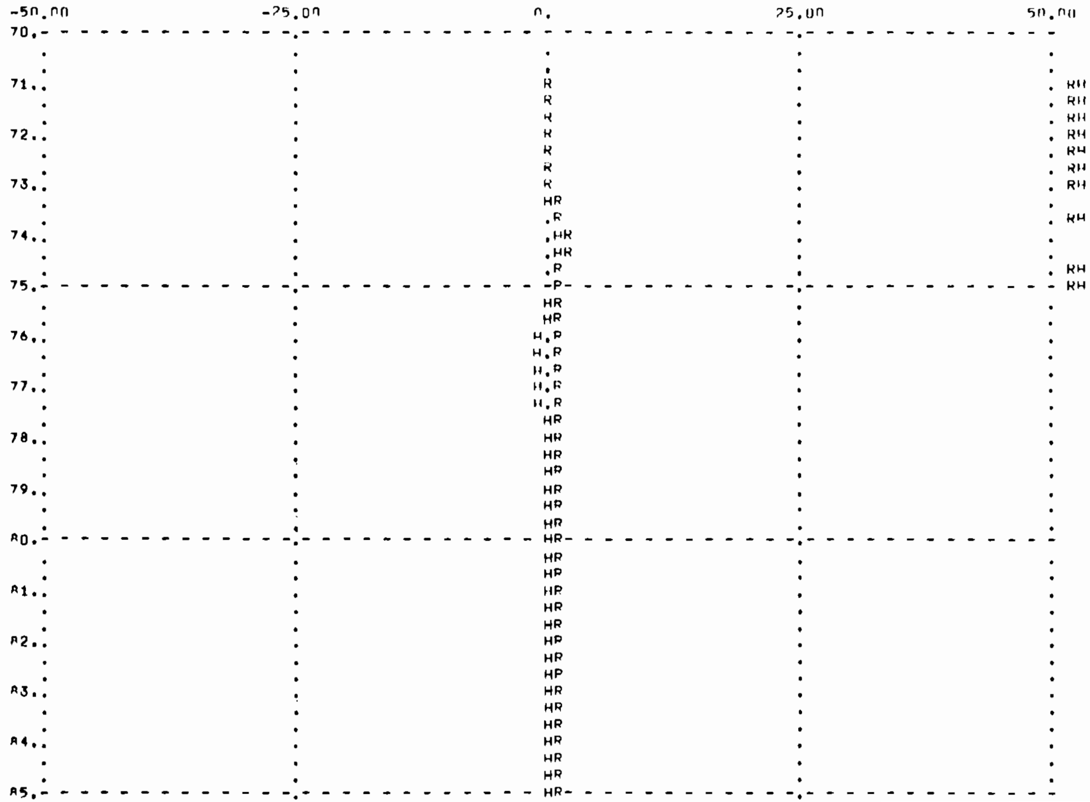
BALANCE OF PAYMENT / X

EAST ASIA=A, ASEAN=S, WEST ASIA=W, OTHER ASIA=P, MIDDLE EAST=M, AFRICA=F, CARIBBEAN AND LATIN AMERICA=L,



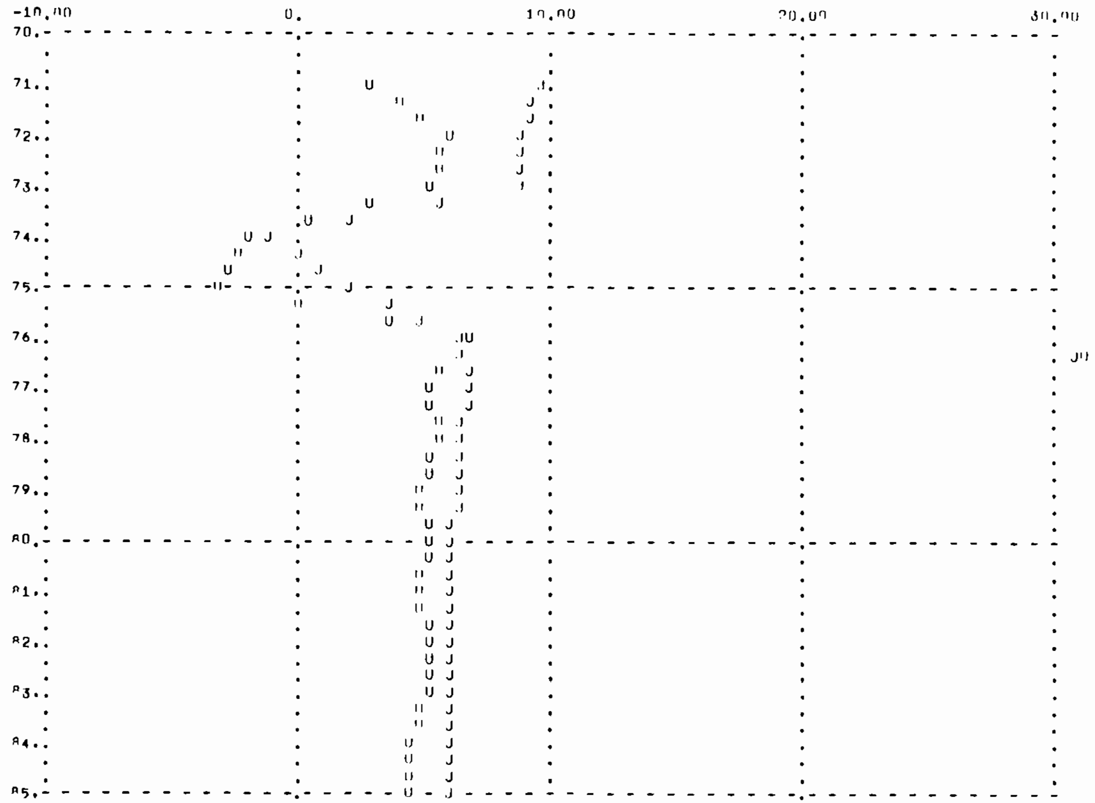
BALANCE OF PAYMENT / X

USSR AND EAST EUROPE (INCLUDING CUBA)=R, CHINA AND OTHER ASIAN SOCIALIST COUNTRIES=H,



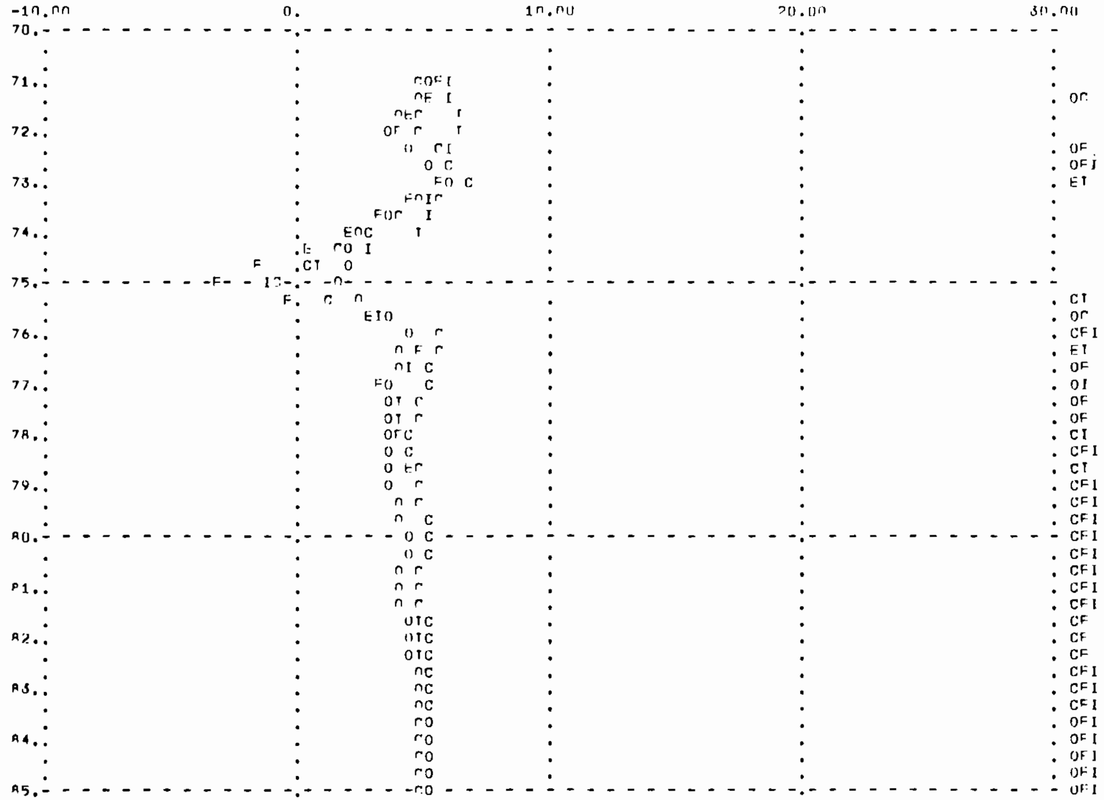
C-1 GRP GROWTH-RATE AT CONSTANT PRICE ANNUAL PERCENTAGE CHANGES (1970 DOLLARS)

JAPAN=J, UNITED STATES=U,



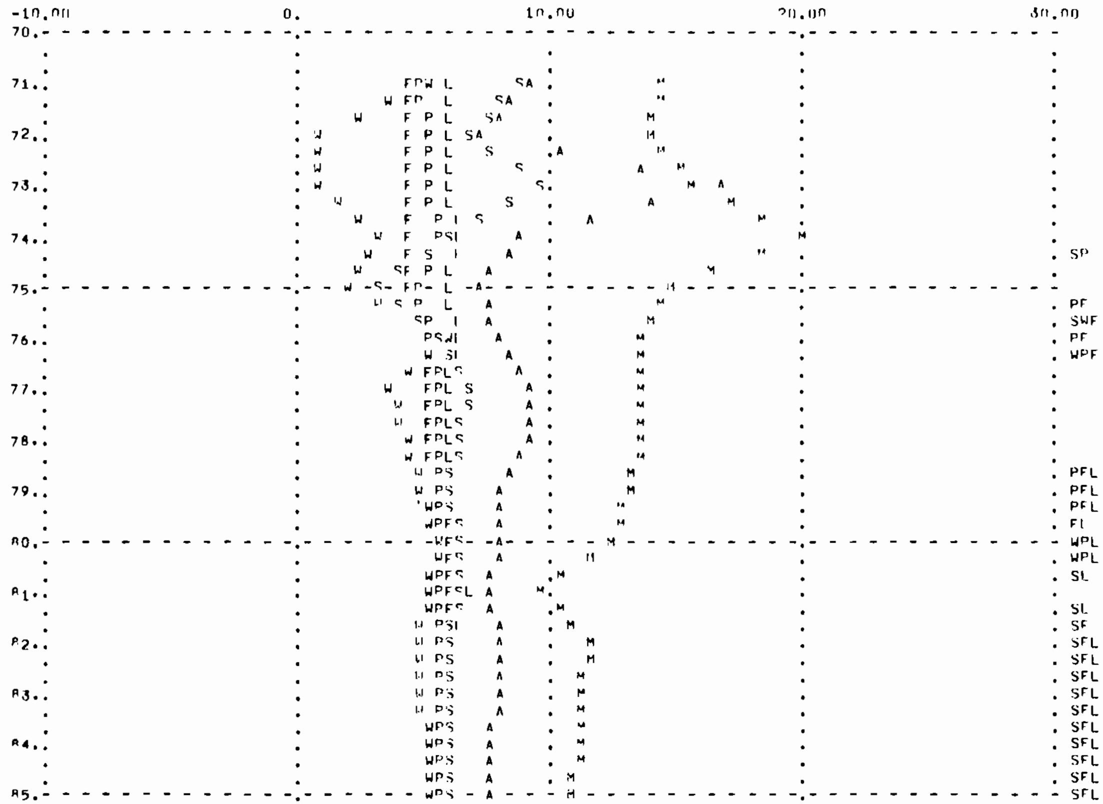
GDP GROWTH-RATE AT CONSTANT PRICE ANNUAL PERCENTAGE CHANGES (1970 DOLLARS)

AUSTRALIA AND NEW ZEALAND=O, CANADA=C, EEC=E, OTHER ADVANCED COUNTRIES=I,



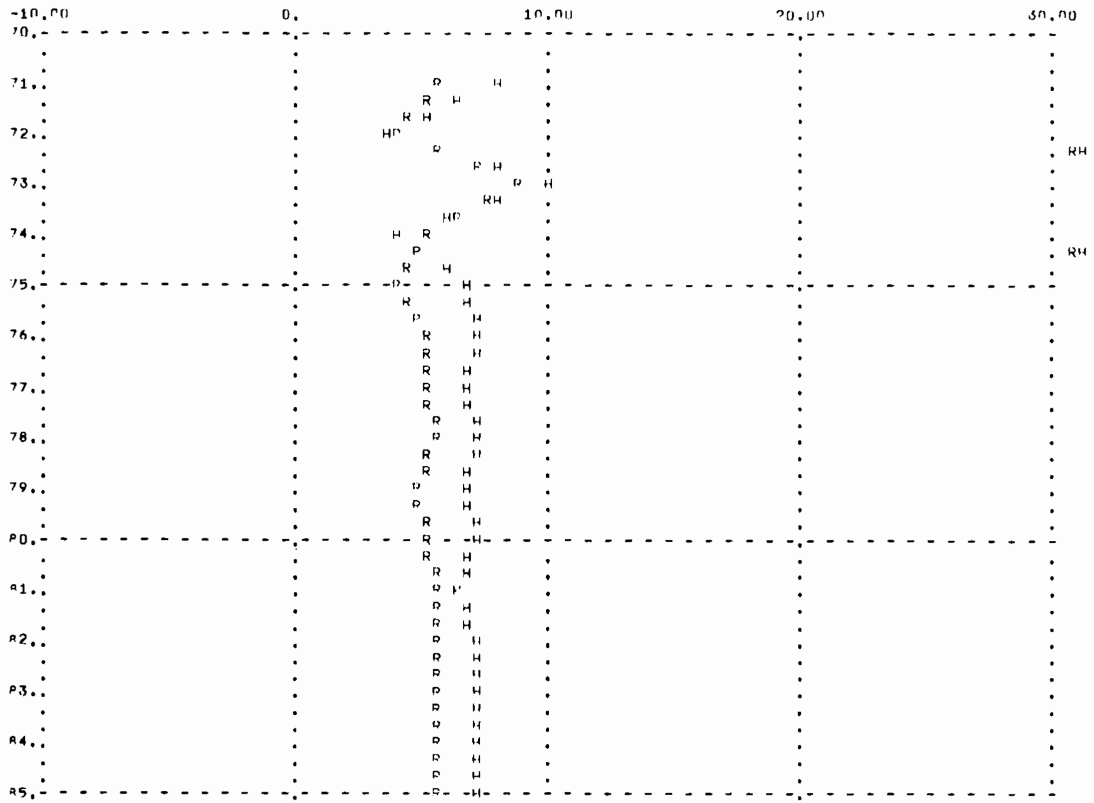
GDP GROWTH-RATE AT CONSTANT PRICE   ANNUAL PERCENTAGE CHANGES   (1970 DOLLARS)

EAST ASIA=A, ASEAN=S, WEST ASIA=W, OTHER ASIA=P, MIDDLE EAST=M, AFRICA=F, CARIBBEAN AND LATIN AMERICA=L,



GDP GROWTH-RATE AT CONSTANT PRICE   ANNUAL PERCENTAGE CHANGES   (1970 DOLLAR)

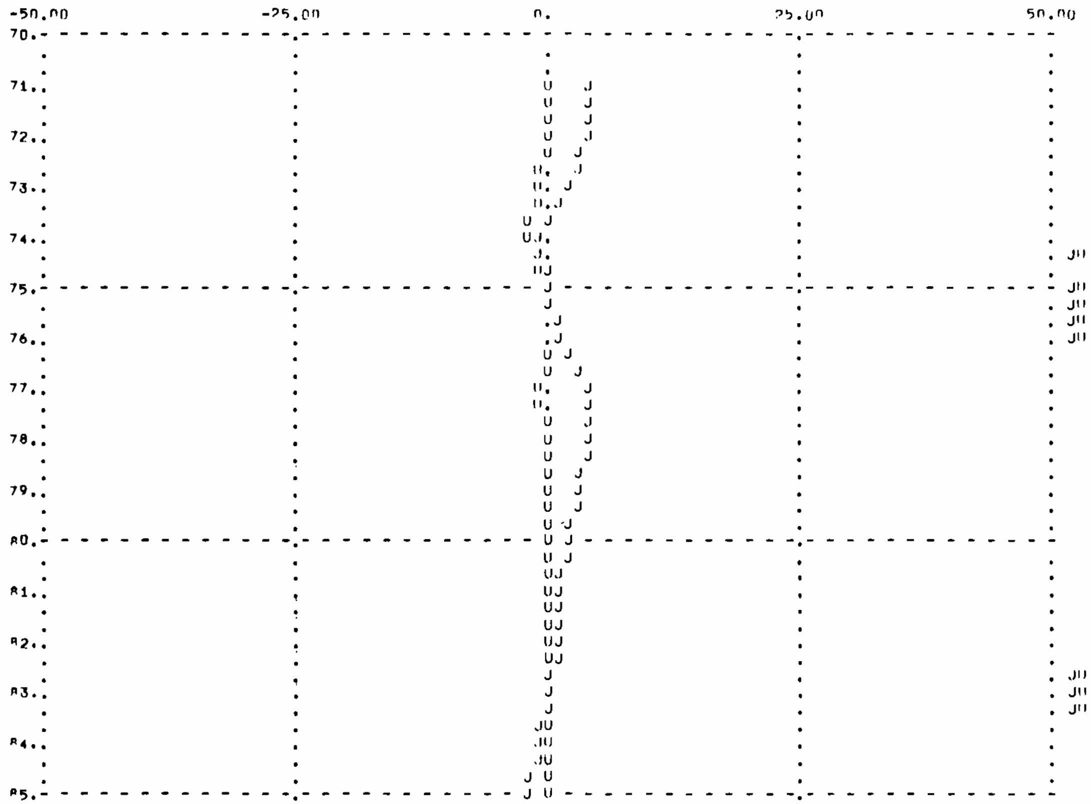
USSR AND EAST EUROPE (INCLUDING CUBA)(R), CHINA AND OTHER ASIAN SOCIALIST COUNTRIES(H),



C-5

BALANCE OF PAYMENT / Y

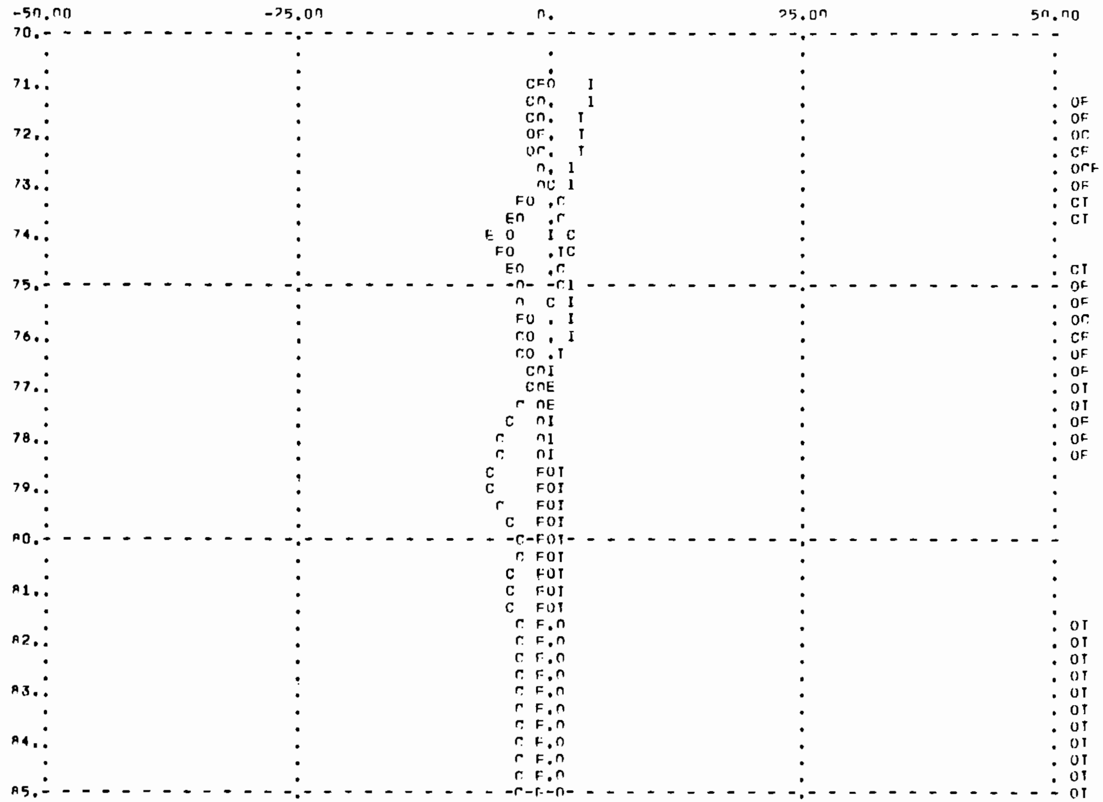
JAPAN=J, UNITED STATES=U,



C-6

BALANCE OF PAYMENT / X

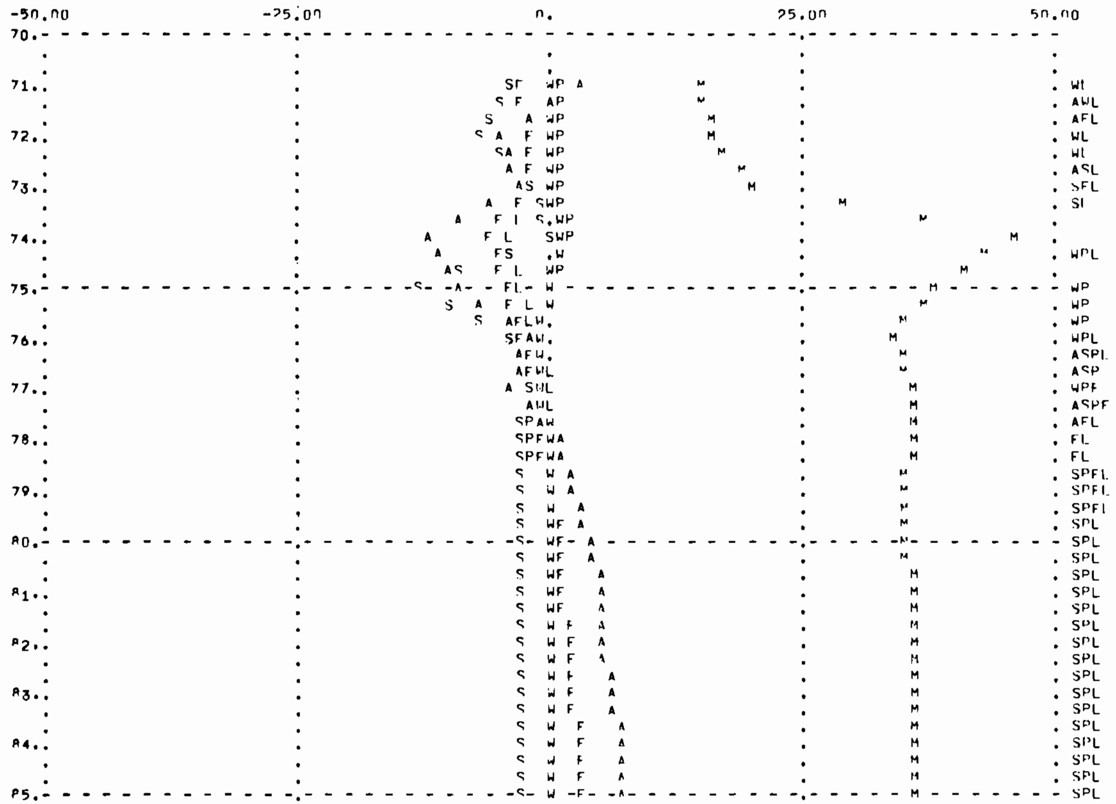
AUSTRALIA AND NEW ZEALAND=O, CANADA=C, EC=E, OTHER ADVANCED COUNTRIES=I,



C-7

BALANCE OF PAYMENT / X

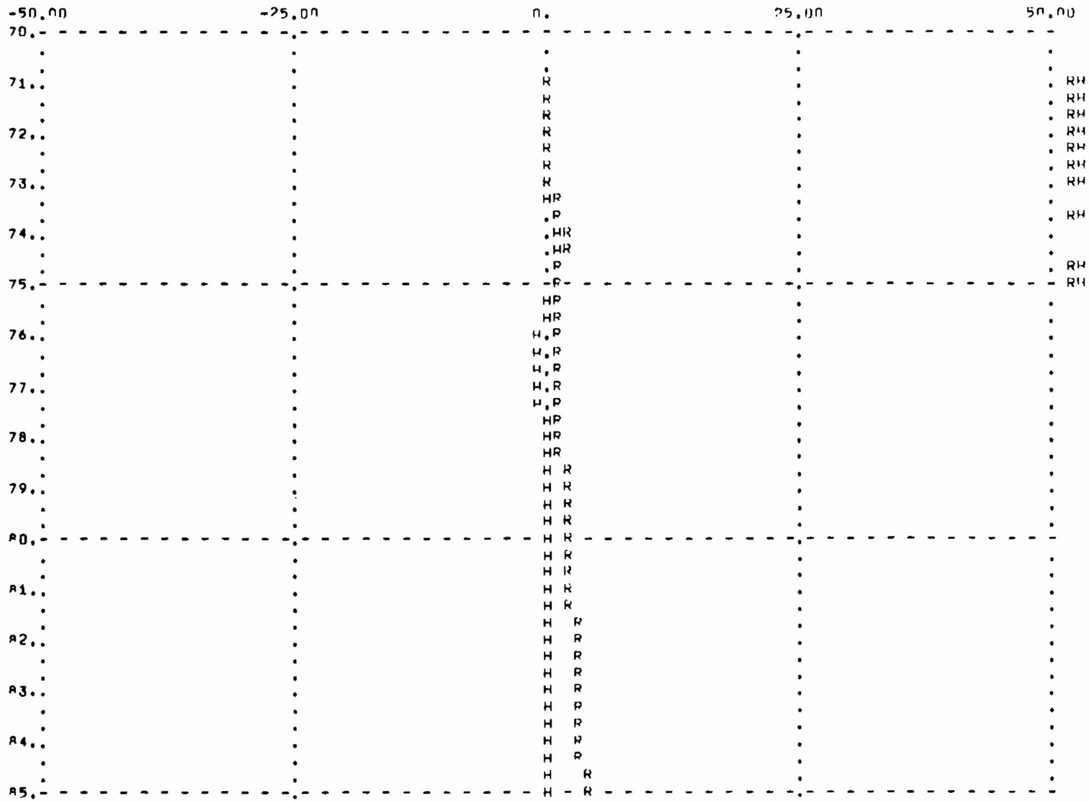
EAST ASIA=A, ASEAN=S, WEST ASIA=W, OTHER ASIA=P, MIDDLE EAST=M, AFRICA=F, CARIBBEAN AND LATIN AMERICA=L.



C-8 47

BALANCE OF PAYMENT / X

USSR AND EAST EUROPE (INCLUDING CUBA)=R, CHINA AND OTHER ASIAN SOCIALIST COUNTRIES=H,



I - 8. Future direction of this study

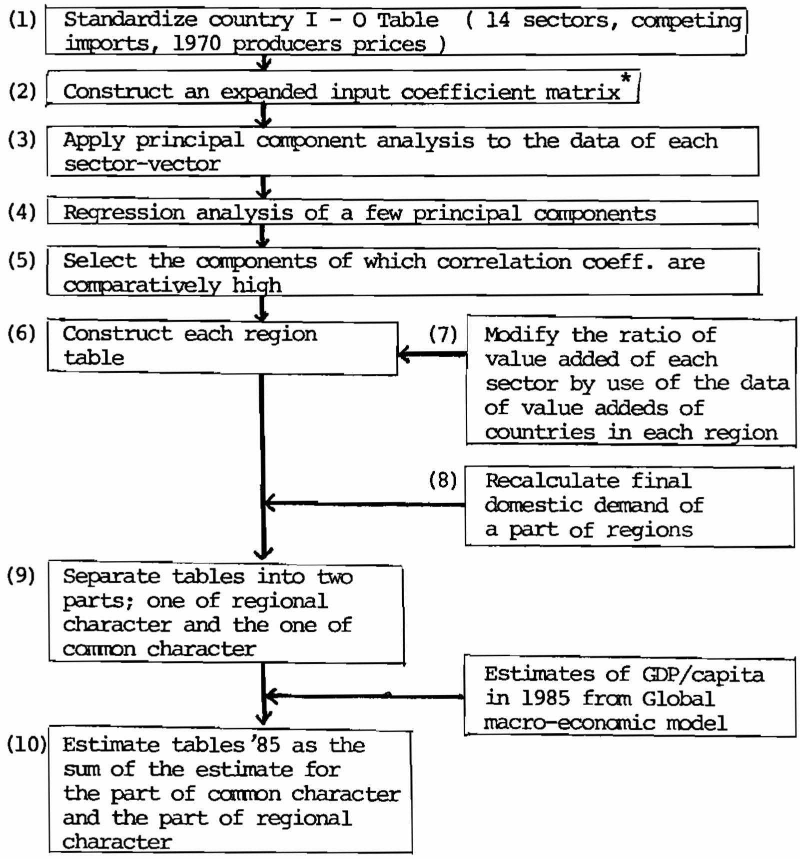
1) To develop a multi-nation type of global macro-economic model covering about 150 countries in the world.

2) To include non-economic sub-systems such as foods, energy, environment, welfare, education, etc. in order to meet the basic human needs.

APPENDIX II. TECHNICAL DETAILS OF THE GLOBAL INPUT-OUTPUT MODEL (EXCERPTS)

II. - 1. Input - Output Tables

II. 1. 1. Flow Chart of Estimation of 1985 Regional Tables



* a matrix comprising technological coefficients and ratios of value added

II. 1.2. References of the data for region tables

Region	Name of countries for base table	for auxiliary data for value addeds *1	for calculation of *2 final domestic demand(1970)
1.Japan	Japan 1970		
2.Australia	Australia 1962/63	New Zealand 1965/66 (non.) *3	
3.Canada	Canada 1961		
4.U.S.A.	U.S.A. 1970 *4		
5.E.C.	France 1965, F.R. Germany 1965, Italy 1971, U.K. 1970		Belgium, Denmark, France, F.R.Germany, Italy, Luxembourg, Netherlands U.K.
6.Other D.C.	E.C.	Austria 1970, Finland 1965, Norway 1964(non) Greece, Israel, Turkey Spain, S.Africa	Austria, Finland,Greece, Norway, Portugal, Spain, Sweden
7.East Asia ASEAN	Korea 1970 Philippines 1969	Malaysia 1970 (non) Thailand 1971 (non) Indonesia, Hong Kong	Korea, Indonesia, Philippines, Singapore, Thailand(1969)
8.West South Asia	India 1964/65	Pakistan, Bangladesh Sri Lanka	India(1968), Pakistan, Fiji
9.Middle East	Iran 1965	Iraq, Syria	Iran(1969), Jordan Saudi Arabia(1969)
10.Africa	Latin America	Zambia 1969, Egypt, Ghana, Nigeria	Egypt, Sudan, Ghana, Madagascar, Malawi
11.Latin America	Argentina 1970 Peru 1969	Brazil 1971(non) Colombia 1970(pur)*5 Mexico, Chile	Guatemala, Honduras, Mexico, Brazil, Chile Colombia
12.European Cent. Plann.c.	U.S.S.R. 1966 *6	Poland, Bulgaria Czechoslovakia	

*1 The ratio of value added of each sector is modified with the use of this data. See Chapter 9, section 4.
*2 Final domestic demand of the corresponding region is recalculated through the process described in Chapter 9, section 4, by using the data of gross domestic products of the countries in the table.
*3 non, denotes the table of the type of non-competing imports.
*4 The estimate by RAS method from 1967 table.
*5 The table in purchasers values. *6 The estimate by Treml.

II. 1.3. Results of the principal component analysis (PCA)

a. Countries for which tables are subject to PCA

1.	Japan	1970
2.	Australia	1962/63
3.	Canada	1961
4.	U.S.A.	1970
5.	Italy	1971
6.	U.K.	1970
7.	Austria	1970
8.	Finland	1965
9.	Korea	1970
10.	Philippines	1969
11.	Argentina	1970
12.	Peru	1969

b. Cumulative contribution to the total variance and results of regression analysis of components are shown in the following.

*1 equation: $y_j = b_{1j} + b_{2j} \log_e g_k^*$

where y_j; the j th principal component

g_k^*; GDP/capita of the k th country (const. price)

*2 O denotes the term adopted as the part of common character.

*3 T(1) and T(2) are t-values for b_{1j} and b_{2j} respectively.

REGRESSION ANALYSIS #1

SECTOR	NO. OF COMPONENT	CUMULATIVE PROPORTION OF TOTAL VARIANCE	CORRELATION COEFF. R	B(1)	T(1)	B(2)	T(2)	#2
1 AGRICULT	1	.3192	.5649	-9.3270	-2.1475	2.9969	2.1647	0
1	2	.5581	.1900	-2.7151	-.6073	.8724	.6121	
1	3	.7497	.5085	-6.5047	-1.8528	2.0900	1.8676	
1	4	.8255	.2337	-1 8812	-.7539	.6045	.7600	
2 MINING	1	.2618	.1033	-1.5444	-.3257	.4962	.3283	
2	2	.4973	.4383	-6.2168	-1.5299	1.9975	1.5421	0
2	3	.6408	.2102	-2.3270	-.6744	.7477	.6798	
2	4	.7622	.1282	1.3056	.4056	-.4195	-.4089	
3 FOOD & T	1	.2785	.3783	-5.8349	-1.2821	1.8748	1.2924	
3	2	.4840	.5167	6.8463	1.8935	-2.1998	-1.9086	0
3	3	.6503	.1784	-2.1269	-.5688	.6834	.5734	
3	4	.7701	.0257	-.2597	-.0806	.0834	.0812	
4 TEX. & F	1	.3582	.3870	6.7689	1.3166	-2.1749	-1.3271	
4	2	.5389	.4298	-5.3396	-1.4933	1.7157	1.5053	0
4	3	.6746	.2517	2.7101	.8158	-.8708	-.8223	
4	4	.7827	.0282	.2712	.0886	-.0871	-.0893	
5 PAPER &	1	.3021	.3859	-6 1984	-1.3122	1.9916	1.3227	0
5	2	.4607	.1386	-1.6133	-.4390	.5184	.4425	
5	3	.6125	.1708	1.9449	.5438	-.6249	-.5482	
5	4	.7327	.3209	-3.2511	-1.0628	1.0446	1.0714	
6 CHEMICAL	1	.3047	.5082	-8.2001	-1.8513	2.6348	1.8662	0
6	2	.5118	.0046	.0617	.0146	-.0198	-.0147	
6	3	.6474	.0675	-.7269	-.2123	.2336	.2140	
6	4	.7635	.4071	-4.0540	-1.3981	1.3026	1.4093	
7 METAL PR	1	.2380	.1836	-2.6180	-.5859	.8412	.5906	
7	2	.4520	.6019	-8.1382	-2.3648	2.6149	2.3837	0
7	3	.6089	.3584	4.1488	1.2042	-1.3330	-1.2139	
7	4	.7379	.2111	-2.2157	-.6774	.7119	.6829	

R E G R E S S I O N   A N A L Y S I S #1

SECTOR	NO.OF COMPONENT	CUMULATIVE PROPORTION OF TOTAL VARIANCE	CORRELATION COEFF. R	B(1)	T(1)	B(2)	T(2)	#2
8 MACHINRY	1	.2445	.2063	2.9821	.6615	-.9582	-.6668	
8	2	.4432	.8059	-10.4686	-4.2698	3.3637	4.3040	0
8	3	.6053	.4863	5.7430	1.7460	-1.8453	-1.7600	
8	4	.7183	.1373	1.3219	.4349	-.4247	-.4384	
9 ELECTRIC	1	.2665	.2623	-3.9569	-.8528	1.2714	.8596	
9	2	.4237	.5112	-5.9271	-1.8661	1.9044	1.8811	0
9	3	.5722	.1621	-1.8254	-.5153	.5865	.5194	
9	4	.6967	.0403	.4154	.1264	-.1335	-.1275	
10 TRANSP.M	1	.2754	.5369	-8.2356	-1.9966	2.6462	2.0126	0
10	2	.4602	.0402	5052	.1262	-.1623	-.1273	
10	3	.6236	.1462	-1.7278	-.4638	.5552	.4675	
10	4	.7402	.2904	2.8992	.9522	-.9315	-.9599	
11 CONSTRUC	1	.2890	.0087	- 1364	-.0272	.0438	.0275	
11	2	.5041	.3886	-5 2674	-1.3229	1.6925	1.3335	
11	3	.6393	.2139	-2 2991	-.6870	.7387	.6925	
11	4	.7666	.4320	4.5050	1.5025	-1.4475	-1.5145	0
12 ELEC,GAS	1	.2236	.1698	2.3463	.5404	-.7539	-.5447	
12	2	.4154	.5485	-7.0198	-2.0577	2.2555	2.0742	0
12	3	.5815	.4030	4.8007	1.3813	-1.5425	-1.3924	
12	4	.7212	.3739	-4.0836	-1.2646	1.3121	1.2748	
13 SERVICE	1	.3265	.4000	-6.6800	-1.3692	2.1464	1.3802	
13	2	.4845	.6045	-7.0226	-2.3804	2.2564	2.3995	0
13	3	.6316	.3738	4.1901	1.2643	-1.3463	-1.2744	
13	4	.7509	.2351	2.3739	.7588	-.7628	-.7649	
14 TRANSP.	1	.2810	.5331	8.2590	1.9766	-2.6537	-1.9925	0
14	2	.4868	.0952	-1.2621	-.3000	.4055	.3024	
14	3	.6490	.3608	4.2470	1.2136	-1.3646	-1.2234	
14	4	.7606	.1150	-1.1230	-.3631	.3608	.3660	

REGRESSION ANALYSIS #1

SECTOR	NO. OF COMPONENT	CUMULATIVE PROPORTION OF TOTAL VARIANCE	CORRELATION COEFF. R	B(1)	T(1)	B(2)	T(2)	#2
15	1	.4412	.4397	-8.2666	-1.3738	2.6449	1.3846	
15	2	.6617	.6713	-8.9243	-2.5417	2.8554	2.5616	0
15	3	.7895	.2199	2.2245	.6326	-.7117	-.6375	
15	4	.8737	.4115	3.3806	1.2671	-1.0816	-1.2771	
16	1	.5194	.1585	-3.2330	-.4505	1.0344	.4540	
16	2	.6659	.5114	5.5421	1.6702	-1.7732	-1.6833	0
16	3	.7840	.1337	1.3007	.3786	-.4162	-.3816	
16	4	.8683	.1329	-1.0915	-.3763	.3492	.3792	
17	1	.3720	.0124	-.2142	-.0390	.0688	.0393	
17	2	.6213	.6858	9.6676	2.9559	-3.1063	-2.9796	0
17	3	.7474	.3983	-3.9946	-1.3624	1.2835	1.3733	
17	4	.8455	.4472	3.9541	1.5686	-1.2705	-1.5812	
REGION 5-6	1	.3054	.0747	2.2851	.2588	-.6917	-.2594	
	2	.5207	.4876	-12.5300	-1.9306	3.7927	1.9347	0
	3	.6930	.4783	10.9935	1.8826	-3.3276	-1.8866	0
	4	.7940	.4352	-7.6587	-1.6710	2.3182	1.6745	
REGION 7-11	1	.2737	.3961	3.7014	1.8900	-1.6081	-1.9292	
	2	.4842	.4684	3.8386	2.3227	-1.6677	-2.3708	0
	3	.6111	.3159	-2.0108	-1.4589	.8736	1.4892	
	4	.7248	.0095	-.0572	-.0416	.0249	.0425	

References

	no of sectors	data year	source
Japan	60	1970	Government of Japan
Austràlia	105	1962/63	Commonwealth Bureau of Census and Statistics, Australian National Accounts
New Zealand	109	1965/66(non.)	Department of Statistics Publication
Canada	64	1961	unknown
U.S.A.	87	1970	U.S. Department of Commerce
France	31	1965	Data from Economic Planning Agency of Japan
F.R.Germany	31	1965	
Italy	45	1971	Instituto Centrale di Statistica
Austria	31	1970	Bundeskammer der Gewerblichen Wirtschaft, Abteilung für Statistikund Dokumentation
Finland	66	1965	Tilastollinen Paatoimisto, Statistika Centralbyrån
Norway	36	1964(non.)	Central Bureau of Statistics of Norway
Korea	56	1970	Statistics Department, The Bank of Korea
Philippines	60	1969	National Census and Statistics Office
Thailand	75	1971(non.)	National Accounts Division
Malaysia	60	1970(non.)	Jabatan Perangkaan
India	77	1964/65	unknown
Iran	29	1965	Ministry of Economy, Bureau of Statistics
Zambia	10	1969	unknown
Argentina	23	1970	Banco Central de la Republica Argentina
Brazil	25	1971(non.)	Instumo-Produto do Brasil
Colombia	33	1970(pur.)	Deparmenta Administrativo Nacional de Estadistica
Peru	40	1969	Instituto Nacional de Planificaccion, Unidad de Investigaciones Socioeconomicas
USSR	70	1966	U.S. Department of Commerce

SCENARIO-A ### JAPAN '85 ### I-O PARAMETER REGION NO. = 1

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.12747	.00411	.36609	.14454	.02784	.01829	.00000	.00079	.00007
2	MINING	.00258	.02716	.00052	.00064	.00368	.11691	.03203	.00992	.00357
3	FOOD & TOBACCO	.09298	.00000	.12951	.00753	.00019	.00489	.00000	.00003	.00000
4	TEX. & FURNIT.	.00859	.00460	.00253	.30355	.03268	.00843	.00244	.00233	.01139
5	PAPER & PRINT	.00568	.00280	.01117	.00512	.39522	.02119	.00095	.00610	.00693
6	CHEMICALS	.06542	.11359	.04984	.08894	.03281	.23917	.04747	.02079	.03106
7	METAL PROD.	.00180	.01736	.01286	.01803	.00363	.01560	.51387	.15788	.13551
8	MACHINERY GEN.	.00803	.01779	.00297	.00390	.00537	.01202	.01465	.24972	.02699
9	ELECTRICAL M.	.00021	.00804	.00010	.00076	.00140	.00475	.00419	.05876	.25523
10	TRANSPORT EQP.	.00651	.03064	.00050	.00144	.00087	.00148	.00255	.01631	.00173
11	CONSTRUCTION	.00900	.01403	.00285	.00285	.00372	.00477	.00146	.00387	.00264
12	ELEC,GAS,STEAM	.00298	.02909	.00652	.00906	.02251	.02625	.02132	.00712	.00682
13	SERVICE	.04599	.07269	.09586	.11443	.09843	.10969	.07092	.10451	.15510
14	TRANSP.& COMM.	.00892	.02198	.02495	.02712	.02435	.02873	.02252	.01598	.02029
15	VALUE ADDED	.61382	.63613	.29371	.27209	.34731	.38783	.25765	.34589	.34266
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

							CONSUMPT.	INVEST.	.FINAL DEMAND
		10	11	12	13	14	15	16	17
1	AGRICULTURE	.00007	.00000	.00000	.00519	.00000	.01237	.00000	.00311
2	MINING	.01055	.02318	.07205	.00014	.00194	.00000	.00003	.00056
3	FOOD & TOBACCO	.00000	.00002	.00005	.01841	.00000	.12504	.00000	.08781
4	TEX. & FURNIT.	.00747	.10512	.00168	.01525	.00666	.05316	.01306	.04257
5	PAPER & PRINT	.00285	.00062	.00433	.03709	.00292	.00861	.00000	.00639
6	CHEMICALS	.05631	.12212	.09373	.03554	.02628	.02084	.00000	.01595
7	METAL PROD.	.14197	.14182	.00046	.00910	.00000	.00376	.00000	.00463
8	MACHINERY GEN.	.09517	.02520	.00725	.00617	.00000	.01067	.15253	.06726
9	ELECTRICAL M.	.03814	.03479	.02387	.00212	.00066	.01976	.08462	.04486
10	TRANSPORT EQP.	.19678	.00707	.00475	.00768	.05584	.01628	.10238	.05349
11	CONSTRUCTION	.00296	.00323	.03485	.01766	.01230	.00629	.57035	.21533
12	ELEC,GAS,STEAM	.00814	.00495	.03106	.01065	.01264	.02281	.00141	.01628
13	SERVICE	.08301	.12941	.07140	.14326	.06948	.62944	.06750	.39087
14	TRANSP.& COMM.	.01249	.03429	.01872	.02102	.08877	.07097	.00812	.05089
15	VALUE ADDED	.34407	.36819	.63580	.67074	.72253	######	######	######
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

SCENARIO-A ### AUSTRALIA '85 ### I-O PARAMETER REGION NO. = 2

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.01322	.00938	.44009	.06498	.02753	.00045	.00009	.00026	.00000
2	MINING	.00240	.11121	.00182	.00100	.00353	.01101	.07159	.00924	.00402
3	FOOD & TOBACCO	.04579	.00000	.07600	.01466	.00171	.01284	.00029	.00011	.00000
4	TEX. & FURNIT.	.01973	.00783	.00401	.26629	.00595	.01636	.00571	.00183	.01873
5	PAPER & PRINT	.00171	.00700	.03238	.00740	.24334	.02608	.00210	.00412	.01468
6	CHEMICALS	.08686	.04091	.01765	.02532	.02761	.11187	.02942	.02875	.07783
7	METAL PROD.	.01343	.03831	.02659	.01385	.00722	.03032	.22992	.15046	.15687
8	MACHINERY GEN.	.02024	.02168	.00395	.00330	.00443	.00799	.01466	.02918	.01570
9	ELECTRICAL M.	.00549	.00610	.00169	.00168	.00156	.00403	.00815	.04889	.01689
10	TRANSPORT EQP.	.00273	.00149	.00000	.00022	.00000	.00032	.00199	.00404	.00272
11	CONSTRUCTION	.00260	.01015	.00240	.00214	.00294	.00441	.00398	.00362	.00233
12	ELEC,GAS,STEAM	.01144	.04779	.00978	.00815	.01578	.02071	.02508	.00786	.00978
13	SERVICE	.06784	.08205	.07586	.03962	.04118	.03004	.05391	.02271	.03805
14	TRANSP.& COMM.	.01706	.01100	.04026	.02648	.01501	.03235	.04702	.01044	.01502
15	VALUE ADDED	.68945	.60511	.26751	.52491	.60221	.69123	.50609	.67849	.62736
	TOTAL	1.00000	1.00000	1,00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

							CONSUMPT.	INVEST.	FINAL DEMAND
		10	11	12	13	14	15	16	17
1	AGRICULTURE	.00005	.00009	.00107	.00005	.00175	.00607	.00000	.00232
2	MINING	.00826	.01791	.10960	.00000	.00512	.00000	.00126	.00114
3	FOOD & TOBACCO	.00000	.00028	.00020	.00000	.00025	.13172	.00000	.10435
4	TEX. & FURNIT.	.00952	.08788	.00286	.00698	.00491	.07822	.01666	.06548
5	PAPER & PRINT	.00231	.00000	.00249	.03617	.00160	.01108	.00000	.00885
6	CHEMICALS	.05779	.14635	.02517	.01255	.02701	.03144	.00168	.02624
7	METAL PROD.	.12339	.12413	.01930	.00391	.00153	.00236	.04695	.01637
8	MACHINERY GEN.	.02182	.02240	.00846	.00466	.00046	.02179	.13654	.05670
9	ELECTRICAL M.	.01943	.01217	.01318	.00280	.03300	.01043	.04166	.02053
10	TRANSPORT EQP.	.00000	.01065	.00069	.01295	.06272	.03322	.08039	.05040
11	CONSTRUCTION	.00322	.00149	.00877	.03002	.03937	.00434	.55148	.15537
12	ELEC,GAS,STEAM	.00940	.00285	.02771	.02149	.01129	.02570	.00114	.01982
13	SERVICE	.03425	.08380	.05435	.14248	.09729	.57759	.07835	.41128
14	TRANSP.& COMM.	.01169	.06686	.03675	.03743	.01566	.06604	.04388	.06115
15	VALUE ADDED	.69886	.42314	.68940	.68853	.69805	######	######	######
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

SCENARIO-A *** CANADA '85 *** I-O PARAMETER REGION NO. = 3

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.06245	.00019	.30514	.08543	.12918	.00000	.00000	.00000	.00000
2	MINING	.00375	.05158	.00219	.00177	.01321	.19888	.17200	.01399	.00496
3	FOOD & TOBACCO	.08218	.00002	.16836	.01078	.00133	.01118	.00030	.00029	.00000
4	TEX. & FURNIT.	.00481	.00204	.00353	.29506	.02256	.01312	.00186	.00001	.01084
5	PAPER & PRINT	.00112	.00384	.04221	.01174	.17424	.02165	.00329	.00507	.00975
6	CHEMICALS	.07670	.02873	.02154	.03488	.03971	.16853	.01809	.01623	.04337
7	METAL PROD.	.00210	.00266	.02142	.01364	.00947	.02151	.31630	.20407	.16121
8	MACHINERY GEN.	.01308	.01776	.00080	.00046	.00187	.00383	.01234	.13214	.02428
9	ELECTRICAL M.	.00036	.00019	.00006	.00068	.00046	.00114	.00368	.05138	.16211
10	TRANSPORT EQP.	.00255	.00000	.00000	.00023	.00000	.00022	.00226	.00460	.00153
11	CONSTRUCTION	.02212	.01750	.00326	.00379	.00476	.01179	.00516	.00609	.00279
12	ELEC,GAS,STEAM	.00827	.02527	.00656	.00699	.02733	.02141	.01984	.00629	.00609
13	SERVICE	.17663	.16605	.10038	.12273	.08351	.10446	.08117	.10456	.12695
14	TRANSP.& COMM.	.02725	.01514	.04029	.03162	.03938	.05703	.03079	.02435	.02812
15	VALUE ADDED	.56665	.66903	.28426	.38019	.45299	.36526	.33293	.43093	.41797
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

							CONSUMPT.	INVEST.	FINAL DEMAND
		10	11	12	13	14	15	16	17
1	AGRICULTURE	.00007	.00205	.00000	.01159	.00009	.00000	.00000	.00000
2	MINING	.01288	.01114	.01746	.00000	.00282	.00348	.00331	.00697
3	FOOD & TOBACCO	.00000	.00006	.00005	.01833	.00000	.11438	.00000	.10979
4	TEX. & FURNIT.	.01692	.07114	.00134	.00793	.00168	.06654	.01313	.05624
5	PAPER & PRINT	.00365	.00750	.00326	.03919	.00125	.01147	.00000	.01274
6	CHEMICALS	.04701	.09979	.00000	.02635	.01450	.01983	.00201	.03208
7	METAL PROD.	.12201	.16446	.00000	.01084	.00000	.00014	.02558	.00259
8	MACHINERY GEN.	.01754	.01964	.00282	.01296	.00000	.01020	.18741	.03553
9	ELECTRICAL M.	.02323	.03875	.00276	.00432	.00222	.01579	.07336	.02839
10	TRANSPORT EQP.	.27014	.00206	.00000	.00477	.00810	.03401	.07006	.05609
11	CONSTRUCTION	.00613	.00250	.04861	.02460	.04758	.02706	.57130	.19080
12	ELEC,GAS,STEAM	.00601	.00115	.21040	.00743	.00371	.03467	.00681	.01925
13	SERVICE	.08320	.13079	.05685	.20046	.10483	.52210	.03099	.38614
14	TRANSP.& COMM.	.02571	.03755	.00837	.03596	.09209	.14035	.01602	.06339
15	VALUE ADDED	.36549	.41143	.64807	.59527	.72112	******	******	******
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

SCENARIO-A ### U.S.A '85 ### I-O PARAMETER REGION NO. = 4

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.30594	.00010	.27993	.02728	.00936	.00053	.00000	.00007	.00000
2	MINING	.00335	.06796	.00072	.00079	.00415	.12412	.03882	.00551	.00217
3	FOOD & TOBACCO	.06414	.00000	.17104	.00439	.00275	.00729	.00017	.00031	.00000
4	TEX. & FURNIT.	.00331	.00312	.00213	.35639	.03670	.01288	.00506	.00482	.00698
5	PAPER & PRINT	.00247	.00158	.03440	.01043	.25120	.02336	.00770	.00998	.01155
6	CHEMICALS	.05769	.03300	.02979	.07590	.04744	.23439	.02034	.02991	.04639
7	METAL PROD.	.00077	.01867	.02506	.00753	.01404	.02016	.29421	.14779	.07684
8	MACHINERY GEN.	.00805	.03207	.00727	.01779	.01603	.01868	.05780	.16711	.07344
9	ELECTRICAL M.	.00099	.00807	.00009	.00082	.00082	.00155	.01606	.05592	.17872
10	TRANSPORT EQP.	.00150	.00000	.00000	.00057	.00000	.00117	.01885	.01644	.01204
11	CONSTRUCTION	.00899	.02514	.00345	.00329	.00639	.01023	.00554	.00472	.00377
12	ELEC,GAS,STEAM	.00561	.02011	.00691	.00750	.01343	.02172	.01795	.00639	.00671
13	SERVICE	.14674	.25208	.11225	.11216	.14495	.14788	.13548	.12354	.15436
14	TRANSP.& COMM.	.02079	.01442	.03519	.02406	.03431	.03996	.03637	.01552	.01794
15	VALUE ADDED	.36967	.52368	.29177	.35109	.41841	.33610	.34567	.41196	.40909
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

		10	11	12	13	14	CONSUMPT. 15	INVEST. 16	FINAL DEMAND 17
1	AGRICULTURE	.00004	.00139	.00000	.00416	.00153	.00000	.00000	.00000
2	MINING	.00594	.00894	.10285	.00038	.00131	.00000	.00002	.00066
3	FOOD & TOBACCO	.00000	.00001	.00007	.00579	.00235	.08491	.00000	.07942
4	TEX. & FURNIT.	.02108	.05452	.00038	.00291	.00204	.03694	.01649	.03706
5	PAPER & PRINT	.00270	.00079	.00260	.02604	.00190	.01069	.00000	.00968
6	CHEMICALS	.03207	.10637	.00765	.01467	.02279	.03468	.00000	.03196
7	METAL PROD.	.10301	.12363	.00104	.00224	.00244	.01171	.00000	.00776
8	MACHINERY GEN.	.12628	.04027	.00245	.01086	.00543	.01166	.19171	.04050
9	ELECTRICAL M.	.03250	.02313	.00338	.00343	.00587	.02096	.06626	.02909
10	TRANSPORT EQP.	.22170	.00045	.00001	.00339	.00708	.03740	.12654	.05313
11	CONSTRUCTION	.00332	.00128	.03558	.01921	.02883	.04551	.49910	.11504
12	ELEC,GAS,STEAM	.00496	.00077	.20741	.01136	.00721	.02786	.00075	.02424
13	SERVICE	.09442	.15255	.18057	.16795	.16622	.63188	.07806	.52927
14	TRANSP.& COMM.	.01818	.02787	.02043	.02878	.09218	.04581	.02108	.04220
15	VALUE ADDED	.33379	.45802	.43558	.69883	.65283	######	######	######
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

SCENARIO-A ### E.C. '85 ### I-O PARAMETER REGION NO. = 5

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.19189	.00071	.32534	.03422	.02856	.00449	.00000	.00000	.00009
2	MINING	.00454	.07668	.00282	.00267	.00491	.08948	.08645	.04141	.04555
3	FOOD & TOBACCO	.11397	.00006	.13079	.01281	.00094	.01141	.00037	.00048	.00088
4	TEX. & FURNIT.	.00458	.00943	.00312	.31749	.01287	.00951	.00554	.00714	.01486
5	PAPER & PRINT	.00307	.00672	.02367	.01207	.28741	.02366	.00711	.00945	.01728
6	CHEMICALS	.06377	.03813	.02374	.06618	.04595	.20313	.02594	.01805	.03877
7	METAL PROD.	.00456	.05355	.01581	.01579	.01154	.02621	.31561	.19153	.14894
8	MACHINERY GEN.	.01911	.03546	.00347	.00347	.00701	.01039	.02140	.10869	.03854
9	ELECTRICAL M.	.00089	.01769	.00231	.00259	.00375	.00426	.00937	.03993	.11544
10	TRANSPORT EQP.	.00902	.00581	.00113	.00130	.00118	.00166	.00375	.00524	.00281
11	CONSTRUCTION	.01188	.03941	.00359	.00457	.00782	.00653	.00710	.01217	.00603
12	ELEC,GAS,STEAM	.00999	.04076	.00851	.01010	.01941	.03311	.02741	.01113	.00939
13	SERVICE	.04176	.01883	.05407	.05641	.06037	.04971	.05598	.05938	.08196
14	TRANSP.& COMM.	.00881	.01694	.03455	.02616	.04758	.03757	.04526	.02430	.02748
15	VALUE ADDED	.51218	.63983	.36708	.43417	.46069	.48885	.38871	.47112	.45199
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

							CONSUMPT.	INVEST.	FINAL DEMAND
		10	11	12	13	14	15	16	17
1	AGRICULTURE	.00010	.00031	.00017	.00403	.00074	.01593	.00000	.00776
2	MINING	.05914	.07963	.09001	.00151	.00709	.00513	.00330	.00000
3	FOOD & TOBACCO	.00061	.00032	.00075	.02866	.00272	.14061	.00000	.09670
4	TEX. & FURNIT.	.01925	.04960	.00188	.00904	.00482	.07586	.01225	.04765
5	PAPER & PRINT	.00734	.00190	.00953	.02764	.00978	.01208	.00000	.01908
6	CHEMICALS	.04572	.05825	.05333	.02083	.02258	.02771	.00276	.06155
7	METAL PROD.	.17142	.08108	.01525	.00853	.00417	.00397	.02805	.03409
8	MACHINERY GEN.	.04407	.02535	.00937	.01446	.00076	.00879	.19051	.03751
9	ELECTRICAL M.	.04518	.01874	.02291	.00812	.00797	.01517	.06775	.00780
10	TRANSPORT EQP.	.13959	.00725	.00119	.01008	.01543	.03314	.07616	.03950
11	CONSTRUCTION	.00451	.03268	.02829	.02003	.03090	.02138	.56819	.13080
12	ELEC,GAS,STEAM	.00864	.00259	.15519	.00942	.01184	.02975	.00527	.01029
13	SERVICE	.03619	.07713	.03872	.08685	.05230	.48699	.03410	.49030
14	TRANSP.& COMM.	.02057	.03409	.02531	.04271	.10428	.12350	.01166	.01698
15	VALUE ADDED	.39767	.53107	.54810	.70808	.72461	######	######	######
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

SCENARIO-A *** OTHER DC '85 *** I-O PARAMETER REGION NO. = 6

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.17563	.00075	.33890	.03419	.02996	.00471	.00000	.00000	.00009
2	MINING	.00434	.08080	.00293	.00268	.00521	.09367	.08681	.04203	.04725
3	FOOD & TOBACCO	.10539	.00007	.13608	.01287	.00101	.01191	.00037	.00049	.00091
4	TEX. & FURNIT.	.00404	.00999	.00326	.31848	.01372	.00993	.00557	.00721	.01545
5	PAPER & PRINT	.00284	.00710	.02458	.01211	.30691	.02466	.00716	.00958	.01794
6	CHEMICALS	.05896	.04050	.02472	.06636	.04902	.21188	.02609	.01829	.04027
7	METAL PROD.	.00412	.05694	.01642	.01584	.01230	.02733	.31782	.19405	.15473
8	MACHINERY GEN.	.01764	.03758	.00361	.00348	.00745	.01082	.02163	.11025	.03995
9	ELECTRICAL M.	.00083	.01877	.00240	.00260	.00399	.00443	.00945	.04051	.11984
10	TRANSPORT EQP.	.00838	.00618	.00117	.00131	.00126	.00173	.00380	.00532	.00290
11	CONSTRUCTION	.01100	.04169	.00373	.00459	.00832	.00681	.00715	.01235	.00625
12	ELEC,GAS,STEAM	.00823	.04315	.00885	.01013	.02064	.03455	.02762	.01128	.00975
13	SERVICE	.03790	.02022	.05628	.05656	.06481	.05208	.05640	.06012	.08501
14	TRANSP.& COMM.	.00784	.01801	.03590	.02629	.05074	.03923	.04562	.02462	.02850
15	VALUE ADDED	.55186	.61824	.34115	.43251	.42464	.46625	.38451	.46391	.43116
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

		10	11	12	13	14	CONSUMPT. 15	INVEST. 16	FINAL DEMAND 17
1	AGRICULTURE	.00010	.00029	.00017	.00394	.00075	.01552	.00000	.05349
2	MINING	.05992	.08002	.08696	.00146	.00721	.00511	.00330	.00000
3	FOOD & TOBACCO	.00062	.00032	.00073	.02809	.00276	.14027	.00000	.06810
4	TEX. & FURNIT.	.01948	.04989	.00179	.00890	.00490	.07574	.01226	.06145
5	PAPER & PRINT	.00744	.00187	.00928	.02730	.00993	.01207	.00000	.00558
6	CHEMICALS	.04627	.05858	.05097	.02047	.02284	.02760	.00275	.05025
7	METAL PROD.	.17353	.08145	.01464	.00839	.00421	.00391	.02801	.01072
8	MACHINERY GEN.	.04464	.02549	.00905	.01424	.00076	.00881	.19046	.03100
9	ELECTRICAL M.	.04575	.01882	.02213	.00800	.00809	.01518	.06783	.02200
10	TRANSPORT EQP.	.14108	.00729	.00114	.00993	.01565	.03316	.07607	.04401
11	CONSTRUCTION	.00457	.03286	.02735	.01967	.03141	.02146	.56823	.12752
12	ELEC,GAS,STEAM	.00874	.00261	.14984	.00929	.01203	.02983	.00529	.01190
13	SERVICE	.03650	.07753	.03712	.08538	.05310	.48758	.03406	.47554
14	TRANSP.& COMM.	.02081	.03426	.02436	.04198	.10598	.12376	.01172	.03844
15	VALUE ADDED	.39056	.52872	.56447	.71296	.72038	******	******	******
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

SCENARIO-A *** ASEAN '85 *** I-O PARAMETER REGION NO. = 7

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.12726	.01386	.37316	.12203	.03137	.03776	.00138	.00121	.00013
2	MINING	.00270	.02154	.00208	.00072	.00204	.16071	.03891	.01025	.00707
3	FOOD & TOBACCO	.05528	.00013	.12216	.00664	.00282	.00916	.00034	.00008	.00014
4	TEX. & FURNIT.	.00957	.00456	.00682	.28469	.01049	.00999	.00596	.00850	.01325
5	PAPER & PRINT	.00071	.00196	.01305	.00534	.30498	.01897	.01344	.00497	.01735
6	CHEMICALS	.05847	.06045	.03112	.09534	.04353	.18147	.04628	.02593	.05638
7	METAL PROD.	.00375	.04182	.01667	.00469	.01238	.01241	.40769	.19745	.16986
8	MACHINERY GEN.	.00303	.01182	.00183	.00367	.00361	.00378	.00895	.10784	.01028
9	ELECTRICAL M.	.00042	.00368	.00067	.00057	.00126	.00150	.00290	.01864	.20366
10	TRANSPORT EQP.	.00287	.00454	.00062	.00061	.00110	.00175	.00280	.00267	.00215
11	CONSTRUCTION	.00212	.00639	.00069	.00076	.00134	.00221	.00063	.00257	.00084
12	ELEC,GAS,STEAM	.00132	.02407	.00885	.01117	.02006	.02026	.03660	.01067	.01098
13	SERVICE	.05357	.06048	.09697	.08775	.09068	.08778	.09193	.08168	.12056
14	TRANSP.& COMM.	.00847	.01168	.02063	.01474	.02951	.03353	.04281	.01622	.01990
15	VALUE ADDED	.67045	.73303	.30467	.36128	.44483	.41869	.29937	.51132	.36745
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

							CONSUMPT.	INVEST.	FINAL DEMAND
		10	11	12	13	14	15	16	17
1	AGRICULTURE	.00012	.01715	.00060	.01745	.00135	.20513	.01907	.25223
2	MINING	.00986	.02092	.03727	.00015	.00146	.00030	.00003	.00000
3	FOOD & TOBACCO	.00003	.00003	.00015	.01455	.00391	.18571	.00000	.14762
4	TEX. & FURNIT.	.00958	.06851	.00126	.00842	.00435	.05281	.01164	.03046
5	PAPER & PRINT	.00302	.00414	.00703	.01723	.00497	.00694	.00099	.00000
6	CHEMICALS	.04054	.05521	.13207	.02977	.09982	.03425	.00259	.00300
7	METAL PROD.	.09464	.24385	.00766	.00481	.00212	.00131	.02225	.00000
8	MACHINERY GEN.	.01343	.01271	.00921	.00193	.00145	.00388	.15437	.03498
9	ELECTRICAL M.	.01606	.04572	.01251	.00236	.00772	.00500	.05275	.01797
10	TRANSPORT EQP.	.21264	.00086	.00239	.00193	.05307	.00458	.12077	.02843
11	CONSTRUCTION	.00127	.00593	.01549	.01524	.00608	.00697	.54258	.10409
12	ELEC,GAS,STEAM	.00545	.00131	.05547	.00757	.00346	.01021	.00127	.00644
13	SERVICE	.07172	.09352	.08016	.09460	.08486	.42031	.06515	.33085
14	TRANSP.& COMM.	.01060	.03730	.02541	.02217	.04122	.06260	.00654	.04394
15	VALUE ADDED	.51105	.39284	.61332	.76182	.68417	******	******	******
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

SCENARIO-A *** WEST.OTH.ASI'85 *** I-O PARAMETER REGION NO. = 8

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.13137	.00032	.27545	.13188	.03638	.00776	.00000	.00354	.00000
2	MINING	.00460	.14803	.00264	.00385	.02172	.06108	.05395	.07067	.14934
3	FOOD & TOBACCO	.03849	.00000	.06834	.00546	.00000	.05009	.00000	.00005	.00001
4	TEX. & FURNIT.	.00000	.00166	.19945	.24699	.04978	.06237	.00089	.00200	.02337
5	PAPER & PRINT	.00079	.00411	.01126	.00616	.18071	.01101	.00000	.00581	.00917
6	CHEMICALS	.02581	.00231	.01356	.02858	.05987	.13390	.00827	.03317	.03877
7	METAL PROD.	.00000	.00000	.01089	.00122	.00196	.02129	.22055	.13513	.05030
8	MACHINERY GEN.	.00371	.01950	.00075	.00053	.00232	.00405	.01285	.10661	.01654
9	ELECTRICAL M.	.00029	.00032	.00009	.00018	.00079	.00129	.00291	.02411	.09170
10	TRANSPORT EQP.	.00317	.00000	.00000	.00038	.00000	.00023	.00319	.00737	.00182
11	CONSTRUCTION	.00299	.01034	.00074	.00069	.00169	.00131	.00000	.00397	.00054
12	ELEC,GAS,STEAM	.00373	.03151	.00488	.00875	.03220	.01986	.02415	.00896	.00564
13	SERVICE	.03273	.07739	.10876	.13494	.26243	.19814	.31023	.26599	.27617
14	TRANSP.& COMM.	.00000	.26731	.04110	.01532	.03043	.02736	.07114	.01538	.01942
15	VALUE ADDED	.75234	.43719	.26209	.41508	.31970	.40025	.29188	.31722	.31722
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

							CONSUMPT.	INVEST.	FINAL DEMAND
		10	11	12	13	14	15	16	17
1	AGRICULTURE	.00013	.00000	.00001	.00000	.00000	.30861	.00000	.44036
2	MINING	.03740	.01218	.15148	.05832	.00281	.00000	.00006	.00000
3	FOOD & TOBACCO	.00000	.00003	.00009	.00000	.00000	.08012	.00000	.05173
4	TEX. & FURNIT.	.00515	.04767	.00000	.00083	.00015	.07854	.00155	.02391
5	PAPER & PRINT	.00187	.00000	.00509	.00712	.00000	.00807	.00000	.01097
6	CHEMICALS	.06039	.16632	.00000	.00726	.09337	.01094	.00000	.01362
7	METAL PROD.	.15219	.16461	.00000	.00023	.00000	.00849	.03214	.01740
8	MACHINERY GEN.	.01503	.00268	.00214	.00138	.00000	.00582	.12121	.02505
9	ELECTRICAL M.	.01173	.00000	.00477	.00084	.00000	.00572	.07972	.01910
10	TRANSPORT EQP.	.09155	.00138	.00000	.09776	.06503	.01066	.06492	.00000
11	CONSTRUCTION	.00127	.00332	.00679	.00000	.00706	.00973	.60405	.13381
12	ELEC,GAS,STEAM	.01040	.00034	.02972	.01123	.00000	.01164	.00254	.01301
13	SERVICE	.28595	.24749	.38415	.18299	.36196	.41548	.08664	.16428
14	TRANSP.& COMM.	.01678	.00084	.00161	.02695	.01904	.04617	.00717	.08675
15	VALUE ADDED	.31016	.35314	.41414	.60509	.45058	******	******	******
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

SCENARIO-A ### MIDDLE EAST '85 ### I-O PARAMETER REGION NO. = 9

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.08638	.00043	.44541	.20074	.04199	.00359	.00035	.00000	.00000
2	MINING	.00816	.21613	.00984	.01994	.01470	.04662	.02802	.09878	.08806
3	FOOD & TOBACCO	.04439	.02364	.11038	.01479	.00000	.08601	.00000	.00007	.00001
4	TEX. & FURNIT.	.00273	.00219	.01182	.33425	.05187	.02250	.00677	.03588	.05571
5	PAPER & PRINT	.00106	.00287	.01520	.00634	.41860	.01289	.00120	.00538	.00382
6	CHEMICALS	.02860	.00065	.00786	.01579	.01545	.15953	.02455	.00930	.02483
7	METAL PROD.	.00000	.00192	.00716	.01155	.00528	.01497	.33290	.08174	.12117
8	MACHINERY GEN.	.00854	.00611	.00143	.00673	.00311	.00717	.01949	.13591	.02267
9	ELECTRICAL M.	.00054	.00055	.00042	.00509	.00106	.00248	.00501	.05228	.02409
10	TRANSPORT EQP.	.00660	.00250	.00645	.02658	.00000	.02503	.03955	.00248	.00256
11	CONSTRUCTION	.00404	.01371	.00102	.00097	.00227	.00179	.00000	.00605	.00075
12	ELEC,GAS,STEAM	.00290	.01152	.00156	.00405	.02857	.01173	.00840	.01071	.01261
13	SERVICE	.00379	.00000	.03923	.01516	.00000	.00000	.01477	.00000	.05081
14	TRANSP.& COMM.	.00000	.00000	.08885	.02431	.00376	.05302	.01549	.01893	.02777
15	VALUE ADDED	.80224	.71779	.25338	.31373	.41336	.55267	.50348	.54248	.56515
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

		10	11	12	13	14	CONSUMPT. 15	INVEST. 16	FINAL DEMAND 17
1	AGRICULTURE	.00016	.03631	.00001	.00556	.00000	.13288	.00000	.00943
2	MINING	.06547	.02853	.08252	.00176	.06259	.00609	.00007	.00000
3	FOOD & TOBACCO	.00000	.00004	.00013	.00157	.00000	.12334	.00000	.17729
4	TEX. & FURNIT.	.02539	.06298	.00000	.01046	.00717	.10349	.00239	.09150
5	PAPER & PRINT	.00259	.00000	.00688	.01506	.00000	.00168	.00000	.00823
6	CHEMICALS	.12294	.13821	.02407	.00632	.00000	.00947	.00000	.00000
7	METAL PROD.	.11117	.08035	.01324	.00236	.00000	.00624	.02368	.03619
8	MACHINERY GEN.	.02765	.01240	.00719	.00238	.00000	.00867	.10888	.04136
9	ELECTRICAL M.	.02554	.00496	.01707	.00142	.00813	.01211	.04990	.03372
10	TRANSPORT EQP.	.16930	.00283	.00000	.00357	.00000	.00851	.07399	.03236
11	CONSTRUCTION	.00163	.00447	.00918	.02056	.00918	.01312	.70604	.12360
12	ELEC,GAS,STEAM	.00646	.00046	.04038	.00678	.00053	.02291	.00341	.01921
13	SERVICE	.00000	.07463	.00562	.07209	.04517	.45080	.01065	.37239
14	TRANSP.& COMM.	.00000	.06655	.01356	.01395	.02745	.10069	.02097	.05473
15	VALUE ADDED	.44169	.48727	.78015	.83616	.83977	******	******	******
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

SCENARIO-A ### AFRICA '85 ### I-O PARAMETER REGION NO. = 10

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.10461	.00010	.34428	.03929	.01319	.01190	.00000	.00000	.00005
2	MINING	.00200	.03225	.00108	.00098	.00339	.11931	.09122	.00771	.00417
3	FOOD & TOBACCO	.02550	.00065	.09742	.02640	.00096	.01124	.00000	.00001	.00003
4	TEX. & FURNIT.	.02616	.00521	.01511	.33670	.00468	.01507	.00291	.00879	.01601
5	PAPER & PRINT	.00030	.00320	.00840	.00398	.30701	.01536	.00249	.00440	.01530
6	CHEMICALS	.02736	.04078	.02547	.05128	.04125	.16248	.03604	.03058	.03908
7	METAL PROD.	.01009	.05053	.01005	.00748	.00599	.01554	.27760	.13096	.10789
8	MACHINERY GEN.	.00433	.02725	.00342	.00231	.00662	.00603	.00684	.12151	.00991
9	ELECTRICAL M.	.00028	.00752	.00003	.00007	.00024	.00045	.00413	.02508	.12260
10	TRANSPORT EQP.	.00154	.00125	.00387	.00241	.00758	.00835	.00451	.01017	.00627
11	CONSTRUCTION	.00092	.00553	.00023	.00022	.00052	.00041	.00000	.00121	.00017
12	ELEC,GAS,STEAM	.00066	.00656	.00495	.00571	.01407	.01153	.01490	.00645	.00553
13	SERVICE	.09977	.05652	.14319	.16776	.15588	.10655	.08459	.10610	.18364
14	TRANSP.& COMM.	.05591	.05647	.04100	.05877	.07763	.07683	.09454	.08062	.07266
15	VALUE ADDED	.64059	.70620	.30148	.29664	.36098	.43895	.38022	.46640	.41670
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

							CONSUMPT.	INVEST.	FINAL DEMAND
		10	11	12	13	14	15	16	17
1	AGRICULTURE	.00028	.00000	.00001	.00000	.00109	.08974	.04586	.31464
2	MINING	.00749	.01160	.05671	.00000	.00212	.00157	.00002	.00000
3	FOOD & TOBACCO	.00000	.00001	.00003	.01455	.00191	.27986	.00000	.08871
4	TEX. & FURNIT.	.00883	.05510	.00149	.00401	.00520	.12256	.01034	.10695
5	PAPER & PRINT	.00399	.00000	.00291	.01866	.01964	.02047	.00000	.00955
6	CHEMICALS	.02683	.22450	.13185	.01606	.18338	.08100	.00083	.02687
7	METAL PROD.	.05871	.12490	.00978	.00281	.03782	.02813	.02625	.00000
8	MACHINERY GEN.	.02012	.00175	.00403	.00138	.01662	.00713	.25634	.02885
9	ELECTRICAL M.	.01060	.01141	.00370	.00134	.00727	.02096	.04874	.02091
10	TRANSPORT EQP.	.23900	.00042	.00105	.00172	.06550	.04749	.18884	.02304
11	CONSTRUCTION	.00039	.00101	.00218	.00173	.00260	.00294	.41229	.08343
12	ELEC,GAS,STEAM	.00973	.00066	.09080	.02437	.01027	.01629	.00077	.00554
13	SERVICE	.10911	.05757	.06707	.08629	.10318	.22768	.00752	.26248
14	TRANSP.& COMM.	.06662	.00193	.01559	.03462	.03002	.05416	.00218	.02903
15	VALUE ADDED	.43831	.50913	.61279	.79245	.51337	######	######	######
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

SCENARIO-A *** LATIN AMERI '85 *** I-O PARAMETER REGION NO. = 11

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.09326	.00013	.32863	.03399	.01545	.01096	.00000	.00000	.00004
2	MINING	.00234	.03455	.00107	.00101	.00315	.10872	.08148	.00910	.00450
3	FOOD & TOBACCO	.02588	.00059	.09486	.02442	.00076	.01053	.00000	.00002	.00003
4	TEX. & FURNIT.	.02292	.00495	.01450	.30850	.00419	.01414	.00265	.00782	.01430
5	PAPER & PRINT	.00037	.00318	.00885	.00372	.26166	.01508	.00229	.00441	.01392
6	CHEMICALS	.02615	.03774	.02445	.04663	.03544	.15532	.03328	.02913	.03548
7	METAL PROD.	.00885	.04627	.01016	.00686	.00525	.01508	.26090	.12362	.09683
8	MACHINERY GEN.	.00431	.02583	.00339	.00211	.00597	.00610	.00778	.11883	.01046
9	ELECTRICAL M.	.00028	.00703	.00004	.00009	.00031	.00057	.00418	.02530	.11248
10	TRANSPORT EQP.	.00175	.00103	.00373	.00224	.00644	.00786	.00456	.00984	.00595
11	CONSTRUCTION	.00118	.00627	.00030	.00028	.00067	.00053	.00000	.00156	.00021
12	ELEC,GAS,STEAM	.00085	.00705	.00485	.00516	.01270	.01120	.01433	.00620	.00504
13	SERVICE	.08806	.05080	.13844	.15274	.13033	.09764	.07978	.09934	.16972
14	TRANSP.& COMM.	.04924	.05225	.04055	.05442	.06671	.07207	.08946	.07670	.06713
15	VALUE ADDED	.67456	.72233	.32617	.35783	.45096	.47420	.41931	.48814	.46392
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

		10	11	12	13	14	CONSUMPT. 15	INVEST. 16	FINAL DEMAND 17
1	AGRICULTURE	.00029	.00000	.00001	.00000	.00102	.08563	.04504	.05672
2	MINING	.00920	.01188	.04296	.00000	.00230	.00134	.00002	.00000
3	FOOD & TOBACCO	.00000	.00001	.00004	.01519	.00177	.27636	.00000	.12620
4	TEX. & FURNIT.	.00899	.05579	.00096	.00436	.00493	.12136	.01048	.05016
5	PAPER & PRINT	.00424	.00000	.00294	.02053	.01825	.02040	.00000	.01309
6	CHEMICALS	.02763	.22561	.08947	.01717	.16937	.07993	.00072	.03564
7	METAL PROD.	.06179	.12499	.00670	.00303	.03507	.02759	.02592	.04352
8	MACHINERY GEN.	.02151	.00199	.00319	.00158	.01525	.00735	.25605	.03302
9	ELECTRICAL M.	.01156	.01129	.00343	.00149	.00671	.02107	.04960	.02992
10	TRANSPORT EQP.	.24187	.00054	.00070	.00191	.06064	.04768	.18802	.02152
11	CONSTRUCTION	.00050	.00131	.00274	.00173	.00321	.00379	.41322	.10683
12	ELEC,GAS,STEAM	.01003	.00069	.06846	.02630	.00964	.01706	.00100	.00214
13	SERVICE	.10945	.05800	.04584	.09249	.09634	.23362	.00710	.46471
14	TRANSP.& COMM.	.06824	.00200	.01112	.03704	.03004	.05681	.00282	.01652
15	VALUE ADDED	.42471	.50589	.72143	.77718	.54547	******	******	******
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

SCENARIO-A *** USSR,EE '85 *** I-O PARAMETER REGION NO. = 12

		1	2	3	4	5	6	7	8	9
1	AGRICULTURE	.20804	.00021	.46874	.09158	.00715	.00071	.00003	.00002	.00001
2	MINING	.00300	.16492	.00243	.00157	.03549	.05108	.10477	.00979	.00435
3	FOOD & TOBACCO	.01551	.00128	.30828	.01348	.00748	.01982	.00196	.00230	.00247
4	TEX. & FURNIT.	.00494	.04313	.01240	.48724	.18584	.02956	.01281	.01741	.02073
5	PAPER & PRINT	.00022	.00056	.00397	.00131	.11956	.00888	.00128	.00372	.00463
6	CHEMICALS	.02576	.02506	.00696	.03209	.04764	.23355	.05970	.03951	.07643
7	METAL PROD.	.00310	.01271	.00640	.00602	.00988	.03388	.27118	.14017	.18943
8	MACHINERY GEN.	.01559	.03320	.00328	.00517	.01033	.01355	.02169	.14883	.07885
9	ELECTRICAL M.	.00053	.00720	.00055	.00079	.00206	.00234	.00460	.04885	.11223
10	TRANSPORT EQP.	.00333	.00227	.00023	.00141	.00074	.00121	.00214	.02759	.00743
11	CONSTRUCTION	.00065	.00226	.00016	.00015	.00035	.00029	.00000	.00088	.00012
12	ELEC,GAS,STEAM	.00285	.04296	.00341	.00618	.04585	.04347	.03184	.02025	.01358
13	SERVICE	.01568	.00212	.02257	.01148	.04316	.01708	.02890	.00945	.01498
14	TRANSP.& COMM.	.00924	.01926	.01766	.02581	.09781	.07378	.05271	.03032	.03054
15	VALUE ADDED	.69156	.64287	.14294	.31574	.38665	.47080	.40639	.50089	.44423
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

		10	11	12	13	14	CONSUMPT. 15	INVEST. 16	FINAL DEMAND 17
1	AGRICULTURE	.00004	.00004	.00000	.01532	.00029	.17908	.07388	.13259
2	MINING	.00769	.00209	.23173	.00412	.00965	.00565	.00466	.00581
3	FOOD & TOBACCO	.00372	.00278	.00083	.04988	.00053	.32472	.00797	.19097
4	TEX. & FURNIT.	.02017	.07113	.00187	.06849	.01380	.19143	.00000	.09633
5	PAPER & PRINT	.00165	.00000	.00121	.01676	.00000	.00056	.00000	.00069
6	CHEMICALS	.07056	.19460	.03611	.04932	.05324	.01963	.02161	.02172
7	METAL PROD.	.14061	.07658	.00292	.02678	.00558	.01396	.01241	.01442
8	MACHINERY GEN.	.09011	.01549	.01192	.00632	.01247	.02034	.23765	.11943
9	ELECTRICAL M.	.07933	.02201	.00506	.00436	.00138	.00632	.03041	.01766
10	TRANSPORT EQP.	.12133	.00386	.00034	.00380	.01908	.00507	.06388	.03390
11	CONSTRUCTION	.00028	.00073	.00149	.00000	.00156	.00212	.50500	.22794
12	ELEC,GAS,STEAM	.01579	.00444	.00829	.01192	.01579	.01013	.00110	.00680
13	SERVICE	.00697	.04178	.01790	.03365	.00915	.18979	.01532	.10109
14	TRANSP.& COMM.	.03388	.08148	.13092	.03089	.02995	.03120	.02611	.03067
15	VALUE ADDED	.40784	.48298	.54941	.67838	.82752	******	******	******
	TOTAL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000

II-2. International Trade

II-2-1. Data Analysis

Time series data of the following variables of the international trade from 1962 to 1973 are collected from the statistics listed below.

- ${}_je_i^*$: The total amount of exported goods of sector j of i-th country.
- ${}_jm_i^*$: The total amount of imported goods of sector j of i-th country.
- ${}_Me_i^*$: The total amount of export of i-th country. Corresponding data in reference 3 (Purchasers' values at 1970 current prices) are used.
- ${}_Mm_i^*$: The total amount of import of i-th country.
- ${}_{\cdot}X_i^*$: Gross national product of i-th country.
- P_{ei} : Export price index of i-th country.
- P_{mi} : Import price index of i-th country.
- P_{gi} : GNP deflator.
- ρ_i : Official exchange rate in 1970 by US dollars.

<u>Conversion into values in 1970 constant prices</u>

It would be the most desirable to estimate deflators by sectors and by regions, but the present data status enables only the estimation of price indices of the total export by regions, which are then used to convert exports and imports in current prices into the values in 1970 constant prices.

Values in current prices by each currency are converted to those in 1970 US dollars.

$$ {}_jX_i^*(t) = {}_jX_i(t)\,\frac{P_{gi}('70)}{P_{gi}(t)}\cdot\frac{1}{\rho_i}\ , \qquad (1)$$

$$ {}_je_i^*(t) = {}_je_i(t)\,\frac{P_{ei}('70)}{P_{ei}(t)}\cdot\frac{1}{\rho_i}\ , \qquad (2)$$

$$ {}_jm_i^*(t) = {}_jm_i(t)\ \frac{P_{mi}('70)}{P_{mi}(t)} \cdot \frac{1}{\rho_i} , \qquad (3) $$

Aggregation to regional data

After these data of individual countries are converted into constant prices, all available data of the countries belonging to each region are summed up, and are used as the regional data.

Regression analysis of the data

Regression analysis, or the least-squares method is applied to each time series data of export and import of each region. Several types of equations have been examined but eventually the following simple equations are adopted.

$$ \log {}_je_i^* = {}_j\alpha_i^E + {}_j\beta_i^E \log .X_i^* , \qquad (4) $$

$$ \log {}_jm_i^* = {}_j\alpha_i^M + {}_j\beta_i^M \log .X_i^* , \qquad (5) $$

where $i=1,\cdots\cdots,12,$
$j=1,\cdots\cdots,10,$and for the total of all sectors.

The list of the countries for which the trade data are available is shown in Table II-2-1, where * denotes values at 1970 constant prices; otherwise they are at current prices. And results of the regression analysis are shown in Table II-2-2, where R_e, R_m and R_{net} denote the correlation coefficient of the estimate and the data of exports, imports and net exports respectively.

II-2-2. Steps of determining the upper and lower bounds of net exports.

The steps are briefly discussed in Chapter 9, section 4, and are illustrated in Fig. II-2-1.

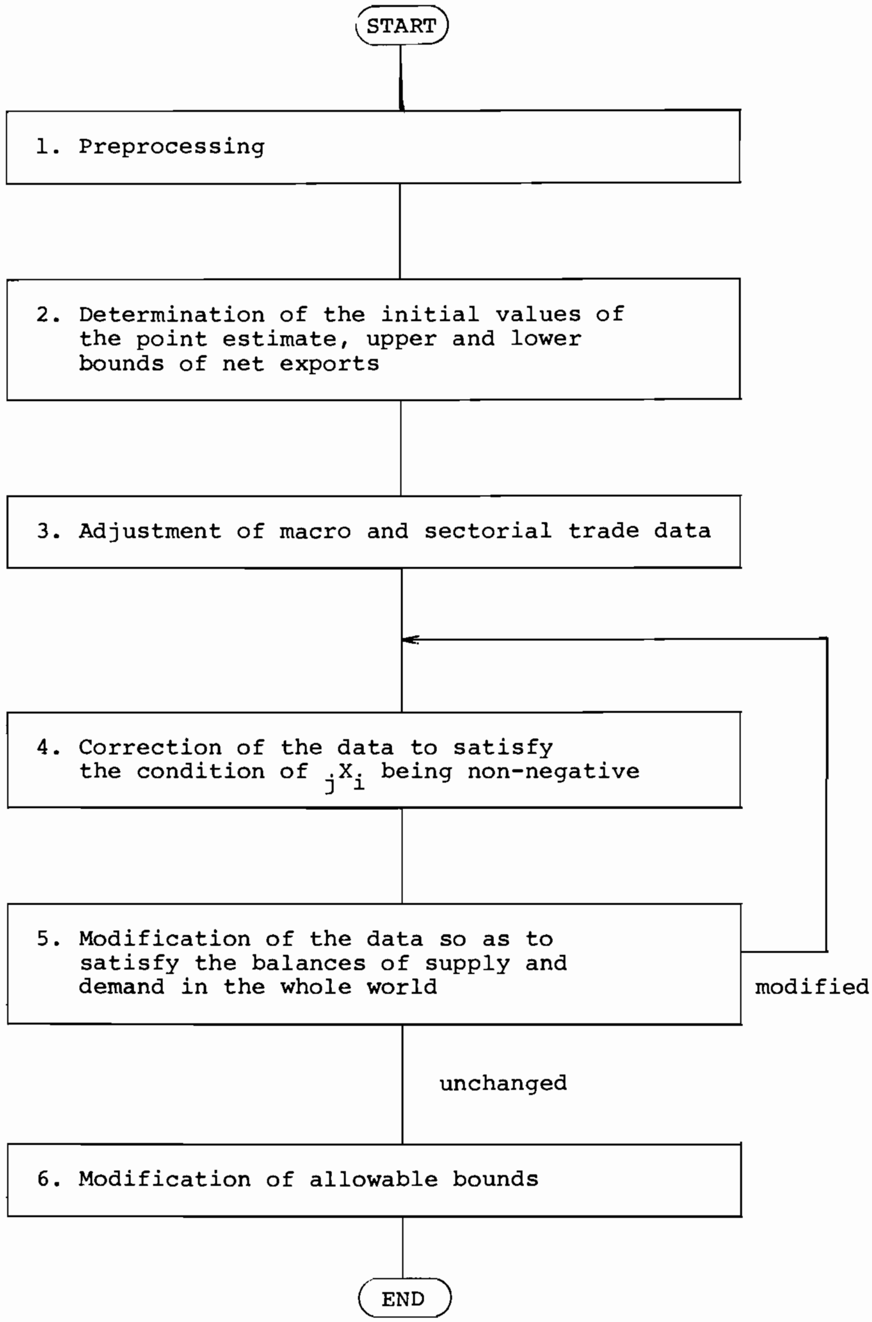


Fig. II.2.1 Flow chart of the algorithm to get the allowable bounds of trade.

The number in the figure corresponds to the step number quoted in Chapter 9, section 4. The equations used in each step of the data modification are shown in the following.

Hereafter all values are estimated in 1970 constant prices so that the symbol * indicating constant prices is omitted only for brevity.

Step 1

First of all, estimates of β^E or β^M are replaced into new estimates in the following equation.

$$f(\beta) = \begin{cases} a_1 \tan^{-1} \dfrac{\beta - 1}{a_1} + 1 , & \beta < 1 \\ a_2 \tan^{-1} \dfrac{\beta - 1}{a_2} + 1 , & \beta \geqq 1 \end{cases} \tag{6}$$

where

$$\begin{cases} a_1 = \dfrac{2}{\pi} (1 - K_1) , \\ a_2 = \dfrac{2}{\pi} (K_2 - 1) , \end{cases} \tag{7}$$

and K1 and K2 are arbitrary predetermined values satisfying K1<1<K2. This step plays an important role in the process of generating consistent trade estimates, by reducing extraordinarily high growth rates to certain normal ones. K1 and K2 are in ordinary computer runs set to 1/3 and 3 respectively.

After β^E and β^M are modified, the following values are calculated:

$${}_j\hat{e}_i = {}_je_i('70) \left[\frac{.X_i(t)}{.X_i('70)} \right]^{{}_j\beta_i^E} , \tag{8}$$

$${}_ju_i^E = \max_t \frac{{}_je_i(t)}{.X_i(t)} , \tag{9}$$

$${}_jl_i^E = \min_t \frac{{}_je_i(t)}{.X_i(t)} , \tag{10}$$

$${}_j\sigma^2_{E_i} = \mathrm{var} ({}_je_i - {}_j\hat{e}_i) , \tag{11}$$

$${}_j\sigma^2_{Y_i} = \mathrm{var} ({}_je_i - {}_jm_i) . \tag{12}$$

Here, only the equations relating to exports are shown. Those relating to imports are obtained by replacing suffix E or e in equations (8) - (11) by M or m.

Step 2

According to the results of the regression analysis, ${}_jy_i^0$, initial point estimate of the net export of j-th sector in region i, and its deviation ${}_jd_i^0$ are determined in the following way. j = M indicates the total trade.

Case 1. $R_e \geqq 0.95$ and $R_m \geqq 0.95$.

$${}_jy_i^0 = {}_j\hat{e}_i - {}_j\hat{m}_i \quad , \tag{13}$$

$${}_jd_i^0 = 2 \; {}_j\sigma_{y_i} \frac{.X_i(t)}{.X_i('70)} \quad . \tag{14}$$

Case 21. $R_e \geqq 0.95$ and $R_m < 0.95$.

$${}_jy_i^0 = {}_j\hat{e}_i - \frac{{}_ju_i^M + {}_jl_i^M}{2} \; .X_i(t) \quad , \tag{15}$$

$${}_jd_i^0 = 2 \; {}_j\sigma_{E_i} \frac{.X_i(t)}{.X_i('70)} + \frac{{}_ju_i^M - {}_jl_i^M}{2} \; .X_i(t) \quad . \tag{16}$$

Case 22. $R_e < 0.95$ and $R_m \geqq 0.95$.

$${}_jy_i^0 = \frac{{}_ju_i^E + {}_jl_i^E}{2} \; .X_i(t) - {}_j\hat{m}_i \quad , \tag{17}$$

$${}_jd_i^0 = \frac{{}_ju_i^E - {}_jl_i^E}{2} \; .X_i(t) + 2 \; {}_j\sigma_M \frac{.X_i(t)}{.X_i('70)} \quad . \tag{18}$$

Case 3. $R_e < 0.95$ and $R_m < 0.95$.

$${}_jy_i^0 = \frac{{}_ju_i^E + {}_jl_i^E}{2} \; .X_i(t) - \frac{{}_ju_i^M + {}_jl_i^M}{2} \; .X_i(t) \quad , \tag{19}$$

$${}_jd_i^0 = \frac{{}_ju_i^E - {}_jl_i^E}{2} \; .X_i(t) + \frac{{}_ju_i^M - {}_jl_i^M}{2} \; .X_i(t) \quad . \tag{20}$$

Then, ${}_jU_i^0$ and ${}_jL_i^0$, the upper and lower bounds of net export, are determined by,

$$ {}_jU_i^0 = {}_jY_i^0 + {}_jd_i^0 , \tag{21} $$

$$ {}_jL_i^0 = {}_jY_i^0 - {}_jd_i^0 . \tag{22} $$

As for sectors 1 and 2 in region 9, ${}_jy_i^0$ is fixed to the predetermined value throughout this algorithm. These predetermined ${}_jy_i$'s are indicated in this algorithm by setting the index(j,i) to be 1. Otherwise, the index(j,i) is 0.

<u>Step 3</u>

The revised estimates ${}_jy_i$ and ${}_My_i$ (macro-trade) are determined in the following equations.

$$ {}_My_i = \frac{\cdot d_i^0 \; {}_My_i^0 + {}_Md_i^0 \; \cdot y_i^0}{\cdot d_i^0 + {}_Md_i^0} = \cdot y_i , \tag{23} $$

$$ {}_jy_i = {}_jy_i^0 + \frac{{}_jd_i^0}{\cdot d_i^0} (\cdot y_i - \cdot y_i^0) , \tag{24} $$

where

$$ \cdot y_i \triangleq \sum_{j=1}^{10} {}_jy_i , \tag{25} $$

$$ \cdot y_i^0 \triangleq \sum_{j=1}^{10} {}_jy_i^0 , \tag{26} $$

$$ \cdot d_i^0 \triangleq \sum_{j=1}^{10} {}_jd_i^0 , \tag{27} $$

When the index(j,i)=1, ${}_jd_i^0$ is set to be 0 in this step.

Step 4

The flow chart of this step is shown in Fig. II-2-2.

Step 5

See section 4 in Chapter 9.

Step 6

The allowable bound of ${}_jy_i$, ${}_jd_i$ is enlarged according to the change of ${}_jy_i$ from the initial value ${}_jy_i^0$.

This correction is made so that ${}_jd_i$ may become less than 3.0 ${}_jd_i^0$, and become 1.5 ${}_jd_i^0$ when the following equation holds:

$$\left| {}_jy_i - {}_jy_i^0 \right| / {}_jd_i^0 = 1 \quad . \tag{28}$$

More precisely,

$${}_jd_i = {}_jd_i^0 \left[3 - 2 \exp\left(- \frac{1}{a} \left| \frac{{}_jy_i - {}_jy_i^0}{{}_jd_i^0} \right| \right) \right] , \tag{29}$$

where

$$a = 3.476 \quad .$$

The shape of this function is shown in Fig. II-2-3.

The upper and lower bounds are then,

$${}_jU_i = {}_jy_i + {}_jd_i \quad , \tag{30}$$

$${}_jL_i = {}_jy_i - {}_jd_i \quad . \tag{31}$$

Table II-2-6 shows an example of y_i^0 and the final y_i obtained through the above steps.

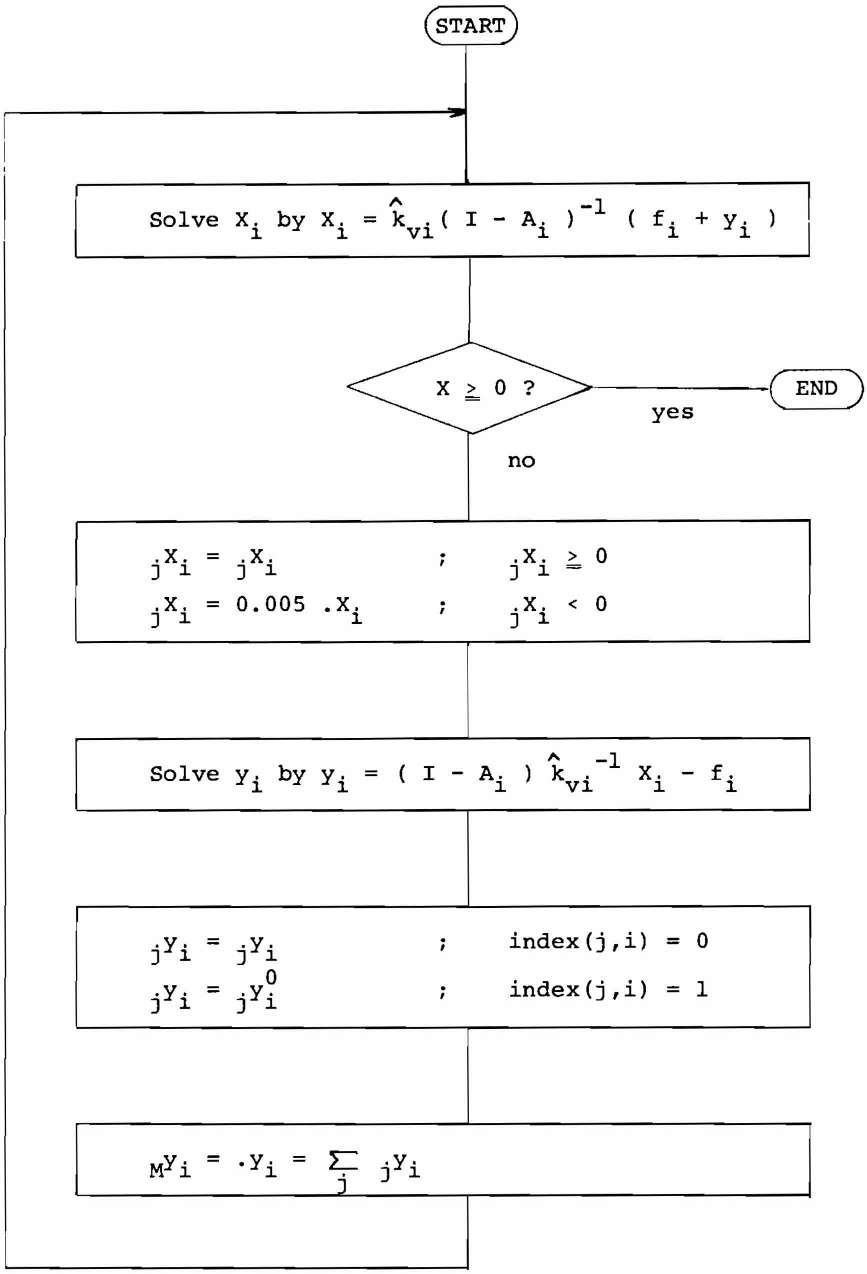


Fig. II.2.2 The flow chart of Step 4.

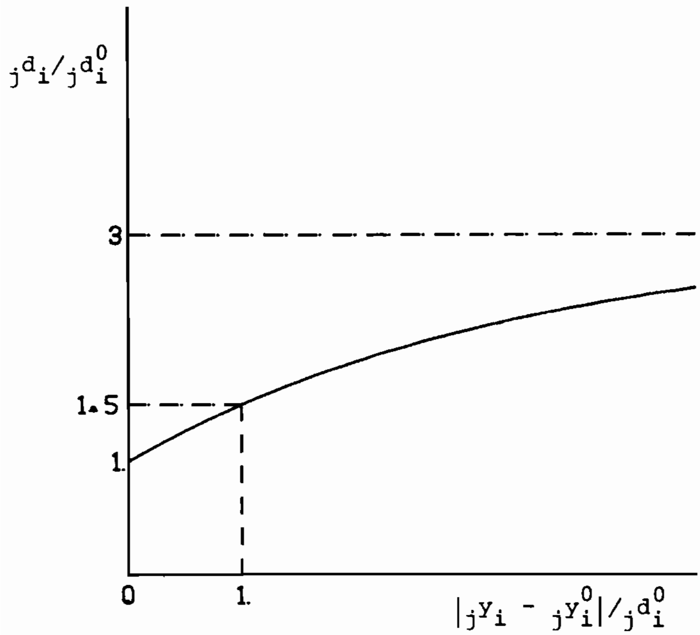


Fig. II.2.3 The function modifying the width of the allowable region of net export.

Table II.2.1 Export (f.o.b.) and import (c.i.f.) by regions and by sectors in 1970.

(million US dollars)

	MACRO	SEC- 1	SEC- 2	SEC- 3	SEC- 4	SEC- 5	SEC- 6	SEC- 7	SEC- 8	SEC- 9	SEC-10
EXPORT (1970)											
REG- 1	22169	909	19	53	3655	476	2009	4919	2593	3082	4450
REG- 2	7107	4192	1107	73	120	80	397	670	159	73	232
REG- 3	10978	3637	2689	342	313	2738	876	2681	1553	680	4465
REG- 4	56500	10454	2916	1740	2189	2011	6802	4336	12207	4369	9472
REG- 5	142888	16967	2734	3136	18261	4266	21522	19646	25830	11357	19168
REG- 6	28957	5253	621	952	3340	4436	2387	4525	2976	1572	2862
REG- 7	6607	2393	961	352	619	255	1289	577	39	85	33
REG- 8	3596	1465	226	83	1152	14	279	223	51	26	74
REG- 9	5496	192	4397	4	65	0	804	3	2	1	5
REG-10	3032	1399	662	70	223	18	72	574	4	3	4
REG-11	14252	7262	2551	301	435	144	1521	1484	257	179	94
REG-12	39506	6706	3589	997	1865	960	2498	4460	9479	2606	6343
IMPORT (1970)											
REG- 1	19543	6514	6394	182	554	366	1840	1389	1357	498	436
REG- 2	7275	651	340	127	885	326	1107	668	1459	528	1181
REG- 3	17663	1920	1151	170	1362	361	1682	1519	3692	1189	4613
REG- 4	54560	10396	4048	1570	5628	3522	5053	6983	4672	3516	9108
REG- 5	159057	31752	17198	3591	14011	6989	15096	18707	14956	7520	9324
REG- 6	32118	6864	2771	524	3409	977	4622	4157	4773	2318	3689
REG- 7	7962	1467	660	124	748	257	1120	908	1317	506	830
REG- 8	4713	1279	240	146	247	115	785	677	782	218	220
REG- 9	3412	555	3	112	311	119	380	600	650	338	341
REG-10	3154	669	105	148	289	119	561	301	458	186	314
REG-11	14374	1751	705	203	689	632	2530	1785	3148	1271	1658
REG-12	39540	13904	2144	2107	2086	938	3393	3682	5833	807	4643

Table II.2.2 The matrix of correlation coefficients between estimates and actual data of exports and imports.

	MACRO	SEC- 1	SEC- 2	SEC- 3	SEC- 4	SEC- 5	SEC- 6	SEC- 7	SEC- 8	SEC- 9	SEC-10
R (EXPORT)											
REG- 1	.9948	.8633	.9448	.1419	.9639	.9565	.9890	.9760	.9962	.9964	.9883
REG- 2	.9917	.9766	.9391	.9143	.9613	.9572	.9578	.9642	.9604	.9758	.9889
REG- 3	.9926	.5550	.9749	.9642	.9727	.9684	.9882	.8589	.9873	.8645	.9037
REG- 4	.9804	.6922	.6846	.7464	.9414	.9626	.9714	.6751	.9782	.9750	.9660
REG- 5	.9991	.9867	.5077	.9865	.9970	.9998	.9978	.9892	.9967	.9957	.9924
REG- 6	.9989	.9860	.8609	.8909	.9900	.9911	.9847	.9834	.9964	.9991	.9929
REG- 7	.9771	.9755	.9761	.8051	.9874	.9702	.7709	.8946	.9206	.9866	.8390
REG- 8	.6052	.8999	.7428	.2799	.8030	.6312	.0921	.8217	.7590	.9116	.7396
REG- 9	.9837	.8763	.9949	.6413	.9547	.6677	.2007	.9493	.7357	.8424	.8777
REG-10	.9791	.8848	.1307	.6969	.9788	.5754	.8507	.8590	.5790	.7161	.2959
REG-11	.9696	.7487	.5441	.9264	.9776	.9726	.8896	.7277	.9892	.9324	.9822
REG-12	.9842	.6885	.8994	.4431	.9534	.9504	.9800	.9192	.9638	.7771	.7372
R (IMPORT)											
REG- 1	.9965	.9959	.9948	.9407	.9910	.9813	.9788	.7613	.9399	.9626	.9324
REG- 2	.9232	.8723	.2583	.9400	.9559	.9561	.9689	.7509	.9035	.9633	.8519
REG- 3	.9941	.7999	.8223	.9202	.9787	.9460	.9730	.9350	.9707	.9923	.9530
REG- 4	.9927	.8745	.8138	.9284	.9868	.9522	.9782	.9521	.9886	.9842	.9732
REG- 5	.9960	.9457	.9885	.9264	.9906	.9946	.9971	.9585	.9929	.9923	.9970
REG- 6	.9972	.9677	.9869	.8868	.9850	.9868	.9899	.9216	.9948	.9976	.9923
REG- 7	.9765	.9270	.9664	.8319	.8460	.9267	.9805	.9013	.9638	.9629	.9492
REG- 8	.4328	.3356	.6998	.4993	.1126	.4223	.6320	.0496	.7473	.5745	.5706
REG- 9	.9839	.7977	-.0125	.9321	.9559	.9643	.9635	.9674	.9780	.9742	.8251
REG-10	.9841	.9679	.8084	.9328	.8044	.9735	.8998	.9182	.9182	.9439	.8541
REG-11	.9970	.9603	.9556	.8911	.9882	.9319	.9846	.9598	.9971	.9833	.8792
REG-12	.9962	.2920	.4094	.5365	.9553	.9910	.9784	.7082	.8774	.9631	.9271
R (NET)											
REG- 1	.9039	.9913	.9947	.9518	.8727	.7051	.8935	.9416	.9726	.9946	.9883
REG- 2	.8114	.9838	.9554	.1241	.9184	.7553	.7684	.7140	.8671	.9440	.7026
REG- 3	.6793	.3575	.9625	.8609	.9601	.9324	.7748	.4350	.8285	.8554	.5076
REG- 4	.9476	.2882	.0158	.2554	.9858	.2891	.6223	.8451	.7607	.8467	.9462
REG- 5	.5510	-.0729	.9894	.8993	.6839	.9207	.9703	.1255	.9842	.9466	.9591
REG- 6	.6976	.5869	.9875	.6946	.9249	.9691	.9803	.7739	.8584	.7293	.6747
REG- 7	.7774	.3624	.0482	.5420	.9600	.9287	.7897	-.0680	.9628	.9488	.9464
REG- 8	.5831	.2844	.5728	.4435	.8097	.1799	.4422	.3538	.7791	.6947	.6399
REG- 9	.5330	.6827	.9950	.9172	.8311	.9644	.5134	.9669	.9781	.9740	.8203
REG-10	-.9413	.6626	-.6404	.9130	.7945	.9293	.8680	.7428	.9146	.9418	.8442
REG-11	.9372	.9241	.4613	-.1268	.8554	.8711	.9437	.7290	.9942	.9648	.7693
REG-12	.6164	.1584	.6119	.3504	-.0296	.7385	.7075	.9276	.8446	.4847	.6860

Table II.2.3 Constant terms of the estimates of exports and imports.

		MACRO	SEC- 1	SEC- 2	SEC- 3	SEC- 4	SEC- 5	SEC- 6	SEC- 7	SEC- 8	SEC- 9	SEC-10
ALPHA (EXPORT)												
	REG- 1	-3.51	.22	-14.59	2.36	.06	-1.69	-4.63	-4.24	-7.51	-6.45	-7.93
	REG- 2	-4.76	-1.30	-21.70	-7.38	-10.63	-15.15	-12.85	-9.69	-12.01	-13.00	-18.34
	REG- 3	-4.21	1.79	-4.31	-3.23	-8.03	-.31	-4.14	-1.71	-9.72	-11.62	-27.08
	REG- 4	-5.17	-.15	-5.49	-.74	-2.90	-8.54	-3.87	-3.69	-7.85	-9.61	-14.59
	REG- 5	-6.65	-5.57	-1.57	-9.35	-7.42	-12.13	-8.29	-6.11	-8.29	-8.76	-8.31
	REG- 6	-3.64	-.75	-.56	-1.57	-7.16	-1.33	-6.55	-5.22	-7.19	-11.63	-8.99
	REG- 7	-3.30	-.94	-2.66	-3.53	-21.13	-11.84	-2.62	-13.77	-16.15	-29.76	-7.53
	REG- 8	2.33	9.53	-3.87	4.84	-3.43	-12.32	-.03	-37.74	-31.64	-35.23	-46.35
	REG- 9	-.55	-.72	-1.19	-5.18	-4.14	-3.44	2.43	-8.96	-7.38	-5.93	-10.25
	REG-10	-.52	-3.02	1.06	3.58	-8.43	-2.55	-.98	-11.11	-6.77	-5.88	-1.70
	REG-11	-.10	-.01	2.00	-1.55	-11.06	-13.98	-.44	-.65	-21.44	-29.09	-21.54
	REG-12	-3.17	-.74	-.93	-.33	-12.48	-18.05	-5.78	-3.26	-6.10	-19.93	-1.35
ALPHA (IMPORT)												
	REG- 1	-2.48	-1.32	-4.48	-2.62	-9.85	-6.51	-2.00	-5.12	-3.30	-7.57	-5.81
	REG- 2	-2.27	-2.15	4.39	-2.28	-3.04	-2.51	-3.88	-4.17	-4.15	-5.44	-4.00
	REG- 3	-3.80	1.37	-.21	-2.59	-2.94	-3.80	-2.90	-1.90	-3.42	-7.75	-13.89
	REG- 4	-9.50	.84	.24	-4.37	-9.53	-2.33	-8.02	-10.56	-24.47	-30.35	-38.83
	REG- 5	-6.30	-.06	-7.22	-2.85	-11.23	-8.61	-9.28	-8.64	-10.81	-13.57	-17.04
	REG- 6	-2.83	-.59	-6.22	-.47	-4.14	-8.53	-3.30	-4.13	-4.46	-6.17	-3.85
	REG- 7	-3.88	-1.74	-6.27	-8.11	-4.09	-7.18	-3.64	-4.62	-9.16	-9.66	-4.21
	REG- 8	5.16	7.52	-15.49	-2.36	2.90	-.21	-.82	2.68	9.74	6.93	7.94
	REG- 9	-2.73	-1.35	-.24	-5.36	-1.44	-5.41	-2.84	-5.31	-5.36	-7.28	-2.02
	REG-10	-.37	-2.02	-5.68	-3.85	.53	-2.49	-1.77	-.59	-.59	-1.90	-.76
	REG-11	-2.32	-.08	-4.23	-4.01	-3.91	-4.39	-3.77	-2.74	-4.68	-6.09	-.76
	REG-12	-5.05	.05	1.44	-4.85	-22.96	-10.19	-4.99	-.49	-9.94	-11.55	-8.31

Table II.2.4 Values of elasticity of export and import to gross regional product.

	MACRO	SEC- 1	SEC- 2	SEC- 3	SEC- 4	SEC- 5	SEC- 6	SEC- 7	SEC- 8	SEC- 9	SEC-10
BETA (EXPORT)											
REG- 1	1.48	.51	3.01	-.12	.66	.82	1.50	1.49	2.06	1.88	2.19
REG- 2	1.86	1.07	5.32	1.98	2.74	3.68	3.32	2.69	3.06	3.20	4.46
REG- 3	1.72	.36	1.56	1.17	2.13	.76	1.43	1.03	2.61	2.92	6.22
REG- 4	1.65	.70	1.47	.66	1.04	1.97	1.28	1.20	1.98	2.20	3.10
REG- 5	2.04	1.69	.86	2.22	2.02	2.72	2.18	1.79	2.19	2.21	2.18
REG- 6	1.59	.88	.65	.89	2.10	.97	1.95	1.74	2.09	2.90	2.44
REG- 7	1.57	.95	1.24	1.33	5.27	3.14	1.26	3.66	3.93	6.98	1.99
REG- 8	.25	-1.31	1.27	-.58	1.35	2.75	.51	8.23	6.86	7.55	9.87
REG- 9	1.01	.70	1.15	1.42	1.45	.73	.07	2.24	1.84	1.42	2.60
REG-10	.96	1.50	.37	-.40	2.60	.92	.69	3.37	1.81	1.48	.55
REG-11	.83	.76	.27	.78	2.68	3.16	.70	.74	4.65	6.10	4.60
REG-12	1.34	.78	.78	.58	2.73	3.62	1.59	1.18	1.73	4.03	.89
BETA (IMPORT)											
REG- 1	1.27	.97	1.56	.93	2.38	1.71	.99	1.55	1.20	1.92	1.59
REG- 2	1.32	1.07	-.40	.94	1.30	1.08	1.49	1.50	1.57	1.76	1.52
REG- 3	1.63	.39	.66	.97	1.23	1.30	1.24	1.03	1.42	2.20	3.56
REG- 4	2.37	.53	.56	1.26	2.21	.98	1.95	2.40	4.69	5.64	7.13
REG- 5	1.97	.79	1.98	1.10	2.66	2.15	2.32	2.22	2.58	3.01	3.63
REG- 6	1.44	.84	1.89	.62	1.50	2.26	1.37	1.50	1.60	1.87	1.45
REG- 7	1.71	1.08	2.00	2.26	1.53	2.11	1.48	1.67	2.70	2.72	1.58
REG- 8	-.30	-.91	3.67	.92	-.10	.46	.77	.03	-1.40	-.93	-1.13
REG- 9	1.49	.98	.20	1.74	.94	1.76	1.29	1.92	1.95	2.33	1.08
REG-10	.92	1.17	1.88	1.43	.46	1.09	1.07	.73	.76	1.01	.78
REG-11	1.27	.65	1.39	1.23	1.32	1.40	1.40	1.17	1.60	1.79	.77
REG-12	1.66	.66	.34	1.38	4.54	2.27	1.47	.69	2.38	2.51	2.07

Table II.2.5 Standard deviations of the estimates of exports and imports.

		MACRO	SEC- 1	SEC- 2	SEC- 3	SEC- 4	SEC- 5	SEC- 6	SEC- 7	SEC- 8	SEC- 9	SEC-10
SD (EXPORT)												
	REG- 1	689.1	61.5	5.2	10.7	158.5	26.6	91.1	306.1	92.9	98.7	313.5
	REG- 2	196.3	128.0	157.6	6.9	9.2	9.1	35.6	47.0	13.6	5.2	13.4
	REG- 3	494.5	336.8	113.1	13.7	20.1	71.3	25.3	177.2	73.8	94.9	1120.2
	REG- 4	1671.3	835.5	311.0	108.2	83.8	89.7	189.8	413.9	433.6	196.8	660.0
	REG- 5	1310.5	534.0	186.9	125.4	296.1	24.1	309.1	500.4	454.0	230.3	563.1
	REG- 6	285.7	117.3	83.0	63.6	136.4	80.2	104.2	179.1	68.1	26.6	105.1
	REG- 7	363.1	204.5	43.6	48.9	60.7	26.0	176.3	165.3	9.6	11.5	5.3
	REG- 8	94.9	85.2	15.5	21.1	94.1	2.8	67.3	40.1	11.7	4.1	15.7
	REG- 9	216.3	17.2	113.4	1.8	8.7	.1	141.1	.5	.7	.2	1.2
	REG-10	149.3	210.3	213.9	19.6	16.4	6.8	8.7	137.5	2.3	.8	2.0
	REG-11	446.6	283.9	160.7	13.9	41.5	14.9	79.4	134.5	18.9	33.3	19.5
	REG-12	1500.1	400.4	262.2	246.2	327.6	168.8	143.6	378.4	632.0	935.9	765.3
SD (IMPORT)												
	REG- 1	419.1	128.3	195.1	15.5	40.4	21.2	77.2	256.3	115.7	40.1	64.8
	REG- 2	451.6	46.2	61.4	5.5	44.9	12.9	49.8	82.4	114.8	30.0	108.3
	REG- 3	400.2	83.6	80.8	8.9	49.1	25.2	59.4	76.8	162.4	40.8	563.9
	REG- 4	1388.3	308.0	178.2	69.2	188.7	106.0	185.3	447.2	233.7	218.3	913.6
	REG- 5	2644.5	1036.4	547.0	187.6	541.0	161.0	271.8	1039.8	452.9	276.8	276.5
	REG- 6	469.6	156.5	104.8	26.9	121.4	45.5	123.2	287.5	104.1	38.7	92.0
	REG- 7	464.7	106.4	50.5	25.7	105.2	29.1	53.9	107.9	131.5	52.1	71.1
	REG- 8	248.3	251.8	60.3	13.7	17.4	8.5	55.7	97.2	86.7	29.2	35.7
	REG- 9	201.5	95.4	3.1	15.0	21.1	10.1	29.7	56.8	56.1	34.9	48.9
	REG-10	131.4	46.2	26.2	16.4	28.8	6.9	64.9	25.2	37.4	16.1	43.0
	REG-11	209.5	51.7	50.8	17.7	20.1	43.5	92.4	82.7	57.1	57.0	101.7
	REG-12	1358.5	3342.7	508.6	441.2	391.8	43.1	192.1	457.2	2279.3	96.6	701.2
SD (NET)												
	REG- 1	822.5	173.8	195.6	14.0	192.3	29.4	111.7	386.4	158.9	104.4	287.7
	REG- 2	345.3	90.8	141.8	9.8	49.2	13.9	62.5	79.5	111.5	29.5	99.8
	REG- 3	631.5	295.5	105.3	17.0	44.0	80.2	74.0	197.7	148.9	106.3	636.7
	REG- 4	956.7	821.7	389.4	166.1	153.8	136.8	219.4	632.6	439.0	254.9	567.8
	REG- 5	1901.7	616.2	442.6	130.4	413.7	168.0	307.7	738.8	358.2	142.8	352.0
	REG- 6	479.0	136.2	93.4	75.2	121.0	87.1	55.3	223.3	136.4	58.8	159.9
	REG- 7	392.5	274.0	51.9	49.4	63.3	15.8	168.9	110.2	126.4	42.6	69.7
	REG- 8	267.7	307.6	61.8	28.1	93.2	8.8	80.8	127.1	90.3	29.8	50.2
	REG- 9	239.6	101.1	111.7	16.2	27.1	10.0	141.2	56.8	55.8	34.9	48.3
	REG-10	126.2	220.7	225.2	26.0	32.5	9.6	68.4	147.4	37.5	16.1	44.3
	REG-11	349.9	277.8	197.7	23.0	53.0	33.3	126.9	137.1	69.2	63.5	109.4
	REG-12	2089.2	2975.8	383.6	430.5	571.7	186.3	177.6	164.2	2591.4	921.7	1175.6

Table II.2.6 Estimate of net export in 1985 and the ratio of change in the estimate after modification to the width of the allowable region. (billion US dollars)

	MACRO	SEC- 1	SEC- 2	SEC- 3	SEC- 4	SEC- 5	SEC- 6	SEC- 7	SEC- 8	SEC- 9	SEC-10
INITIAL VALUE											
REG- 1	19.66	-12.44	-12.22	-.26	3.34	-.53	2.82	14.68	10.48	11.61	22.88
REG- 2	8.49	6.59	.51	-.11	-1.42	-.28	-1.02	1.38	-1.43	-1.10	-.63
REG- 3	9.45	4.08	5.23	.44	-1.98	3.82	-1.59	1.59	-2.91	-3.54	-18.06
REG- 4	-35.54	-.62	-3.72	.45	-13.44	-.40	-.25	-16.41	14.43	-2.79	-8.51
REG- 5	22.27	-14.86	-47.86	4.08	4.10	-6.49	18.82	-6.73	30.09	7.41	21.83
REG- 6	-2.10	1.66	-14.81	1.36	5.38	8.65	-6.17	13.60	-5.24	-.70	3.74
REG- 7	-15.52	3.77	-1.40	.76	10.05	3.08	-2.71	-1.44	-16.81	-4.60	-2.49
REG- 8	-3.21	.88	-.05	.01	2.22	-.21	-1.03	-1.25	-1.91	-.58	-.55
REG- 9	-23.38	-4.99	13.77	-.66	-.81	-4.00	-.40	-24.56	-27.59	-21.36	-3.25
REG-10	-.14	1.77	5.14	.82	.54	-.44	-1.56	.42	-1.99	-.80	-1.63
REG-11	-19.76	21.17	5.19	.32	1.16	-.25	-6.91	-2.37	-14.00	-7.74	-4.33
REG-12	-25.59	-5.02	1.87	-1.31	-4.81	1.82	-1.98	.92	15.17	-1.01	1.73
MODIFIED VALUE											
REG- 1	26.48	-13.61	-11.93	-.91	2.07	-1.09	1.29	12.48	7.38	11.65	19.16
REG- 2	6.35	7.25	2.18	-.14	-1.28	-.29	-.96	2.06	-1.18	-.89	-.40
REG- 3	7.86	7.79	7.90	.42	-1.81	4.23	-1.61	3.03	-2.73	-2.49	-6.87
REG- 4	-28.33	.09	11.64	-1.24	-13.93	-1.95	-3.64	-12.46	7.59	-.32	-14.10
REG- 5	23.18	-11.25	-36.39	3.57	4.63	-7.13	17.26	-2.50	26.49	9.39	19.10
REG- 6	1.47	1.57	-11.36	.28	4.84	7.94	-7.23	11.37	-7.48	-.23	1.77
REG- 7	-3.02	3.25	-.56	.47	9.51	2.71	-4.07	-4.27	-4.65	-2.26	-3.16
REG- 8	-2.42	.80	1.24	-.13	2.15	-.33	-1.34	-.92	-2.52	-.37	-1.00
REG- 9	-.07	-4.99	13.77	1.17	-.99	-2.87	15.90	-9.03	-7.89	-5.19	.05
REG-10	.18	1.32	4.89	.57	41	-.50	-1.78	.24	-2.31	-.75	-1.91
REG-11	-16.43	18.78	6.77	-.30	.83	-.97	-9.01	-2.46	-15.98	-7.65	-6.43
REG-12	-15.35	-10.99	11.86	-3.78	-6.50	.27	-4.83	2.45	3.28	-.90	-6.20
SHIFT/WIDTH											
REG- 1	1.72	-.94	.10	-3.54	-1.38	-3.95	-2.86	-.84	-2.86	.08	-2.03
REG- 2	-.79	1.01	1.51	-.40	.83	-.36	.27	1.26	.43	2.00	.46
REG- 3	-.64	1.52	3.26	-.20	1.02	1.07	-.07	1.55	.30	1.78	1.70
REG- 4	2.11	.15	8.26	-2.87	-.52	-3.15	-4.31	1.41	-4.36	2.70	-2.75
REG- 5	.13	.67	4.33	-.47	.35	-1.03	-1.36	1.55	-2.71	3.74	-2.09
REG- 6	1.87	-.16	4.90	-1.58	-1.13	-2.06	-4.80	-.64	-4.11	2.00	-3.09
REG- 7	5.55	-.24	2.82	-.48	-.45	-.92	-.79	-1.20	13.85	9.55	-.81
REG- 8	28	-.03	4.46	-1.01	-.14	-2.48	-.67	.60	-.97	1.07	-1.83
REG- 9	7.53	.00	.00	4.38	-.52	8.51	4.33	20.75	26.69	35.36	3.28
REG-10	.57	-.15	-.05	-.21	-.18	-.77	-.34	-.09	-.55	.24	-.47
REG-11	1.94	-.83	.64	-2.74	-1.26	-1.99	-1.61	-.07	-5.83	.14	-2.60
REG-12	1.11	-.48	3.42	-1.11	-.67	-1.88	-3.62	.49	-.99	.03	-1.13

Table II.2.7 Data sources of the international trade model.

Region and Country\Item	E_i	M_i	E	M	G	P_e	P_m	P_g
1. Japan								
Japan	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
2. Oceania								
Australia	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
New Zealand	(3)	(3)	(1)	(1)	(1)	(2)	(2)	#1
3. Canada								
Canada	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
4. U.S.A.								
U.S.A.	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
5. E.C.								
Belgium/Luxembourg	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Denmark	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
France	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
F.R. Germany	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Ireland	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Italy	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Netherlands	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
United Kingdom	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
6. Other D.C.								
Austria	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Finland	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Greece	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Iceland	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Norway	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Portugal	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Spain	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Sweden	(4)	(4)	(1)	(1)	(1)	(1)	(1)	(1)
Israel	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
7. East Asia and ASEAN								
Korea Rep.	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Indonesia	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Malaysia	(3)	(3)	(2)	(2)	(2)	#2	#2	#2
Philippines	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Thailand	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
8. West Asia and Other Asia								
India	(3)	(3)	(1)	(1)	(1)	(2)	(2)	(1)
Pakistan	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Sri Lanka	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Burma	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
9. Middle East								
Iran	(3)	(3)	(1)	(1)	(1)	#3	(2)	(1)
Iraq	(3)	(3)	(1)	(1)	(1)	(2)	#4	#4
Jordan	(3)	(3)	(1)	(1)	(1)	#5	#5	#5
Kuwait	(3)	(3)	(1)	(1)	(1)	#3	#4	#4
Saudi Arabia	(3)	(3)	(1)	(1)	(1)	#3	#4	(1)

Table II.2.7 (continued)

Region and Country\Item	E_i	M_i	E	M	G	P_e	P_m	P_g
10. Africa								
Egypt	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Libya	(3)	(3)	(1)	(1)	(1)	#3	#6	(1)
Sudan	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Tunisia	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Ghana	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Nigeria	(3)	(3)	(1)	(1)	(1)	(2)	(2)	(1)
Zambia	(3)	(3)	(1)	(1)	(1)	(2)	#7	(1)
11. Latin America								
Costa Rica	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
El Salvador	(3)	(3)	(1)	(1)	(1)	(2)	(2)	(1)
Guatemala	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Honduras	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Mexico	(3)	(3)	(1)	(1)	(1)	(2)	(2)	(1)
Nicaragua	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Panama	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Argentina	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Brazil	(3)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Chile	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Colombia	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
Venezuela	(3)	(3)	(1)	(1)	(1)	(1)	(1)	(1)
12. CPC Europe								
Bulgaria	(3)	(3)	(3)	(3)	(1)	#8	#8	(1)
Czechoslovakia	(3)	(3)	(3)	(3)	(1)	#8	#8	(1)
German D.R.	(3)	(3)	(3)	(3)	(1)	#9	#9	#9
Hungary	(3)	(3)	(3)	(3)	(1)	(1)	(1)	(1)
Poland	(3)	(3)	(3)	(3)	(1)	#8	#8	(1)
U.S.S.R.	(3)	(3)	(3)	(3)	(1)	#8	#8	(1)

Source: (1) Yearbook of National Accounts Statistics, UN.
(2) International Financial Statistics, IMF.
(3) Yearbook of Trade Statistics, UN.
(4) Trade by commodities, OECD.

Note: #1 Replaced by the price index of Australia.
#2 Replaced by the price index of Thailand.
#3 Replaced by the price index of Iraq.
#4 Replaced by the price index of Iran.
#5 Replaced by the price index of Syria.
#6 Replaced by the price index of Tunisia.
#7 Replaced by the price index of Nigeria.
#8 Replaced by P_g.
#9 Replaced by P_g USSR.

Table II.2.8 Countries excluded from the international trade model due to shortage of data.

Region	Country
2. Oceania	
	Fiji, Nauru, Tonga, Western Samoa.
6. Other D.C.	
	Liechtenstein, Malta, Monaco, San Marino, Switzerland, Vatican, Yugoslavia, Turkey, Rhodesia, South Africa Rep..
7. East Asia and ASEAN	
	Hong Kong, Macao, Taiwan, Singapore.
8. West Asia and Othe Asia	
	Afghanistan, Bangladesh, Bhutan, Maldives, Nepal.
9. Middle East	
	Bahrain, Cyprus, Lebanon, Oman, Qatar, Syria, U. Arab Emirates, Yemen Arab Rep., Yemen P.D.R..
10. Africa	
	Algeria, Morocco, Dahomey, Gambia, Guinea Rep., Ivory Coast, Liberia, Mali, Mauritania, Niger, Senegal, Sierra Leone, Togo, Upper Volta, Burundi, Cameroun, Cent. African Rep., Chad, Congo, Equ. Guinea, Gabon, Rwanda, Zaire, Botswana, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Somalia, Swaziland, Tanzania, Uganda.
11. Latin America	
	Bahama, Barbados, Dominican Rep., Haiti, Jamaica, Trinidad & Tobago, Bolivia, Ecuador, Guyana, Paraguay, Peru, Uruguay.
12. CPC Europe	
	Albania, Romania, Cuba.
13. CPC Asia	
	China P.R., North Korea, Mongolian P.R., North Viet Nam, Khmer Rep., Laos, South Viet Nam.

Appendix II.3 Other data

Table II.3.1 Labor cost per unit production, ${}_jS_i$

REGION=	1	2	3	4	5	6	7	8	9	10	11	12
3 FOOD & T	.31	.37	.44	.35	.28	.31	.19	.26	.22	.38	.20	.17
4 TEX. & F	.36	.47	.57	.52	.48	.45	.45	.47	.34	.49	.30	.31
5 PAPER &	.36	.42	.59	.51	44	.46	.42	.48	.34	.53	.31	.37
6 CHEMICAL	.19	.25	.44	.34	.34	.31	.19	.26	.18	.33	.19	.16
7 METAL PR	.34	.40	.55	.52	.49	.51	.38	.45	.36	.45	.22	.32
8 MACHINRY	.35	.43	.54	.52	.55	.59	.45	.48	.43	.46	.33	.41
9 ELECTRIC	.31	.47	.60	.53	.58	.54	.43	.46	.24	.36	.27	.26
10 TRANSP.M	.32	.45	.55	.54	.53	.59	.48	.71	.21	.59	.29	.30

REGION

NO.		NO.	
1	JAPAN	7	SE.A
2	OCEAN	8	SW.A
3	CANAD	9	M.EST
4	USA	10	AFRIC
5	EC	11	L.A.
6	DC O	12	CPC.E

Table II.3.2. Capital coefficient, ${}_jC_i$

3 FOOD & T	1.85
4 TEX. & F	1.64
5 PAPER &	2.13
6 CHEMICAL	2.84
7 METAL PR	2.38
8 MACHINRY	.83
9 ELECTRIC	1.02
10 TRANSP.M	1.54

Table II.3.3 Employment per unit production, ${}_j l_i$

$${}_j l_i = 1.0/(BETA+ALPHA*GDP/P) \text{ ; PERSON/1000 US \$}$$

	ALPHA	(T-VALUE)	BETA	(T-VALUE)
3 FOOD & T	.00241	(7.93)	2.24910	(4.69)
4 TEX. & F	.00136	(10.29)	1.11790	(5.36)
5 PAPER &	.00230	(10.45)	1.60710	(4.57)
6 CHEMICAL	.00276	(7.50)	2.85320	(4.89)
7 METAL PR	.00207	(6.50)	2.04570	(4.03)
8 MACHINRY	.00224	(9.02)	1.44210	(3.49)
9 ELECTRIC	.00265	(3.87)	2.18150	(1.97)
10 TRANSP.M	.00278	(4.65)	2.08180	(2.10)

1970 VALUE

REGION=	1	2	3	4	5	6	7	8	9	10	11	12
3 FOOD & T	.15	.11	.08	.07	.12	.16	.38	.40	.31	.40	.26	.16
4 TEX. & F	.28	.20	.15	.13	.22	.30	.74	.80	.60	.80	.49	.29
5 PAPER &	.17	.12	.09	.08	.14	.19	.50	.54	.40	.55	.32	.18
6 CHEMICAL	.13	.10	.07	.06	.10	.14	.30	.32	.25	.32	.21	.13
7 METAL PR	.17	.13	.10	.08	.14	.18	.42	.44	.35	.45	.29	.18
8 MACHINRY	.18	.13	.10	.08	.14	.20	.55	.60	.43	.61	.34	.19
9 ELECTRIC	.14	.10	.08	.07	.12	.15	.38	.41	.31	.41	.25	.15
10 TRANSP.M	.14	.10	.08	.07	.11	.15	.39	.42	.31	.43	.25	.15

SCENARIO A (1985)

REGION=	1	2	3	4	5	6	7	8	9	10	11	12
3 FOOD & T	.09	.09	.06	.05	.08	.12	.33	.39	.16	.39	.21	.10
4 TEX. & F	.16	.16	.11	.10	.15	.21	.65	.77	.29	.76	.38	.18
5 PAPER &	.10	.10	.07	.06	.09	.13	.43	.53	.18	.52	.24	.11
6 CHEMICAL	.08	.08	.05	.05	.07	.10	.27	.31	.13	.31	.17	.09
7 METAL PR	.10	.10	.07	.06	.10	.13	.37	.43	.18	.43	.23	.12
8 MACHINRY	.10	.10	.07	.06	.10	.14	.47	.58	.19	.57	.26	.12
9 ELECTRIC	.08	.08	.06	.05	.08	.11	.33	.40	.15	.39	.20	.09
10 TRANSP.M	.08	.08	.05	.05	.08	.11	.34	.41	.15	.40	.20	.09

SCENARIO B (1985)

REGION=	1	2	3	4	5	6	7	8	9	10	11	12
3 FOOD & T	.10	.10	.07	.06	.10	.14	.33	.39	.15	.38	.20	.10
4 TEX. & F	.19	.18	.13	.11	.18	.25	.64	.76	.29	.76	.38	.18
5 PAPER &	.11	.11	.08	.06	.11	.16	.42	.52	.18	.51	.24	.11
6 CHEMICAL	.09	.09	.06	.05	.09	.12	.26	.31	.13	.31	.17	.09
7 METAL PR	.12	.11	.08	.07	.12	.16	.37	.43	.18	.43	.23	.12
8 MACHINRY	.12	.12	.08	.07	.12	.16	.46	.57	.19	56	.26	.12
9 ELECTRIC	.10	.09	.07	.06	.09	.13	.33	.39	.15	.39	.20	.09
10 TRANSP.M	.09	.09	.06	.05	.09	.13	.33	.41	.14	.40	.19	.09

II. 4. Examples of Detailed Computational Results

1. Scenarios
   1) 1970 data
   2) 1985 scenario A-1 (standard)
   3) 1985 scenario A-2 (LDC Max)

2. Values are mostly in 1970 billion U.S. dollars.

3. Nomenclature (only principal ones)

M. LABOUR/POP	: ratio of the total employment in manufacturing industries to the total population
M. WAGE RAT	: ratio of the average wage in manufacturing industries to GDP per capita
M. RATIO	: share of production of manufacturing industries in GDP
6-10/3-10	: ratio of production of heavy industries (sectors 6 to 10) to the total production of manufacturing industries (sectors 3 to 10)
8-10/3-10	: ratio of production of machine industries (sectors 8 to 10) to the total production of manufacturing industries (sectors 3 to 10)

4. In the table of 'BALANCE OF TRADE'

   U indicates the solution is on the upper bound of net exports, L indicates it is on the lower bound and otherwise it is inbetween. The sign indicates whether the resultant net export is positive or negative.

*** 1970 DATA PRINT (1) ***

MAJOR INDICES

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC D	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR
BALANCE OF TOTAL TRADE	.0133	-.0039	.0271	.0020	.0062	-.0247	-.0390	-.0157	.1266	-.0084	-.0009	-.0001
M. LABDUR/POP	.1041	.1010	.0981	.0938	.1169	.0874	.0125	.0076	.0225	.0088	.0463	.1293
M. WAGE RAT	1.0034	1.0822	1.3774	1.2323	1.3028	1.4312	3.8554	8.1215	1.6896	8.7559	1.1743	.8800
M. PATTERN	-.8625	-.1060	-.1150	-.4361	-.3007	-.2219	-.0094	-.3462	.1545	-.1153	-.0801	-.5284

	1 AGRICULT	2 MINING	3 FOOD & T	4 TEX. & F	5 PAPER &	6 CHEMICAL	7 METAL PR	8 MACHINRY	9 ELECTRIC	10 TRANSP.M
B. OF GOODS	-.0201	-.0929	-.0007	.0041	.0242	-.0004	.0069	.0251	.0229	.0403

OTHER INDICES

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC D	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
TOTAL GRP	189.33	43.03	85.82	980.16	612.67	229.90	44.71	78.92	23.73	27.68	180.15	585.63	2726.54	355.20	3081.74
POPULATION	103.50	15.32	21.43	206.04	249.92	141.09	258.68	770.81	60.02	301.25	264.79	346.82	1084.12	1655.55	2739.67
GRP/C	1829.34	2807.74	4005.22	4757.18	2451.42	1629.43	172.85	102.39	395.31	91.88	680.35	1688.58	2514.98	214.55	1124.86
M. RATIO	33.90	27.94	25.60	24.54	34.64	28.28	17.12	14.60	14.80	17.92	23.12	39.62	31.10	19.51	29.76
6-10/3-10	71.31	60.96	53.11	67.10	66.59	56.89	43.11	56.11	40.17	43.90	55.78	65.70	65.68	52.79	64.70
8-10/3-10	34.84	24.57	23.58	38.40	26.68	22.45	9.20	21.89	10.27	8.37	14.15	33.83	32.14	14.28	30.79

MANUFUCTURE TOTAL LDC= 69.31 WORLD= 917.23 RATIO (%) = 7.5563

FINAL DEMAND

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC D	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR
1 AGRICULT	4.75	.53	.08	6.27	25.74	20.94	13.20	36.26	1.62	9.33	14.88	77.66
2 MINING	.01	.01	.34	.37	.00	.00	.22	.00	.00	.00	.11	3.40
3 FOOD & T	17.31	4.44	8.41	78.92	50.58	12.67	6.82	4.14	3.66	2.47	22.74	111.84
4 TEX. & F	7.99	2.76	4.93	36.12	28.41	14.20	1.47	1.95	1.96	3.01	9.25	56.41
5 PAPER &	1.06	.36	.78	8.90	6.41	.00	.00	.87	.15	.26	2.29	.40
6 CHEMICAL	3.25	1.10	1.61	31.31	37.27	11.71	.02	1.02	.00	.71	6.09	12.72
7 METAL PR	.93	.67	.61	11.04	25.81	4.49	.00	1.38	.73	.00	7.80	8.44
8 MACHINRY	11.81	2.26	4.00	41.15	22.66	7.20	1.59	1.99	.83	.80	5.87	69.94
9 ELECTRIC	7.74	.78	2.28	27.40	6.26	5.78	.74	1.48	.61	.55	5.12	10.34
10 TRANSP.M	9.24	1.99	3.52	51.66	24.62	10.56	1.30	.00	.65	.64	3.82	19.86
11 CONSTRUC	39.31	6.44	11.76	117.81	72.76	27.21	4.52	10.55	2.27	2.22	18.35	133.50
12 ELEC.GAS	2.12	.76	2.24	20.68	7.45	3.26	.21	.99	.32	.12	.12	3.98
13 SERVICE	74.59	18.71	33.95	513.20	290.55	108.48	14.70	12.79	7.13	7.11	82.03	59.20
14 TRANSP.C	6.69	2.37	8.98	33.36	10.39	9.06	1.68	6.74	.79	.68	1.86	17.96
15 TOTAL	186.81	43.19	83.49	978.20	608.90	235.57	46.45	80.16	20.72	27.91	180.32	585.67

*** 1970 DATA PRINT (2) ***

VALUE ADDED

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	10.70	4.78	5.12	24.83	28.74	22.74	15 24	34.46	3.84	8.86	25.45	149.64	246.56	87.85	334.40
2 MINING	1.26	1.05	4.26	14.74	15.02	4.91	1.28	2.08	6.45	1.20	5.53	19.96	61.21	16.55	77.76
3 FOOD & T	6.95	1.36	3.54	31.13	28.67	8.57	2.84	1.65	1.03	.96	9.16	25.53	105.74	15.64	121.38
4 TEX. & F	7.45	2.26	3.21	27.20	28.60	11.81	1.13	2.93	.98	1.60	6.41	52.15	132.68	13.06	145.74
5 PAPER &	4.02	1.07	3.56	20.79	13.63	7.64	.38	.48	.08	.22	2.85	1.91	52.62	4.02	56.64
6 CHEMICAL	11.84	2.51	2.85	38.53	47.09	12.51	1.84	2.49	.81	1.04	9.86	44.34	159.68	16.04	175.73
7 METAL PR	11.56	1.86	3.64	30.50	37.61	9.88	.75	1.46	.24	.72	7.48	29.61	124.65	10.65	135.30
8 MACHINRY	8.62	1.12	1.70	44.12	26.22	5.11	.08	.59	.00	.08	1.70	53.35	140.24	2.45	142.69
9 ELECTRIC	6.76	.57	1.50	22.39	11.18	4.08	.26	.50	.12	.14	2.29	12.18	58.66	3.31	61.97
10 TRANSP.M	6.98	1.26	1.97	25.84	19.22	5.41	.37	1.43	.24	.20	1.91	12.96	73.64	4.14	77.79
11 CONSTRUC	16.11	3.21	6.15	65.82	48.20	18.00	1.98	3.87	1.27	1.16	9.59	64.78	222.27	17.88	240.14
12 ELEC,GAS	4.38	1.31	3.09	21.44	14.29	5.56	.48	.93	.36	.39	3.15	10.97	61.05	5.31	66.36
13 SERVICE	81.13	17.39	34.26	555.42	257.38	96.45	15.94	21.55	6.93	9.62	86.78	56.64	1098.66	140.82	1239.47
14 TRANSP.C	11.57	3.28	10.97	57.41	36.81	17.23	2 13	4.52	1.37	1.48	7.99	51.62	188.88	17.50	206.38
15 TOTAL	189.33	43.03	85.82	980.16	612.67	229.90	44.71	78.92	23.73	27.68	180.15	585.63	2726.54	355.20	3081.74
(MACRO GRP)	189.34	43.03	85.82	980.17	612.67	229.90	44.71	78.92	23.73	27.68	180.16	585.64	2726.55	355.20	3081.75
RATIO	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

GROWTH RATE (%)

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	.00	.00	.00	.00	.00	.00	00	.00	.00	.00	.00	.00	.00	.00	.00
2 MINING	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
3 FOOD & T	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	00	.00	.00	.00
4 TEX. & F	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
5 PAPER &	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
6 CHEMICAL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
7 METAL PR	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
8 MACHINRY	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
9 ELECTRIC	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10 TRANSP.M	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
11 CONSTRUC	.00	.00	.00	.00	.00	.00	00	.00	.00	.00	.00	.00	.00	.00	.00
12 ELEC,GAS	.00	.00	.00	.00	.00	.00	00	.00	.00	.00	.00	.00	.00	.00	.00
13 SERVICE	.00	.00	.00	.00	.00	.00	00	.00	.00	.00	.00	.00	.00	.00	.00
14 TRANSP.C	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
15 TOTAL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00

*** 1970 DATA PRINT (3) ***

SHARE OF VALUE ADDED IN THE WORLD AT EACH SECTOR (%)

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	3.20	1.43	1.53	7.43	8.59	6.80	4.56	10.30	1.15	2.65	7.61	44.75	73.73	26.27	100.00
2 MINING	1.62	1.35	5.48	18.96	19.32	6.31	1.65	2.68	8.29	1.55	7.12	25.68	78.72	21.28	100.00
3 FOOD & T	5.73	1.12	2.91	25.65	23.62	7.06	2.34	1.36	.85	.79	7.54	21.03	87.12	12.88	100.00
4 TEX. & F	5.11	1.55	2.20	18.67	19.62	8.10	.78	2.01	.67	1.10	4.40	35.78	91.04	8.96	100.00
5 PAPER &	7.10	1.89	6.28	36.71	24.07	13.49	.67	.85	.15	.39	5.03	3.37	92.90	7.10	100.00
6 CHEMICAL	6.74	1.43	1.62	21.93	26.80	7.12	1.05	1.42	.46	.59	5.61	25.23	90.87	9.13	100.00
7 METAL PR	8.55	1.38	2.69	22.54	27.79	7.30	.56	1.08	.18	.54	5.53	21.88	92.13	7.87	100.00
8 MACHINRY	6.04	.79	1.19	30.92	18.38	3.58	.06	.41	.00	.05	1.19	37.39	98.28	1.72	100.00
9 ELECTRIC	10.91	.91	2.43	36.13	18.05	6.59	.41	.81	.19	.23	3.69	19.65	94.67	5.33	100.00
10 TRANSP.M	8.97	1.63	2.54	33.22	24.71	6.95	.47	1.84	.31	.26	2.45	16.66	94.67	5.33	100.00
11 CONSTRUC	6.71	1.34	2.56	27.41	20.07	7.49	.82	1.61	.53	.48	4.00	26.97	92.56	7.44	100.00
12 ELEC.GAS	6.60	1.98	4.65	32.31	21.54	8.39	.73	1.39	.54	.58	4.75	16.54	92.00	8.00	100.00
13 SERVICE	6.55	1.40	2.76	44.81	20.77	7.78	1.29	1.74	.56	.78	7.00	4.57	88.64	11.36	100.00
14 TRANSP.C	5.60	1.59	5.32	27.82	17.84	8.35	1.03	2.19	.67	.72	3.87	25.01	91.52	8.48	100.00
15 TOTAL	6.14	1.40	2.78	31.81	19.88	7.46	1.45	2.56	.77	.90	5.85	19.00	88.47	11.53	100.00

CONFIGULATION.OF VALUE ADDED IN EACH REGION (%)

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	5.65	11.10	5.97	2.53	4.69	9.89	34.09	43.66	16.17	32.01	14.13	25.55	9.04	24.73	10.85
2 MINING	.66	2.43	4.97	1.50	2.45	2.14	2.86	2.64	27.17	4.35	3.07	3.41	2.24	4.66	2.52
3 FOOD & T	3.67	3.16	4.12	3.18	4.68	3.73	6.35	2.09	4.36	3.46	5.08	4.36	3.88	4.40	3.94
4 TEX. & F	3.93	5.25	3.74	2.78	4.67	5.14	2.54	3.71	4.14	5.79	3.56	8.90	4.87	3.68	4.73
5 PAPER &	2.12	2.49	4.14	2.12	2.23	3.32	.85	.61	.35	.81	1.58	.33	1.93	1.13	1.84
6 CHEMICAL	6.26	5.84	3.32	3.93	7.69	5.44	4.12	3.15	3.42	3.75	5.47	7.57	5.86	4.52	5.70
7 METAL PR	6.11	4.32	4.24	3.11	6.14	4.30	1.68	1.85	1.01	2.62	4.15	5.06	4.57	3.00	4.39
8 MACHINRY	4.55	2.61	1.98	4.50	4.28	2.22	.18	.75	.01	.27	.94	9.11	5.14	.69	4.63
9 ELECTRIC	3.57	1.32	1.75	2.28	1.83	1.78	.57	.63	.50	.51	1.27	2.08	2.15	.93	2.01
10 TRANSP.M	3.69	2.94	2.30	2.64	3.14	2.35	.82	1.81	1.01	.72	1.06	2.21	2.70	1.17	2.52
11 CONSTRUC	8.51	7.46	7.16	6.72	7.87	7.83	4.43	4.90	5.36	4.20	5.33	11.06	8.15	5.03	7.79
12 ELEC.GAS	2.31	3.05	3.60	2.19	2.33	2.42	1.08	1.17	1.51	1.40	1.75	1.87	2.24	1.49	2.15
13 SERVICE	42.85	40.41	39.92	56.67	42.01	41.95	35.66	27.30	29.20	34.76	48.17	9.67	40.29	39.64	40.22
14 TRANSP.C	6.11	7.61	12.78	5.86	6.01	7.49	4.77	5.73	5.79	5.36	4.43	8.81	6.93	4.93	6.70
15 TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

*** 1970 DATA PRINT (4) ***

BALANCE OF TRADE AT EACH SECTOR

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	-5.36	3.51	1.72	.06	-14.56	.70	1.17	.21	-.52	1.39	7.56	-6.53	-20.47	9.80	-10.67
2 MINING	-6.10	.76	1.54	-1.12	-14.24	-3.88	.39	-.02	6.34	1.06	2.53	1.31	-21.72	10.29	-11.43
3 FOOD & T	-.12	-.05	.17	.17	-.36	.82	.29	-.07	-.16	-.15	.13	-1.01	-.38	.05	-.33
4 TEX. & F	2.97	-.76	-1.05	-3.39	4.18	-.12	-.17	1.01	-.33	-.12	-.35	-.20	1.63	.04	1.67
5 PAPER &	.11	-.24	2.38	-1.49	-2.68	6.21	-.00	-.11	-.17	-.19	-.67	.02	4.30	-1.15	3.16
6 CHEMICAL	.16	-.70	-.81	1.72	6.33	-4.01	.22	-.56	.61	-.93	-1.38	-.81	1.88	-2.05	-.17
7 METAL PR	3.38	.00	1.17	-2.61	.92	.66	-.43	-.50	-.86	.52	-.41	.71	4.23	-1.68	2.55
8 MACHINRY	1.18	-1.29	-2.15	7.42	10.71	-3.22	-1.64	-.81	-.93	-.87	-3.95	3.31	15.97	-8.21	7.76
9 ELECTRIC	2.47	-.45	-.51	.84	3.78	-1.34	-.54	-.21	-.49	-.35	-1.49	1.63	6.42	-3.08	3.34
10 TRANSP.M	3.84	-.94	-.15	.36	9.69	-1.48	-1.02	-.16	-.49	-.59	-2.14	1.54	12.86	-4.40	8.46
TOTAL	2.52	-.17	2.32	1.97	3.77	-5.67	-1.74	-1.24	3.00	-.23	-.17	-.03	4.72	-.38	4.34

BALANCE OF TRADE , RATIO (%) BY VA TOTAL

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	-2.83	8.16	2.01	.01	-2.38	.30	2.61	.26	-2.21	5.02	4.20	-1.12	-.75	2.76	-.35
2 MINING	-3.22	1.77	1.80	-.11	-2.32	-1.69	.87	-.02	26.70	3.83	1.40	.22	-.80	2.90	-.37
3 FOOD & T	-.07	-.12	.20	.02	-.06	.36	.65	-.09	-.65	-.54	.07	-.17	-.01	.01	-.01
4 TEX. & F	1.57	-1.76	-1.23	-.35	.68	-.05	-.37	1.28	-1.37	-.45	-.19	-.03	.06	.01	.05
5 PAPER &	.06	-.57	2.78	-.15	-.44	2.70	-.01	-.14	-.72	-.69	-.37	.00	.16	-.32	.10
6 CHEMICAL	.09	-1.63	-.94	.18	1.03	-1.74	.49	-.71	2.57	-3.37	-.77	-.14	.07	-.58	-.01
7 METAL PR	1.78	.00	1.36	-.27	.15	.29	-.95	-.64	-3.62	1.88	-.23	.12	.16	-.47	.08
8 MACHINRY	.62	-3.00	-2.50	.76	1.75	-1.40	-3.68	-1.03	-3.94	-3.13	-2.19	.57	.59	-2.31	.25
9 ELECTRIC	1.31	-1.05	-.59	.09	.62	-.58	-1.21	-.27	-2.05	-1.27	-.83	.28	.24	-.67	.11
10 TRANSP.M	2.03	-2.19	-.17	.04	1.58	-.65	-2.29	-.21	-2.05	-2.13	-1.19	.26	.47	-1.24	.27
TOTAL	1.33	-.39	2.71	.20	.62	-2.47	-3.90	-1.57	12.66	-.84	-.09	-.01	.17	-.11	.14

BALANCE OF TRADE

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR
1 AGRICULT	-	+	+	+	-	+	+	+	-	+	+	-
2 MINING	-	+	+	-	-	-	+	-	+	+	+	+
3 FOOD & T	-	-	+	+	-	+	+	-	-	-	+	-
4 TEX. & F	+	-	-	-	+	-	-	+	-	-	-	-
5 PAPER &	+	-	+	-	-	+	-	-	-	-	-	+
6 CHEMICAL	+	-	-	+	+	-	+	-	+	-	-	-
7 METAL PR	+	+	+	-	+	+	-	-	-	+	-	+
8 MACHINRY	+	-	-	+	+	-	-	-	-	-	-	+
9 ELECTRIC	+	-	-	+	+	-	-	-	-	-	-	+
10 TRANSP.M	+	-	-	+	+	-	-	-	-	-	-	+

U ; UPPER   L ; LOWER   BLANK ; MEDIUM

Standard case *** 1985 DATA PRINT (1) — An Example of Computer Runs ***

MAJOR INDICES

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR
BALANCE OF TOTAL TRADE	.0534	.0657	.0383	-.0075	.0181	-.0048	-.0114	-.0152	.0010	.0043	-.0374	-.0105
M. LABOUR/POP	.1200	.1053	.0914	.0950	.1267	.0995	.0305	.0101	.0731	.0136	.0577	.1495
M. WAGE RAT	.8860	1.0606	1.3056	1.2104	1.2263	1.3264	2.2286	6.1502	.7821	5.7224	.9098	.7445
M. PATTERN	-.9114	-.1306	.1017	-.4913	-.2293	-.1801	.3109	-.2862	.5202	.0514	.1409	-.2766

	1 AGRICULT	2 MINING	3 FOOD & T	4 TEX. & F	5 PAPER &	6 CHEMICAL	7 METAL PR	8 MACHINRY.	9 ELECTRIC	10 TRANSP.M
B. OF GOODS	-.0000	.0000	-.0000	-.0001	.0000	-.0000	-.0000	-.0000	-.0000	.0000

OTHER INDICES

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
TOTAL GRP	375.90	65.70	135.76	1503.75	906.27	354.23	130.25	157.64	163.97	65.49	429.93	1287.93	4629.54	947.28	5576.82
POPULATION	120.99	20.38	28.07	250.74	284.08	170.70	388.52	1131.48	93.73	447.33	391.35	406.38	1281.34	2452.41	3733.75
GRP/C	3106.91	3223.17	4836.97	5997.35	3190.16	2075.20	335.26	139.32	1749.51	146.39	1098.57	3169.26	3613.05	386.26	1493.62
M. RATIO	34.48	28.47	22.74	24.22	35.44	29.70	20.78	14.83	24.14	18.51	22.43	38.74	31.72	20.96	29.90
6-10/3-10	74.90	62.40	49.02	69.54	65.93	57.70	22.19	55.05	52.58	40.47	51.20	65.58	66.51	47.32	64.22
8-10/3-10	37.74	25.20	17.09	41.15	27.02	22.10	6.58	20.45	13.34	6.35	10.25	33.35	33.04	11.33	30.45

MANUFUCTURE TOTAL LDC= 198.58 WORLD= 1667.26 RATIO (%) = 11.9106

FINAL DEMAND

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR
1 AGRICULT	5.18	.56	.00	.00	19.67	24.26	32.76	69.84	1.54	20.44	25.15	172.57
2 MINING	.00	.01	.49	.00	.00	.00	.00	.00	.00	.00	.00	7.56
3 FOOD & T	30.64	6.79	12.44	107.31	81.01	22.17	19.45	8.29	29.04	5.79	56.29	248.55
4 TEX. & F	14.48	4.17	7.46	51.43	42.04	21.73	3.99	3.80	14.99	6.97	22.37	125.37
5 PAPER &	2.06	.56	1.20	12.94	13.81	.69	.00	1.77	1.35	.62	5.84	.89
6 CHEMICAL	5.26	1.66	2.29	43.30	54.65	17.83	.43	2.23	.00	1.76	15.91	28.26
7 METAL PR	1.05	.70	.80	14.89	33.40	5.05	.00	2.79	5.93	.00	19.41	18.76
8 MACHINRY	20.74	2.65	6.12	75.23	33.27	10.98	4.62	4.02	6.78	1.88	14.73	155.44
9 ELECTRIC	14.63	.98	3.58	45.89	7.85	8.21	2.39	3.09	5.52	1.37	13.35	22.99
10 TRANSP.M	16.16	2.58	5.44	85.55	35.50	15.81	3.75	.00	5.30	1.50	9.60	44.12
11 CONSTRUC	69.29	6.49	18.13	212.99	112.22	43.68	13.80	21.53	20.25	5.45	47.67	296.67
12 ELEC.GAS	5.30	1.25	3.67	32.48	9.88	4.53	.87	2.12	3.15	.37	.96	8.85
13 SERVICE	155.19	29.37	54.33	775.50	431.46	167.27	43.77	26.54	61.00	17.14	207.31	131.57
14 TRANSP.C	16.85	3.63	14.62	57.55	15.14	13.70	5.90	14.02	8.97	1.91	7.40	39.92
15 TOTAL	355.81	61.39	130.57	1515.06	889.89	355.93	131.74	160.04	163.82	65.21	446.00	1301.52

Standard case *** 1985 DATA PRINT (2) ***

VALUE ADDED

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC D	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	13.11	7.60	9.55	28.56	35.43	29.52	39.53	66.10	18.11	18.22	52.03	334.45	458.22	193.99	652.22
2 MINING	2.54	1.85	8.55	25.59	17.98	6.53	1.40	4.66	17.62	4.49	11.66	47.61	110.66	39.83	150.49
3 FOOD & T	12.48	2.10	5.47	42.47	45.75	13.85	8.54	3.52	9.87	2.67	23.08	56.43	178.55	47.69	226.24
4 TEX. & F	12.36	3.21	4.78	36.97	41.21	19.49	9.19	6.00	8.36	3.98	15.99	111.14	229.16	43.52	272.68
5 PAPER &	7.70	1.73	5.48	31.47	22.48	11.16	3.33	.98	.54	.56	7.99	4.16	84.18	13.40	97.58
6 CHEMICAL	23.03	3.65	4.31	56.33	71.38	19.30	3.71	5.14	14.70	2.87	22.25	96.21	274.21	48.68	322.89
7 METAL PR	25.13	3.31	5.55	47.09	53.57	18.15	.52	2.94	.83	1.26	17.24	64.58	217.38	22.80	240.18
8 MACHINRY	17.83	1.77	2.96	73.33	40.95	7.58	.38	.98	.41	.14	1.53	116.87	261.30	3.45	264.74
9 ELECTRIC	15.20	.72	1.89	37.61	17.41	6.69	.50	1.09	.75	.42	3.99	24.64	104.18	6.75	110.93
10 TRANSP.M	15.89	2.22	.42	38.90	28.44	8.98	.90	2.71	4.12	.20	4.36	24.86	119.71	12.29	132.01
11 CONSTRUC	28.24	3.47	9.51	115.18	73.37	28.53	5.95	7.84	11.00	2.85	24.61	143.98	402.26	52.24	454.50
12 ELEC,GAS	9.70	2.10	5.02	33.06	20.42	8.36	1.62	1.94	3.75	1.01	8.46	24.10	102.75	16.77	119.53
13 SERVICE	165.85	27.02	54.45	843.62	381.90	148.83	47.50	43.99	59.13	23.02	215.56	125.49	1747.16	389.19	2136.35
14 TRANSP.C	26.83	4.96	17.81	93.58	55.97	27.25	7.20	9.74	14.78	3.78	21.16	113.42	339.82	56.66	396.48
15 TOTAL	375.90	65.70	135.76	1503.75	906.27	354.23	130.25	157.64	163.97	65.49	429.93	1287.93	4629.54	947.28	5576.82
(MACRO GRP)	375.90	65.70	135.76	1503.75	906.27	354.23	130.26	157.64	163.98	65.49	429.93	1287.93	4629.56	947.29	5576.85
RATIO	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

GROWTH RATE (%)

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 CPC.E	13 DC	14 LDC	15 WORLD
1 AGRICULT	1.29	3.81	5.50	1.03	1.90	2.25	6.10	3.94	10.76	4.69	4.81	5.48	4.32	5.11	4.53
2 MINING	8.54	5.05	6.57	5.14	1.50	2.78	-1.05	5.20	6.90	9.19	5.56	6.34	4.90	6.07	5.17
3 FOOD & T	4.56	3.58	3.87	2.61	5.07	5.06	7.04	4.48	16.10	6.79	6.29	5.41	4.42	7.49	4.90
4 TEX. & F	4.41	3.30	3.86	2.77	3.95	5.40	13.81	4.38	15.26	6.00	6.31	5.22	4.41	8.03	4.82
5 PAPER &	5.36	4.40	4.09	3.85	5.65	4.21	14.51	4.22	13.07	6.06	7.09	5.50	4.62	8.04	4.92
6 CHEMICAL	5.46	3.68	3.87	3.32	4.43	4.60	4.30	4.22	21.22	6.64	5.48	5.26	4.50	7.48	4.82
7 METAL PR	6.33	5.73	4.25	3.70	3.55	5.93	-3.13	4.14	8.47	3.52	5.68	5.32	4.58	5.05	4.62
8 MACHINRY	5.73	4.87	5.92	4.45	4.67	4.30	7.97	2.12	36.88	.32	-2.25	5.30	4.93	.45	4.87
9 ELECTRIC	6.31	3.03	2.48	4.53	4.36	5.17	4.09	4.67	12.95	7.15	3.78	4.82	4.77	4.71	4.77
10 TRANSP.M	5.98	5.52	-9.73	3.60	4.16	5.60	5.92	3.77	20.80	-.37	5.68	4.46	4.20	7.34	4.40
11 CONSTRUC	5.33	2.11	4.49	5.03	4.52	4.83	7.04	4.23	15.34	5.88	6.43	5.46	5.01	7.20	5.20
12 ELEC,GAS	6.52	4.31	4.63	3.95	3.74	4.18	7.60	4.41	16.81	6.26	6.75	5.40	4.46	7.76	4.78
13 SERVICE	5.82	3.89	4.35	3.79	4.22	4.52	6.97	4.25	15.25	5.72	6.20	5.44	4.23	6.81	4.58
14 TRANSP.C	6.97	4.05	4.62	4.53	4.50	4.81	7.76	4.61	17.04	6.13	6.65	5.38	4.96	7.88	5.25
15 TOTAL	5.63	3.97	4.41	3.86	4.17	4.50	6.78	4.15	13.64	5.65	5.93	5.39	4.48	6.53	4.75

Standard case *** 1985 DATA PRINT (3) ***

SHARE OF VALUE ADDED IN THE WORLD AT EACH SECTOR (%)

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	2.01	1.16	1.46	4.38	5.43	4.53	6.06	10.13	2.78	2.79	7.98	51.28	70.26	29.74	100.00
2 MINING	1.69	1.23	5.68	17.00	11.95	4.34	.93	3.10	11.71	2.99	7.75	31.64	73.53	26.47	100.00
3 FOOD & T	5.52	.93	2.42	18.77	20.22	6.12	3.78	1.56	4.36	1.18	10.20	24.94	78.92	21.08	100.00
4 TEX. & F	4.53	1.18	1.75	13.56	15.11	7.15	3.37	2.20	3.07	1.46	5.86	40.76	84.04	15.96	100.00
5 PAPER &	7.89	1.77	5.62	32.25	23.04	11.44	3.41	1.01	.55	.57	8.19	4.26	86.26	13.74	100.00
6 CHEMICAL	7.13	1.13	1.33	17.45	22.11	5.98	1.15	1.59	4.55	.89	6.89	29.80	84.92	15.08	100.00
7 METAL PR	10.47	1.38	2.31	19.60	22.31	7.56	.21	1.23	.34	.53	7.18	26.89	90.51	9.49	100.00
8 MACHINRY	6.74	.67	1.12	27.70	15.47	2.86	.14	.37	.16	.05	.58	44.15	98.70	1.30	100.00
9 ELECTRIC	13.71	.65	1.71	33.90	15.70	6.03	.45	.98	.68	.38	3.60	22.22	93.91	6.09	100.00
10 TRANSP.M	12.04	1.68	.32	29.47	21.55	6.80	.68	2.06	3.12	.16	3.30	18.83	90.69	9.31	100.00
11 CONSTRUC	6.21	.76	2.09	25.34	16.14	6.28	1.31	1.72	2.42	.63	5.41	31.67	88.51	11.49	100.00
12 ELEC.GAS	8.11	1.76	4.20	27.65	17.08	6.99	1.35	1.62	3.14	.84	7.08	20.16	85.97	14.03	100.00
13 SERVICE	7.76	1.26	2.55	39.49	17.88	6.97	2.22	2.06	2.77	1.08	10.09	5.87	81.78	18.22	100.00
14 TRANSP.C	6.77	1.25	4.49	23.60	14.12	6.87	1.82	2.46	3.73	.95	5.34	28.61	85.71	14.29	100.00
15 TOTAL	6.74	1.18	2.43	26.96	16.25	6.35	2.34	2.83	2.94	1.17	7.71	23.09	83.01	16.99	100.00

CONFIGULATION OF VALUE ADDED IN EACH REGION (%)

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	3.49	11.56	7.04	1.90	3.91	8.33	30.35	41.93	11.04	27.82	12.10	25.97	9.90	20.48	11.70
2 MINING	.68	2.82	6.30	1.70	1.98	1.84	1.07	2.96	10.75	6.86	2.71	3.70	2.39	4.21	2.70
3 FOOD & T	3.32	3.20	4.03	2.82	5.05	3.91	6.56	2.23	6.02	4.08	5.37	4.38	3.86	5.03	4.06
4 TEX. & F	3.29	4.88	3.52	2.46	4.55	5.50	7.05	3.81	5.10	6.08	3.72	8.63	4.95	4.59	4.89
5 PAPER &	2.05	2.63	4.04	2.09	2.48	3.15	2.56	.62	.33	.86	1.86	.32	1.82	1.42	1.75
6 CHEMICAL	6.13	5.56	3.17	3.75	7.88	5.45	2.85	3.26	8.97	4.39	5.18	7.47	5.92	5.14	5.79
7 METAL PR	6.69	5.03	4.09	3.13	5.91	5.12	.40	1.87	.50	1.93	4.01	5.01	4.70	2.41	4.31
8 MACHINRY	4.74	2.69	2.18	4.88	4.52	2.14	.29	.62	.25	.22	.36	9.07	5.64	.36	4.75
9 ELECTRIC	4.04	1.10	1.40	2.50	1.92	1.89	.38	.69	.46	.64	.93	1.91	2.25	.71	1.99
10 TRANSP.M	4.23	3.38	.31	2.59	3.14	2.54	.69	1.72	2.51	.31	1.01	1.93	2.59	1.30	2.37
11 CONSTRUC	7.51	5.28	7.01	7.66	8.10	8.05	4.57	4.97	6.71	4.36	5.72	11.18	8.69	5.52	8.15
12 ELEC.GAS	2.58	3.20	3.70	2.20	2.25	2.36	1.24	1.23	2.29	1.54	1.97	1.87	2.22	1.77	2.14
13 SERVICE	44.12	41.12	40.11	56.10	42.14	42.02	36.47	27.91	36.06	35.15	50.14	9.74	37.74	41.09	38.31
14 TRANSP.C	7.14	7.55	13.12	6.22	6.18	7.69	5.52	6.18	9.02	5.77	4.92	8.81	7.34	5.98	7.11
15 TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Standard case ### 1985 DATA PRINT (4) ###

BALANCE OF TRADE AT EACH SECTOR

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC D	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	-11.24	6.19	5.87	1.56	-14.12	1.67	3.45	.99	-4.99	1.38	19.23	-9.99	-20.05	20.05	-.00
2 MINING	-10.84	1.53	5.46	5.69	-26.29	-8.10	-.35	.87	13.77	4.81	5.46	7.99	-24.55	24.55	.00
3 FOOD & T	-.60	-.10	.36	-.50	1.48	.56	.51	-.09	1.23	.60	-.14	-3.32	-2.12	2.12	-.00
4 TEX. & F	2.25	-1.19	-1.71	-11.42	4.24	1.92	11.62	2.18	-1.12	.42	.45	-7.71	-13.61	13.54	-.07
5 PAPER &	-.86	-.32	3.57	-2.53	-5.77	7.59	3.21	-.39	-2.92	-.53	-1.05	.00	1.69	-1.69	.00
6 CHEMICAL	1.13	-.91	-1.23	-.94	12.41	-6.18	-4.75	-1.32	16.04	-1.77	-8.75	-3.76	.53	-.55	-.02
7 METAL PR	10.34	1.40	2.55	-7.73	.46	7.56	-4.66	-.99	-9.17	.24	-2.49	2.48	17.07	-17.07	-.01
8 MACHINRY	6.00	-1.07	-2.64	9.83	20.12	-5.72	-4.79	-2.41	-7.70	-2.24	-15.24	5.84	32.37	-32.37	-.00
9 ELECTRIC	9.29	-.69	-1.61	2.02	8.18	-.74	-2.41	-.32	-5.19	-.73	-7.52	-.26	16.18	-16.18	-.00
10 TRANSP.M	14.61	-.52	-5.43	-7.30	15.68	-.26	-3.31	-.92	.22	-1.89	-6.01	-4.86	11.91	-11.91	.00
TOTAL	20.09	4.32	5.19	-11.31	16.39	-1.70	-1.48	-2.40	.16	.28	-16.07	-13.58	19.40	-19.51	-.11

BALANCE OF TRADE , RATIO (%) BY VA TOTAL

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC D	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	-2.99	9.41	4.33	.10	-1.56	.47	2.65	.63	-3.05	2.10	4.47	-.78	-.43	2.12	-.00
2 MINING	-2.88	2.33	4.02	.38	-2.90	-2.29	-.27	.55	8.40	7.34	1.27	.62	-.53	2.59	.00
3 FOOD & T	-.16	-.16	.27	-.03	.16	.16	.39	-.06	.75	.92	-.03	-.26	-.05	.22	-.00
4 TEX. & F	.60	-1.81	-1.26	-.76	.47	.54	8.92	1.38	-.69	.64	.10	-.60	-.29	1.43	-.00
5 PAPER &	-.23	-.49	2.63	-.17	-.64	2.14	2.46	-.25	-1.78	-.80	-.25	.00	.04	-.18	.00
6 CHEMICAL	.30	-1.38	-.91	-.06	1.37	-1.74	-3.65	-.84	9.78	-2.70	-2.03	-.29	.01	-.06	-.00
7 METAL PR	2.75	2.13	1.88	-.51	.05	2.14	-3.58	-.63	-5.60	.36	-.58	.19	.37	-1.80	-.00
8 MACHINRY	1.60	-1.63	-1.94	.65	2.22	-1.61	-3.68	-1.53	-4.69	-3.43	-3.54	.45	.70	-3.42	-.00
9 ELECTRIC	2.47	-1.05	-1.19	.13	.90	-.21	-1.85	-.21	-3.17	-1.12	-1.75	-.02	.35	-1.71	-.00
10 TRANSP.M	3.89	-.80	-4.00	-.49	1.73	-.07	-2.54	-.58	.13	-2.89	-1.40	-.38	.26	-1.26	.00
TOTAL	5.34	6.57	3.83	-.75	1.81	-.48	-1.14	-1.52	.10	.43	-3.74	-1.05	.42	-2.06	-.00

BALANCE OF TRADE

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC D	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR
1 AGRICULT	-	+	+	+	-	+	+	+	-	+	+	-
2 MINING	-	+	+	+	-	-	-	+	+	+	+	+
3 FOOD & T	-	-	+	-	+	+	+	-	+	+	-	-
4 TEX. & F	+	-	-	-	+	+	+	+	-	+	+	-
5 PAPER &	-	-	+	-	-	+	+	-	-	-	-	+
6 CHEMICAL	+	-	-	-	+	-	-	-	+	-	-	-
7 METAL PR	+	+	+	-	+	+	-	-	-	+	-	+
8 MACHINRY	+	-	-	+	+	-	-	-	-	-	-	+
9 ELECTRIC	+	-	-	+	+	-	-	-	-	-	-	-
10 TRANSP.M	+	-	-	-	+	-	-	-	+	-	-	-

U ; UPPER L ; LOWER BLANK ; MEDIUM

(2-A) LDC MAN. TO MAX (1)

MAJOR INDICES

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR
BALANCE OF TOTAL TRADE	.0759	.0818	.0398	-.0202	.0174	-.0046	.0237	.0057	.0528	.0144	-.0310	-.0220
M. LABOUR/POP	.1277	.1012	.0879	.0921	.1296	.1064	.0340	.0101	.0953	.0163	.0595	.1491
M. WAGE RAT	.8593	1.0233	1.2673	1.1897	1.1682	1.2336	2.5329	6.6123	.8266	6.1101	.9165	.7476
M. PATTERN	-.0403	-.0290	.1462	-.4394	-.1002	-.0633	-.0214	-.3310	.3835	-.0900	.1107	-.3080

	1 AGRICULT	2 MINING	3 FOOD & T	4 TEX. & F	5 PAPER &	6 CHEMICAL	7 METAL PR	8 MACHINRY	9 ELECTRIC	10 TRANSP.M
B. OF GOODS	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001

OTHER INDICES

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
TOTAL GRP	448.56	76.91	162.17	1718.83	1124.30	440.49	125.18	148.28	169.73	63.74	429.62	1272.62	5243.86	936.55	6180.41
POPULATION	120.99	20.38	28.07	250.74	284.08	170.70	388.52	1131.48	93.73	447.33	391.35	406.38	1281.34	2452.41	3733.75
GRP/C	3707.48	3772.75	5777.84	6855.14	3957.63	2580.50	322.20	131.05	1810.95	142.49	1097.78	3131.59	4092.48	381.89	1655.28
M. RATIO	34.96	26.54	21.43	23.18	34.93	29.96	23.76	15.48	30.88	23.09	23.04	39.08	31.13	23.36	29.95
6-10/3-10	76.25	61.52	48.18	69.04	64.29	55.33	32.16	55.81	62.01	46.75	51.80	65.96	66.00	51.66	64.31
8-10/3-10	38.13	23.47	17.08	41.19	26.43	21.64	13.86	20.88	16.85	8.85	10.98	33.72	32.75	13.67	30.50

MANUFUCTURE TOTAL LDC= 218.80 WORLD= 1851.22 RATIO (%) = 11.8191

FINAL DEMAND

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR
1 AGRICULT	3.28	.34	.00	.00	8.58	23.67	30.86	64.93	1.52	19.77	25.12	172.49
2 MINING	.00	.02	.54	.01	.00	.00	.00	.00	.00	.00	.00	7.55
3 FOOD & T	37.12	7.34	13.86	115.80	106.82	30.13	18.06	7.63	28.58	5.57	55.89	248.43
4 TEX. & F	16.04	4.41	8.52	56.81	52.64	27.19	3.73	3.53	14.75	6.72	22.21	125.31
5 PAPER &	2.28	.62	1.39	14.57	21.07	2.47	.00	1.62	1.33	.60	5.80	.89
6 CHEMICAL	5.52	1.78	2.47	47.30	67.99	22.24	.37	2.01	.00	1.69	15.78	28.25
7 METAL PR	1.00	.03	.90	15.97	37.66	4.74	.00	2.57	5.83	.00	19.27	18.76
8 MACHINRY	25.73	3.25	7.69	90.65	41.43	13.72	4.28	3.69	6.67	1.81	14.62	155.36
9 ELECTRIC	17.94	1.20	4.44	54.42	8.61	9.74	2.20	2.82	5.44	1.31	13.25	22.98
10 TRANSP.M	19.59	3.05	6.54	100.35	43.64	19.48	3.48	.00	5.22	1.45	9.53	44.10
11 CONSTRUC	87.31	8.44	22.96	256.67	144.49	56.43	12.74	19.73	19.93	5.24	47.31	296.53
12 ELEC,GAS	6.25	1.45	4.44	38.29	11.37	5.27	.79	1.92	3.10	.35	.95	8.84
13 SERVICE	176.86	33.36	64.35	892.18	541.62	210.43	40.48	24.22	60.04	16.49	205.80	131.51
14 TRANSP.C	20.02	4.33	17.56	70.69	18.76	17.01	5.38	12.79	8.82	1.82	7.32	39.90
15 TOTAL	415.04	70.61	155.66	1753.70	1104.67	442.52	122.36	147.46	161.23	62.84	442.85	1300.88

(2-A) LOC MAN. TO MAX (2)

VALUE ADDED

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC D	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	14.10	9.09	13.95	31.79	42.62	32.55	35.60	61.92	16.85	16.23	48.63	322.95	467.06	179.23	646.29
2 MINING	5.70	3.69	9.46	34.03	22.38	7.98	.91	4.30	11.98	2.53	13.31	46.30	129.53	33.02	162.56
3 FOOD & T	14.77	2.33	6.34	45.84	59.98	18.49	8.11	3.26	10.20	3.01	23.00	55.51	202.26	47.58	249.84
4 TEX. & F	14.72	3.52	5.52	41.29	49.96	25.95	8.69	5.94	8.77	4.20	16.28	109.57	250.53	43.88	294.41
5 PAPER &	8.75	2.00	6.15	36.19	30.32	14.52	3.37	.95	.94	.63	8.43	4.23	102.17	14.31	116.48
6 CHEMICAL	27.13	4.15	4.94	61.82	88.92	24.09	2.65	4.98	20.47	3.22	22.37	94.22	305.27	53.68	358.95
7 METAL PR	32.67	3.61	5.86	49.11	59.78	20.37	2.79	3.04	3.20	2.36	18.04	66.13	237.52	29.43	266.95
8 MACHINRY	21.07	1.76	3.63	81.46	50.08	8.99	1.76	1.12	1.76	.45	1.61	117.34	284.32	6.70	291.02
9 ELECTRIC	18.55	.71	2.20	41.64	20.06	8.23	.81	1.03	1.65	.27	4.23	25.09	116.48	8.00	124.47
10 TRANSP.M	20.18	2.32	.11	40.99	33.65	11.34	1.55	2.65	5.42	.58	5.02	25.28	133.87	15.22	149.09
11 CONSTRUC	35.22	4.40	11.88	137.40	93.60	36.49	5.51	7.20	10.80	2.74	24.43	143.88	462.87	50.68	513.54
12 ELEC.GAS	11.72	2.51	5.99	38.20	24.65	10.13	1.68	1.80	3.84	1.02	8.48	23.98	117.17	16.83	134.01
13 SERVICE	192.49	30.91	64.64	968.05	477.78	186.83	44.88	41.18	58.46	22.69	214.55	125.16	2045.84	381.76	2427.60
14 TRANSP.C	32.51	5.90	21.51	111.03	70.52	34.51	6.86	8.93	15.38	3.82	21.25	112.98	388.97	56.23	445.20
15 TOTAL	448.56	76.91	162.17	1718.83	1124.30	440.49	125.18	148.28	169.73	63.74	429.62	1272.62	5243.86	936.55	6180.41
(MACRO GRP)	441.52	76.96	163.53	1725.37	1127.84	443.99	119.34	145.04	161.16	63.02	426.43	1285.53	5264.73	914.97	6179.70
RATIO	1.0160	.9993	.9917	.9962	.9969	.9921	1.0490	1.0224	1.0532	1.0115	1.0075	.9900	.9960	1.0236	1.0001

GROWTH RATE (%)

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC D	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	1.86	4.39	6.91	1.66	2.66	2.42	5.82	3.98	10.37	4.12	4.41	5.26	4.35	6.87	4.49
2 MINING	10.60	8.75	5.45	5.73	2.69	3.29	-2.22	4.94	4.22	5.07	6.02	5.77	5.12	4.71	5.04
3 FOOD & T	4.66	3.67	3.96	2.61	5.04	5.26	7.25	4.66	16.48	7.93	6.33	5.32	4.42	7.70	4.93
4 TEX. & F	4.65	2.99	3.68	2.82	3.79	5.39	14.54	4.82	15.71	6.64	6.40	5.07	4.33	8.41	4.80
5 PAPER &	5.32	4.25	3.72	3.76	5.47	4.37	15.68	4.63	17.41	7.15	7.49	5.46	4.52	8.84	4.92
6 CHEMICAL	5.68	3.41	3.75	3.20	4.33	4.46	2.45	4.74	24.01	7.84	5.61	5.15	4.41	8.39	4.88
7 METAL PR	7.17	4.52	3.23	3.23	3.14	4.94	9.14	5.02	18.90	8.19	6.05	5.50	4.39	7.01	4.63
8 MACHINRY	6.14	3.06	5.17	4.17	4.41	3.84	22.78	4.33	55.23	12.73	-.36	5.40	4.82	6.94	4.87
9 ELECTRIC	6.96	1.46	2.58	4.22	3.97	4.79	7.97	4.95	19.14	4.42	4.18	4.94	4.68	6.06	4.76
10 TRANSP.M	7.33	4.14	-17.67	3.12	3.80	5.06	10.09	4.18	23.13	7.39	6.67	4.56	4.06	9.06	4.43
11 CONSTRUC	5.35	2.12	4.49	5.03	4.52	4.83	7.06	4.23	15.33	5.87	6.43	5.46	5.01	7.19	5.20
12 ELEC.GAS	6.78	4.41	4.51	3.92	3.70	4.08	8.65	4.55	17.12	6.69	6.82	5.35	4.44	8.00	4.80
13 SERVICE	5.93	3.91	4.32	3.77	4.21	4.51	7.14	4.41	15.28	5.89	6.22	5.43	4.23	6.87	4.58
14 TRANSP.C	7.13	4.01	4.59	4.50	4.43	4.74	8.10	4.64	17.47	6.50	6.74	5.36	4.93	8.09	5.26
15 TOTAL	5.92	3.95	4.33	3.82	4.13	4.43	7.10	4.29	14.02	5.72	5.96	5.31	4.46	6.68	4.75

SHARE OF VALUE ADDED IN THE WORLD AT EACH SECTOR (%)

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	2.18	1.41	2.16	4.92	6.60	5.04	5.51	9.58	2.61	2.51	7.52	49.97	72.27	27.73	100.00
2 MINING	3.51	2.27	5.82	20.93	13.77	4.91	.56	2.64	7.37	1.55	8.19	28.49	79.68	20.32	100.00
3 FOOD & T	5.51	.93	2.54	18.35	24.01	7.40	3.25	1.30	4.08	1.20	9.21	22.22	80.96	19.04	100.00
4 TEX. & F	5.00	1.20	1.88	14.02	16.97	8.81	2.95	2.02	2.98	1.43	5.53	37.22	85.09	14.91	100.00
5 PAPER &	7.51	1.72	5.28	31.07	26.03	12.47	2.89	.81	.80	.54	7.24	3.63	87.71	12.29	100.00
6 CHEMICAL	7.56	1.16	1.38	17.22	24.77	6.71	.74	1.39	5.70	.90	6.23	26.25	85.04	14.96	100.00
7 METAL PR	12.24	1.35	2.20	18.40	22.39	7.63	1.05	1.14	1.20	.88	6.76	24.77	88.98	11.02	100.00
8 MACHINRY	7.24	.61	1.25	27.99	17.21	3.09	.61	.38	.60	.16	.55	40.32	97.70	2.30	100.00
9 ELECTRIC	14.90	.57	1.77	33.45	16.12	6.61	.65	.83	1.33	.22	3.40	20.16	93.58	6.42	100.00
10 TRANSP.M	13.54	1.56	.07	27.50	22.57	7.61	1.04	1.77	3.63	.39	3.37	16.96	89.79	10.21	100.00
11 CONSTRUC	6.86	.86	2.31	26.75	18.23	7.11	1.07	1.40	2.10	.53	4.76	28.02	90.13	9.87	100.00
12 ELEC+GAS	8.75	1.87	4.47	28.50	18.39	7.56	1.26	1.35	2.87	.76	6.33	17.90	87.44	12.56	100.00
13 SERVICE	7.93	1.27	2.66	39.88	19.68	7.70	1.85	1.70	2.41	.93	8.84	5.16	84.27	15.73	100.00
14 TRANSP.C	7.30	1.33	4.83	24.94	15.84	7.75	1.54	2.01	3.45	.86	4.77	25.38	87.37	12.63	100.00
15 TOTAL	7.26	1.24	2.62	27.81	18.19	7.13	2.03	2.40	2.75	1.03	6.95	20.59	84.85	15.15	100.00

CONFIGULATION OF VALUE ADDED IN EACH REGION (%)

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC D	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	3.14	11.82	8.60	1.85	3.79	7.39	28.44	41.76	9.93	25.47	11.32	25.38	8.91	19.14	10.46
2 MINING	1.27	4.90	5.83	1.98	1.99	1.81	.73	2.90	7.06	3.96	3.10	3.64	2.47	3.53	2.63
3 FOOD & T	3.07	3.04	3.91	2.67	5.33	4.20	6.48	2.20	6.01	4.72	5.35	4.36	3.86	5.08	4.04
4 TEX. & F	3.28	4.58	3.40	2.40	4.44	5.89	6.94	4.01	5.17	6.59	3.79	8.61	4.78	4.69	4.76
5 PAPER &	1.95	2.40	3.79	2.11	2.70	3.30	2.69	.64	.55	.99	1.96	.33	1.95	1.53	1.88
6 CHEMICAL	6.05	5.40	3.05	3.60	7.91	5.47	2.12	3.36	12.06	5.05	5.21	7.40	5.82	5.73	5.81
7 METAL PR	7.28	4.70	3.62	2.86	5.32	4.62	2.23	2.05	1.89	3.70	4.20	5.20	4.53	3.14	4.32
8 MACHINRY	4.70	2.29	2.24	4.74	4.45	2.04	1.41	.75	1.04	.71	.37	9.22	5.42	.72	4.71
9 ELECTRIC	4.13	.92	1.36	2.42	1.78	1.87	.65	.70	.97	.42	.99	1.97	2.22	.85	2.01
10 TRANSP.M	4.50	3.02	.07	2.39	2.99	2.57	1.24	1.78	3.19	.91	1.17	1.99	2.55	1.62	2.41
11 CONSTRUC	7.85	5.72	7.32	7.99	8.33	8.28	4.40	4.85	6.37	4.29	5.69	11.31	8.83	5.41	8.31
12 ELEC+GAS	2.61	3.26	3.69	2.22	2.19	2.30	1.34	1.22	2.26	1.61	1.97	1.88	2.23	1.80	2.17
13 SERVICE	42.91	40.19	39.86	56.32	42.50	42.41	35.85	27.77	34.44	35.60	49.94	9.83	39.01	40.76	39.28
14 TRANSP.C	7.25	7.68	13.26	6.46	6.27	7.84	5.48	6.02	9.06	5.99	4.95	8.88	7.42	6.00	7.20
15 TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

(2-A) LDC MAN. TO MAX)

BALANCE OF TRADE AT EACH SECTOR

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	-11.78	8.23	11.96	5.12	-4.01	2.17	.81	1.02	-7.31	-1.19	14.67	-19.59	-7.91	8.01	.10
2 MINING	-8.83	4.07	6.09	16.87	-29.97	-9.60	-.89	.53	6.34	1.75	7.45	6.22	-15.15	15.18	.03
3 FOOD & T	-.49	-.07	.32	-1.68	2.21	1.46	1.24	.08	2.19	1.89	.18	-7.23	-5.48	5.58	.10
4 TEX. & F	3.60	-1.53	-2.06	-13.22	2.81	4.83	11.00	2.66	-.55	1.22	1.25	-9.92	-15.50	15.59	.08
5 PAPER &	-1.43	-.35	3.65	-2.48	-8.07	8.59	3.30	-.23	-2.50	-.39	-.29	.23	.14	-.11	.03
6 CHEMICAL	.15	-1.22	-1.91	-5.54	15.38	-7.78	-6.48	-.71	24.33	-1.00	-8.49	-6.64	-7.56	7.64	.08
7 METAL PR	15.22	1.20	1.43	-17.12	-7.20	6.71	-.54	-.19	-6.79	2.39	-1.15	5.12	6.35	-6.28	.07
8 MACHINRY	5.08	-1.91	-3.41	3.77	23.72	-8.12	-2.05	-1.59	-5.68	-1.54	-15.09	6.89	26.01	-25.95	.06
9 ELECTRIC	11.13	-1.09	-2.25	-2.22	8.16	-.67	-1.55	-.21	-3.81	-1.01	-7.00	.55	13.61	-13.58	.03
10 TRANSP.M	19.88	-1.02	-7.30	-18.36	16.61	.38	-2.00	-.55	2.28	-1.22	-4.77	-3.89	6.30	-6.26	.04
TOTAL	34.53	6.30	6.51	-34.87	19.63	-2.03	2.83	.82	8.50	.90	-13.23	-28.26	.81	-.18	.63

BALANCE OF TRADE , RATIO (%) BY VA TOTAL

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR	13 DC	14 LDC	15 WORLD
1 AGRICULT	-2.63	10.70	7.37	.30	-.36	.49	.65	.69	-4.30	-1.87	3.42	-1.54	-.15	.86	.00
2 MINING	-1.97	5.29	3.75	.98	-2.67	-2.18	-.71	.36	3.73	2.74	1.74	.49	-.29	1.62	.00
3 FOOD & T	-.11	-.09	.20	-.10	.20	.33	.99	.05	1.29	2.97	.04	-.57	-.10	.60	.00
4 TEX. & F	.80	-1.99	-1.27	-.77	.25	1.10	8.78	1.80	-.32	1.92	.29	-.78	-.30	1.66	.00
5 PAPER &	-.32	-.46	2.25	-.14	-.72	1.95	2.63	-.16	-1.47	-.60	-.07	.02	.00	-.01	.00
6 CHEMICAL	.03	-1.58	-1.18	-.32	1.37	-1.77	-5.18	-.48	14.33	-1.57	-1.98	-.52	-.14	.82	.00
7 METAL PR	3.62	1.56	.88	-1.00	-.64	1.52	-.43	-.13	-4.00	3.75	-.27	.40	.12	-.67	.00
8 MACHINRY	1.13	-2.49	-2.10	.22	2.11	-1.84	-1.64	-1.07	-3.34	-2.42	-3.51	.54	.50	-2.77	.00
9 ELECTRIC	2.48	-1.42	-1.39	-.13	.73	-.15	-1.24	-.14	-2.25	-1.58	-1.63	.04	.26	-1.45	.00
10 TRANSP.M	4.43	-1.33	-4.50	-1.07	1.48	.09	-1.60	-.37	1.35	-1.91	-1.11	-.31	.12	-.67	.00
TOTAL	7.47	8.19	4.01	-2.03	1.75	-.46	2.26	.56	5.01	1.42	-3.08	-2.22	.02	-.02	.01

BALANCE OF TRADE

	1 JAPAN	2 OCEAN	3 CANAD	4 USA	5 EC	6 DC O	7 SE.A	8 SW.A	9 M.EST	10 AFRIC	11 L.A.	12 USSR
1 AGRICULT	-U	+U	+U	+U	-U	+U	+L	+	-L	-	+L	-
2 MINING	-U	+U	+L	+U	-U	-U	-	+L	+L	+	+	+
3 FOOD & T	-U	-U	+L	-	+L	+U	+U	+U	+U	+U	+U	-L
4 TEX. & F	+U	-L	-L	-	+L	+	+U	+U	-U	+U	+U	-L
5 PAPER &	-L	-L	+L	-	-L	+U	+U	-U	-U	-U	-U	+
6 CHEMICAL	+L	-L	-L	-L	+L	-L	-L	-U	+	-U	-	-L
7 METAL PR	+U	+L	+L	-L	-L	+L	-U	-U	-U	+U	-U	+
8 MACHINRY	+L	-L	-L	+L	+L	-	-U	-U	-U	-U	-U	+
9 ELECTRIC	+L	-L	-	-L	+L	-L	-U	-	-U	-L	-U	+
10 TRANSP.M	+	-L	-	-L	+L	+L	-U	-U	+U	-	-U	-

U ; UPPER   L ; LOWER   BLANK ; MEDIUM

Part Three

OTHER INPUT-OUTPUT MODELS

Chapter 12

THE SATISFACTION OF BASIC NEEDS INDEX (SBNI): A PROGRESS REPORT*

John M. Richardson, Jr.†
Eloise Forgette‡

1. INTRODUCTION

This paper presents initial, prototypical results from an on-going joint project of American University's Center for Technology and Administration and the World Population Society.*1* The project's objective is to develop a composite index focusing on the satisfaction of basic human needs at the national level. The Satisfaction of Basic Needs Index (SBNI) takes into account national performance, relative to needs, in the areas of nutrition, medical services, housing and employment. Results are reported, for five-year intervals, from 1950 to 1976 in order to facilitate assessments of individual nations over time, as well as inter-nation comparisons. At the present time, our data base includes data for 20 nations which have been chosen to take into account regional differences as well as differences in economic development and institutional structure. Eventually, a data base which comprises all of the nations of the world is contemplated.*2*

The Issue of Basic Human Needs

In recent years, fulfillment of basic human needs has come to the forefront as a goal of National and International policy. U.N.-sponsored conferences on food (U.N., Rome, 1974), habitat (Vancouver, 1976), employment (ILO, Geneva, 1976), and population (U.N., Bucharest, 1974) have focused attention on non-economic issues in development. Concurrently, there has been growing dissatisfaction with GNP per capita as an indicator of national development (Adelman & Morris, 1973) and a recognition that the distribution of wealth, institutional arrangements and domestic policies can significantly affect the relationship between economic growth and improvements in the human condition (Chenery, H., 1975).

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The Satisfaction of Basic Needs Index (SBNI)

If fulfillment of basic human needs is to become a major, long-term objective of national policy and a focus of attention at international forums, the development of comparable, recognized and widely accessible measures of performance relevant to this goal is essential. There is not presently in existence even an adequate data base which would support such a development. While segments of the total issue are under active study (Sewell, 1977), no attempt has been made to develop an aggregate indicator or set of indicators which would address the issue in its totality. Such an indicator, regularly reported over time, and supported by an adequate data base, could make a very significant contribution to the growing dialogue about basic human needs.

"Basic Human Needs": Nutrition, Medical Services, Employment, Housing

For the purposes of The Satisfaction of Basic Needs Index (SBNI), nutrition, housing, employment, and medical services are defined as basic human needs. We are aware, of course, that more extensive listings have been proposed by others and that other areas of concern - education, political participation, freedom from fear, etc. - have their passionate advocates (OECD, 1976). But we believe few could argue that the four categories of needs which have been chosen are not fundamental to any discussion of "basic needs". Philosophically, it is our position that adequate nutrition, medical care, housing, and probably employment ought to be defined as fundamental, non-controversial rights of citizens in a global society. Achievement of acceptable minimum levels in these areas may be a necessary condition for progress in other areas.

Structure of the SBNI

A recent study by the National Academy of Sciences, Planning for Environmental Quality (1975),has identified six functions of a good index. According to the study, an index should:

(1) Enhance communication; (2) Highlight significant conditions (3) Illustrate major trends; (4) Inform both professionals and laymen about the status of a particular issue (5) Assist in formulating and measuring progress towards goals; and (6) Facilitate the judgement and decision process.

This enumeration of functions emphasizes the symbiosis of science, art and public relations which characterizes indices that have gained wide acceptance. Such a symbiosis is much easier to describe than achieve.

In designing the SBNI we have used an approach that is intended to be easy to grasp intuitively. The same rationale has been used to structure each of the four subindices, nutrition (I_n), housing (I_h), medical services (I_m), and employment (I_e) which are aggregated to form the composite index. This rationale may be summarized as follows:

(a) Associated with each individual in a nation are a set of basic nutritional, medical service, housing and employment needs.

(b) For each category of needs, it is possible to define a per capita threshold denoting a desired or acceptable level of satisfaction. Thresholds may be defined by national leaders, by international organizations or by other interested persons or authorities.[3] Alternatively, arbitrary thresholds might be defined for the purpose of exploring a particular issue or making international comparisons.

(c) Where distributional inequities exist, the threshold is to be applied whenever possible, to the least affluent segment of the population. (Unfortunately, data on distribution is often scarce, or unavailable).

(d) Associated with each threshold, is a measure of national performance, defined in the same units of measurement.

(e) For each category, the index is defined as

$$INDEX = \frac{PERFORMANCE}{NEEDS} \qquad (1)$$

so that values greater than one denote levels of performance above the threshold and values less than one denote levels of performance below the threshold.4

The composite index is, essentially, the arithmetic mean of the four category indices.

$$SBNI = \frac{I_n + I_m + I_e + I_h}{4} \qquad (2)$$

First, standardized category indices are defined where for all nations i and all categories j,

$$I^s_{ij} = \sqrt{e\left(\frac{I_{ij}}{\sigma f_j}\right)} \qquad (3)$$

$$\sigma f_j = \sqrt{\frac{\sum_{i=1}^{n} \left(I_{ij} - 1\right)^2}{N_i}} \qquad (3.1)$$

Second, weighting factors w_j, $w=1$, have been introduced in order that differing degrees of "importance" can, if desired, be assigned to the categories. The calculation of the composite index, taking the above considerations into account is

$$SBNI = w_n I^s_n + w_m I^s_m + w_e I^s_e + s_h I^s_h \qquad (4)$$

In the results reported below, w_j has been assigned a value of 1 for all categories. In other words, each category is assumed to be of equal importance in determining the value of the composite index.

What the SBNI is not

Because there has been so much discussion of developmental issues and of social indicators in recent years, we feel it is important to emphasize the very limited and modest character of our objectives, relative to other approaches which have been presented or proposed. First, the SBNI is not intended to be, in any sense, an indicator of "development". Development, as a concept, poses some extremely difficult definitional and methodological issues which we are aware of, but have not even attempted to address. It may well be that basic needs cannot be satisfied if some level of development is not achieved. Given a well-defined index of development this is an issue which, perhaps, could be investigated using the SBNI. Second, the SBNI is not intended to be an indicator of quality of life. Quality of life, in our judgement, is a concept which is freighted with profound philosophical as well as conceptual and methodological implications. It is doubtful that "quality of life" as it is usually defined could be attained without a relatively high level of satisfaction of basic needs in the areas of nutrition, health, employment and housing. However, it seems quite probable that a widely accepted definition of quality of life will have to include many other considerations as well.5

2. THE SBNI DATA BASE: DEVELOPMENT, STRUCTURE, CONTENT

Data Collection Problems

Although basic human needs have been an object of concern for several years, relatively little progress has been made in developing widely accepted goals or comparable measures of national performance. In particular, almost nothing has been done to investigate changes, over time, in this area. More than anything else, this simply reflects the state of the art of data collection throughout the world. In developing nations, especially, (with the exception of a few ex-colonial nations) the quality of the data which addresses human needs issues is sparse. The data which does exist is often of questionable value. In the industrialized nations, the situation is somewhat better, but, even here, serious limitations exist.

Given these problems, investigators have been understandably reluctant to pursue projects such as the one described in this paper. However, the rationale for avoiding such attempts is circular. Without studies which use the existing data, gaps and inconsistencies will never be identified, let alone remedied. There are few better ways to identify data needs than to attempt to bring existing data to bear on a hitherto unexamined problem.

Category Indices and Data Collection Requirements

The selection of appropriate indicators for our four categories of basic human needs was an iterative process. We began with simple conceptualization of thresholds and performance indicators in each area. Next, attempts were made to collect data on indicators which would provide valid measures of our category indices, as conceptualized. This process led to modifications of the indices, as well as the data collection efforts. In one case, employment, the initial conceptualization of the category index had to be modified very substantially, due to data limitations. In every instance, compromises between what was desirable and what was possible were necessary. The indicators which are presently used in the calculation of the category indices are summarized in Table 1.

Table 1. Indicators used in the calculation of category indices.

Medical Services
1. number of physicians
2. number of hospital beds
3. total medical personnel (excluding physicians)
4. infant mortality
5. life expectancy from birth

Nutrition
1. calories per day per capita

Employment
1. unemployment
2. per capita income (to indicate underemployment)

Table 1 (continued).

Housing
1. number of dwellings
2. number of persons per room
3. number of persons per household
4. annual construction

Principal Sources and the Data Collection Process

Although one of the authors has had extensive experience in the development of large data resources in the area of environmental and food policy, it seems that one must learn again the problems which exist in national and international data sources. Given that the project was located in Washington, D.C., we began our data collection effort with considerable optimism. Our initial plan was to use the national embassies as data sources, as well as for information on national goals. It soon became apparent this approach would not yield results commensurate with the effort required.6

Concurrently, a literature search was initiated in the hope of identifying related research as well as relevant data. While a number of valuable sources were identified (e.g. McGranahan, 1971) none focused on the particular issues with which we were concerned. Ultimately we were forced, with full realization of the attendant problems, to the use of the U.N. Statistical and Demographic Yearbooks (1950-1975 Annuals) along with the collections of U.N. affiliated agencies (WHO, ILO, and FAO 1957-1976 Annuals). Consultation with knowledgeable experts who are working in the same area convinced us that this strategy is probably the only practical one for the moment.7 Where gaps in time series data existed and where it seemed appropriate, we have used reasonable strategies of interpolation and, in some cases, extrapolation. In many instances, however, it has been necessary simply to leave gaps in the data. Data problems are particularly severe for the African countries which, unfortunately, are very incompletely reported in our analysis. 8

3. THE CATEGORY INDICES

In this section the category indices are defined, and preliminary results are presented. Particular attention has been devoted to the difficult issue of threshold-setting. It should be emphasized again that the category index values (and hence, the value of the composite index) are highly sensitive to threshold values.

The Nutrition Index: (I_n)

The nutrition index (I_n) is the simplest and most straightforward of the four category indices. The definition of the index is:

$$I_n = \frac{S_n 40}{N_m} \tag{5}$$

where $S_n 40$ = *food consumption per capita per day (measured in kilocalories per day) for the lowest forty percent of the population* (5.1)

$N^i{}_m$ - *nutritional needs (measured in kilocalories per capita per day)* (5.2)

Data for average percapita consumption is from the U.N. Statistical Yearbook (1950-1975). To calculate the value of S_n40, from average consumption data, we have used the approach developed by P. C. Roberts and David Norse for the U.K. Department of the Environment Global Modeling Project. (Roberts and Norse, 1975).

Originally it was intended to incorporate both protein and calorie consumption in the nutrition index. However, recent literature has argued that protein deficiencies are rarely present if calorie intake is adequate. (Hopkins and Skolnik, 1977).

Threshold Values

The nutritional values used for N_h are based on the regional thresholds for nutritional needs which have been established by FAO (FAO, 1970).

Results

Data was sufficient to permit the calculation of some I_n values for twenty countries. Results are reported graphically in Figure 1.

Values of S_n40 (food consumption) range from a low value of 1,380 (India in 1950) to a maximum of 3,080 (the United States in 1970). *9* The range of index values is from .62 (India in 1950) to 1.22 (Argentina in 1955). In 1950, I_n values for all but four nations were below the 1.0 threshold, denoting inadequate average nutritional levels. By 1965, the last year for which relatively complete data is available, there are 11 countries with I_n values greater than 1.0.

Although these figures show a generally improving trend in the level of nutrition, they hardly offer grounds for complacency. Seven nations in 1965 have index values near or below .8, denoting serious levels of nutritional inadequacy. The majority of these nations are found in Africa and Asia.

In contrast to other categories, there appears to be an upper bound beyond which increases in food consumption do not occur. In several developed nations, in fact, consumption levels have actually declined. However, one observer (Molitar, 1977) has noted that excessive levels of food consumption are causing serious health problems in at least one developed nation (the United States).

The Housing Index: (I_h)

Serious definitional and conceptual problems make the definition of a meaningful housing index a much more difficult task than is the case in the nutrition area. In addition to the usual data availability problems, there is a lack of consensus as to what constitutes a "dwelling" or a "room" in a given nation for which data is reported. While some distributional data is available, we have not as yet figured out a satisfactory way of incorporating it into the housing index. Hence, the index values are somewhat higher than is realistic.

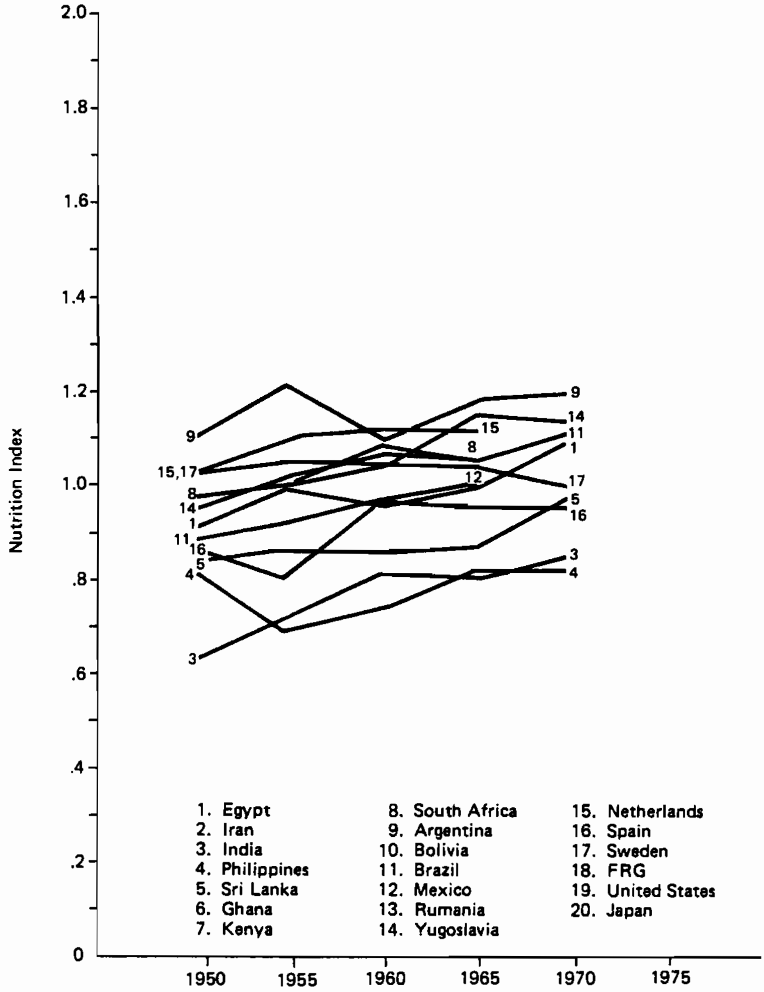

Figure 1. Graphical representation of the nutrition index (I_n).

The definition of the housing index is:

$$I_h = \frac{N_h}{S_h} \tag{6}$$

where S_h = *number of persons/room* (6.1)

N_h = *threshold value for desired number of persons per room* (6.2)

also $S_h = \frac{D \cdot R}{P}$ (6.3)

where D = *number of dwellings*
R = *rooms/dwelling*
P = *population*

As data is skimpy at best, some fairly heroic assumptions have been necessary to fill in gaps in the time series. Most critical is the assumption that the average number of rooms in a "dwelling" can be determined by taking the quotient of two available indicators, household size and persons/room. This requires the further assumption that "dwellings" are inhabited by "households".*10* In addition we have assumed that "dwelling" sizes remain constant over time. While these calculations do produce intuitively plausible results -- one to three room dwellings in developing nations, as high as six room dwellings in the United States -- obviously a great deal of additional work must be done before much confidence can be placed in the housing index.

An additional problem is quality of housing. We have experimented with a version of I_h which is weighted by two "quality" indicators, number of dwellings with piped water and number of dwellings with electricity. However, our data is so incomplete that the reporting of these results did not appear to be justified at this time.

Threshold Value

The same value of N_h, 1.2 persons per room is used for all nations. This value is derived from the standard housing unit used by the Fundacion Bariloche global modeling team (Bruckman, ed., 1975). This unit has four rooms and is occupied by a family of five.

Results

Sufficient housing data presently exists for only 15 of the 22 nations in our data base. Results for the calculations of the housing index are reported graphically in Figure 2.

The distinction between what are generally regarded as developed and developing nations is most apparent in the area of housing. With the exception of a special case, South Africa, all of the developed nations have I_h values above 1.0 after 1960 and show steady increases. Only the United States demonstrates any leveling off in the area of housing.

All of the developing nations have I_h values below the threshold. The fact that all of these nations actually show a decline in the state of housing is an even more striking result. The only nation with an initial I_h value significantly below the threshold to exhibit a steady pattern of improvement is Yugoslavia.

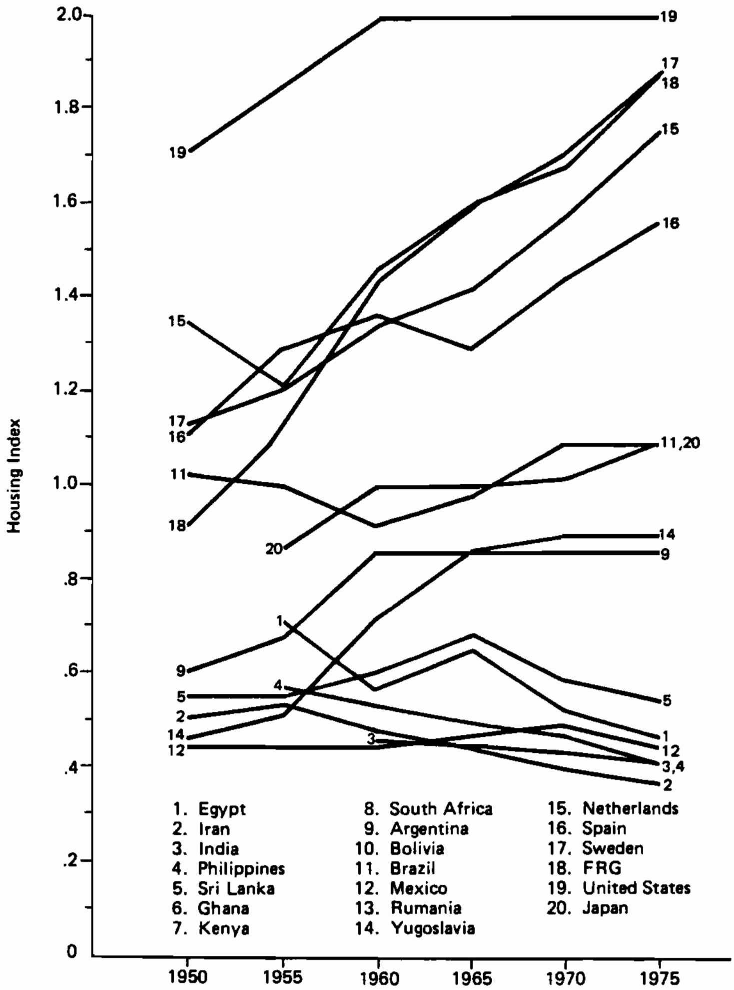

Figure 2. Graphical representation of the housing index (I_h).

The Medical Services Index: (I_m)

The medical services index (I_m) is itself a composite index. Its definition is:

$$I_m = \frac{Iho + Iph + Imp}{3} \quad (7)$$

where

Iho = the hospital services subindex
Iph = the physician services subindex
Imp = the medical personnel subindex

The structure of these subindices is generally similar to the category indices discussed above.

$$I_{ho} = \frac{M_{ho}}{S_{ho}} \quad (7.1)$$

$$I_{ph} = \frac{N_{ph}}{S_{ph}} \quad (7.2)$$

$$I_{mp} = \frac{N_{mp}}{S_{mp}} \quad (7.3)$$

where

S_{ho} = number of persons per hospital bed
S_{ph} = number of persons per physician
S_{mp} = number of persons per medical service person
N_{ho} = threshold value for desired ratio of persons: hospital bed
N_{ph} = threshold value for desired ratio of persons: physician
N_{mp} = threshold value for desired ratio of persons: medical personnel

Data for S_{ho}, S_{mp}, and S_{ph}, as well as two other indicators whose significance is discussed below, infant mortality and life expectancy at birth, were taken from the United Nations Demographic Yearbook (1950-1975).

Threshold Values

Indicators of medical service levels are fairly easy to develop and data problems are less severe than in some other areas. However, this area poses the most difficult problems, conceptually. The source of the problem is the tenuous relationship between indicators of health and indicators of medical service levels. The state of health in a nation is related to many other factors in addition to medical service levels.[11]

We have used the following threshold values in the calculation of the medical service indices:

N_{ho} = 220 persons per hospital bed
N_{ph} = 904 persons per physician
N_{ms} = 257 persons per medical person

The rationale for the use of these numbers is the following, reasonable, but essentially arbitrary approach.

(1) We set, again arbitrarily (but based on an examination of available data), desired levels for our two health indicators, as:

infant mortality ≤ 20
life expectancy at birth ≥ 70

(2) We identified all of the nations which surpassed both of these levels and recorded their S_{ho}, S_{ph}, and S_{mp} values for the first year after this occurred. The nations and the values are as follows:

I_{ho} - Sweden, 230; Netherlands, 238; Japan, 152; USA, 205; Spain, 276;
I_{ph} - Sweden, 1450; Netherlands, 1100; Japan, 950; USA, 620; Spain, 800
I_{mp} - Sweden, 140 (1950); Netherlands, 383 (1955); Japan, 354 (1965); USA, 81 (1970); Spain, 329 (1975)

The threshold values are the column arithmetic mean values.[12]

Results

The available data allowed us to calculate values of the medical services index for 15 nations. These results are reported graphically in Figure 3. As in the case of housing, the range of index values is quite broad, from a low of .06 (Ghana in 1950) to a high of 2.9 (Sweden in 1975). Several of the underdeveloped countries have shown slow, but steady improvement, but two (India and the Philippines) have registered declines. Several more developed countries (Spain, Rumania, Netherlands, and Yugoslavia) have registered truly remarkable gains.

There does not, as yet, appear to be any upper bound or patterns of growth in delivery of medical services.

The Employment Index (I_e)

As noted above, a departure from our overall strategy for category index construction was necessary in the area of employment. Also, I_e is the only index which requires the use of economic data.[13]

The employment index is defined as:

$$I_e = \frac{N_e}{S_e} \qquad (8)$$

where

N_e = *the threshold level for an acceptable level of employment*
S_e = *the per cent of the labor force employed*

$$S_e = 1 - U - I_{un} \qquad (8.1)$$

U = *the fraction of the labor force unemployed*
I_{un} = *the fraction of the labor force underemployed*

Values of U are taken from the International Labor Organization Statistical Yearbook (1976). However, in most developing nations, and several developed nations, it is the number of underemployed rather than the number of unemployed which is the more significant figure.

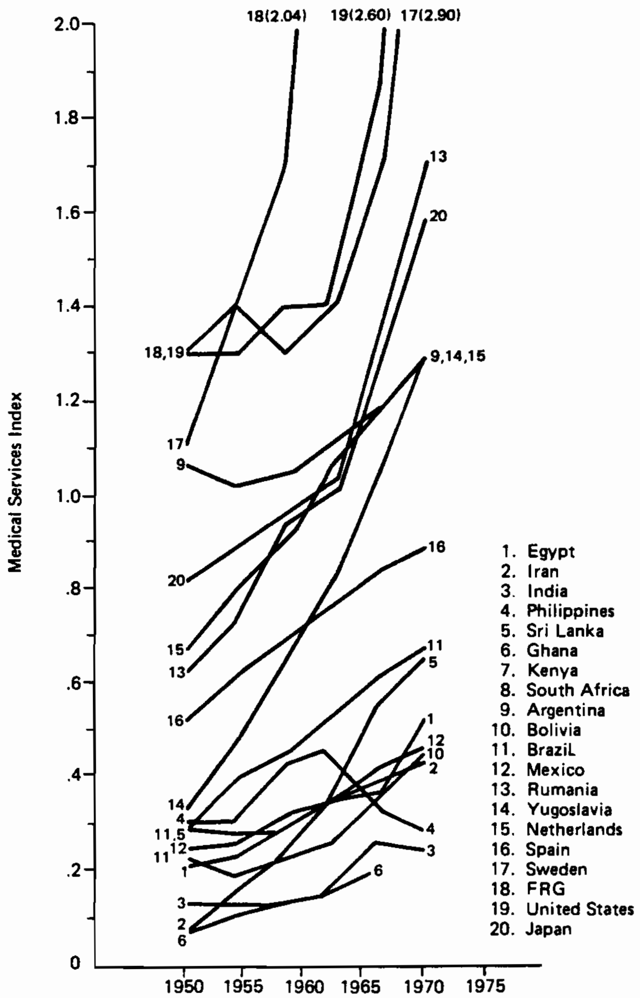

Figure 3. Graphical representation of the medical services index (I_m).

The concept of underemployment refers to the meaningfulness of a job, to the society, but more important, to the individual who holds it. In developing nations, especially in the agricultural and service sectors, underemployment can be quite high, comprising 50% of the total labor force or more.

We have based our approach to defining underemployment on that of Richards (1976), although with significant modifications. Richards establishes regional per capita income thresholds which he defines as "poor", "seriously poor", and "destitute". Income is used as a measure of productivity; workers with very low incomes are referred to as the "invisible unemployed".

We have adopted a very conservative approach to the definition of underemployment, using Richards' "destitute" threshold as the basis for our calculation. Richards' value, deflated to 1970 dollars, is multiplied for each nation by the ratio labor force: population. This ratio, which is sensitive to changes in population age structure, and changes in the composition of the labor force, provides a rough indication of the number of persons each member of the labor force must support. *14*

Thresholds

As noted in the discussion above, there are two thresholds which are of importance in the calculation of the employment index. The income threshold used in defining underemployment has already been covered. The value of the second threshold, N_e, is set at 90%.

Results

Values of the employment index for 20 nations are reported and presented graphically in Figure 4. The results do not show anything particularly surprising. Germany and Japan have made spectacular progress during the postwar period. Most of the developing nations have made little, if any progress. Even nations whose economic growth has been quite spectacular in recent years have not had a great deal of success in alleviating the unemployment/ underemployment problem.

4. THE SATISFACTION OF BASIC NEEDS INDEX

The mathematical definition of the composite index has been presented earlier. In Table 2 and Figure 5 our first results are presented. Where values could not be defined for all four of the category indices, no data is reported, with one exception. The 1975 values of the SBNI have been calculated using 1970 values for I_f.

In Figure 6, the relationship between 1970 SBNI values and GNP per capita is reported. These results suggest that for developing nations, at least, GNP per capita and the SBNI are measuring different phenomena. Different patterns of distribution, and different societal goals can lead to wide disparities in the degree to which nations with comparable levels of economic development are meeting basic human needs.

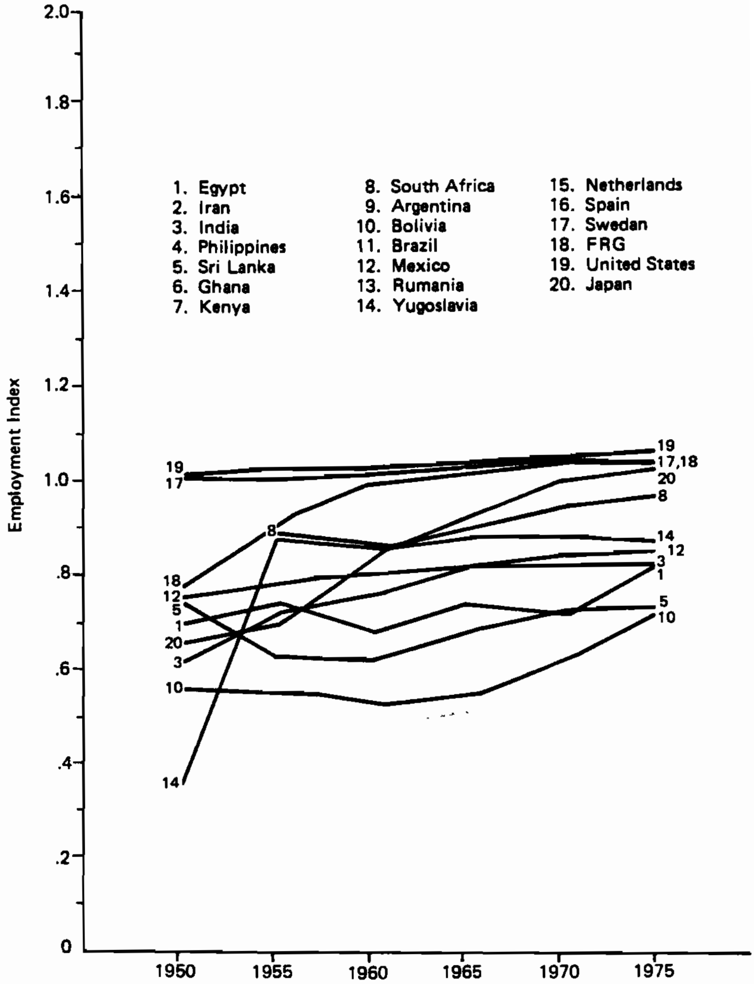

Figure 4. Graphical representation of the employment index (I_e).

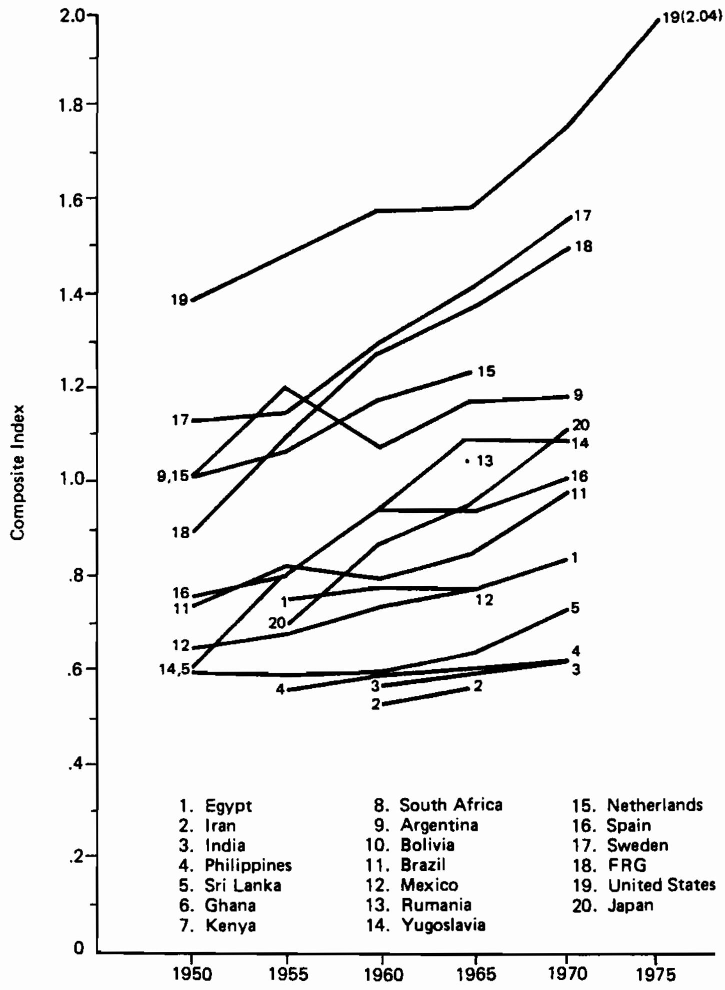

Figure 5. Graphical representation of the composite index.

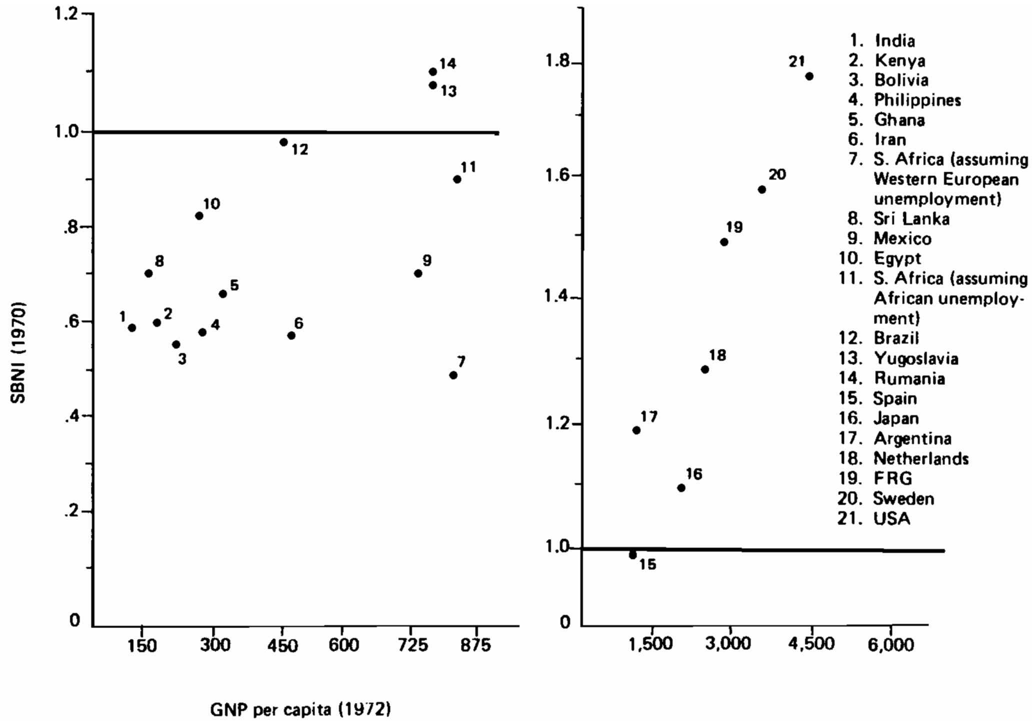

Figure 6. Scattergram of SBNI versus GNP per capita.

This paper has been written at a time when we are just beginning to explore the potential uses of the SBNI and the manner in which inter-nation comparisons can best be presented. We have deliberately delayed the implementation of a data base on the computer in order to avoid the false sense of rigor, precision and finality, which can sometimes be created by computer printout. A consequence of this strategy is, of course, that each new calculation of the SBNI is an arduous process. But, we believe that the immersion into the data and calculations, which this approach necessitates, is giving us a better "feel" for the data and a clearer insight into areas where potentially significant results are most likely to emerge.

Some of the patterns which do emerge in Table 2 and Figure 5 do merit brief comment. First, the SBNI results provide one more indication of the gross disparities which exist in today's world as well as the fact that they are increasing, not decreasing. In the less developed nations of the world, it is tragic to note how slight the progress has been in the area of basic human needs. The degree of human suffering depicted by the SBNI values below .8 is, in our judgement, incalculable and intolerable. In assessing these results, moreover, it is important to recall how conservative we have been in the setting of the thresholds.

In the developed nations of the world, allocation of the human needs sector has continued apace with economic growth. To the degree that our thresholds are meaningful, it could be observed that these nations have evolved to the satisfaction of human wants as opposed to human needs. In the areas of food, and possibly housing, some developed nations may be approaching a state of satiation, or approaching fixed limits. But this will be at a level which cannot possibly be attained by most nations of the world in the foreseeable future. The questions of whether this pattern is sustainable and whether it is moral go beyond the scope of this paper. But it is absolutely essential, in our judgement, that there be the widest possible awareness of the disparities which exist. Hopefully, a refined and widely published SBNI (supported by an adequate data base) can contribute significantly to achieving this awareness.

We believe that another potential use of the SBNI is as an integral component of ongoing and contemplated global modeling efforts. To date, only one global modeling project, the Bariloche project, has focused on a broad spectrum of basic needs issues. We would argue that the areas and concerns discussed in this paper should be given high priority in future global modeling activities and that, where possible, existing models be modified to include SBNI forecasts as part of their output.

During the coming months, we will devote our attention to extending the SBNI data base and exploring modifications and refinements in the index itself. We shall undertake this effort with outside resources if they are available or, as in the past year, with our very limited resources if they are not. We do not claim and we do not believe that an index will solve any of the world human needs problems. We are not certain, in fact, that the problems are solvable at all. But we are certain that the problems will not be solved if their magnitude and severity continue to be ignored by the more affluent members of the global community of nations.

Table 2. Composite index for selected countries.

	1950	1955	1960	1965	1970	1975*
1. Egypt		.762	.787	.782	.845	.68
2. Iran			.54	.578	.63	.74
3. India			.58	.602	.63	
4. Philippines		.57	.60	.612	.62	.66
5. Sri Lanka	.61	.605	.61	.65	.74	.69
6. Ghana						
7. Kenya						
8. South Africa						
9. Argentina	1.03	1.22	1.09	1.19	1.20	.97
10. Bolivia						
11. Brazil	.75	.84	.81	.86	.99	.87
12. Mexico	.66	.69	.745	.79		
13. Rumania						
14. Yugoslavia	.61	.82	.96	1.13	1.12	1.00
15. Netherlands	1.03	1.08	1.19	1.27		
16. Spain	.76	.81	.95	.94	1.02	1.17
17. Sweden	1.14	1.16	1.31	1.43	1.57	2.06
18. FRG	.09	1.11	1.29	1.39	1.51	1.86
19. United States	1.40	1.50	1.59	1.60	1.77	2.04
20. Japan		.70	.88	.96	1.12	1.16

*calculated on the basis of 1970 food data

NOTES

1 The rationale for the project is described in Richardson (1978). The assistance of Professor R. Berrian Moore (Department of Mathematics, University of New Hampshire) and Mr. Frank Oram (World Population Society) in the initial conceptualization and development of the project is gratefully acknowledged.

2 A listing of the nations selected is shown in Figure 1.

3 For example, we have made extensive use of thresholds presented by Hopkins and Skolnick (1977). These in turn were greatly influenced by the Fundacion Bariloche Global Modeling Project (see Bruckman, ed., 1974).

4 For computational reasons, and because of variations in the variable data used to measure performance, not all of the category indices appear in precisely this form. However, in every case but one, the category indices are mathematically equivalent. The one exception, employment, posed some special data problems which necessitated the use of a somewhat different approach. This is discussed in greater detail in subsequent pages.

5 Recently, an attempt to define a physical quality of life index has been presented by Morris D. Morris of the Overseas Development Council. (See Morris, Morris D., 1976).

6 Sources indicated in bibliographic listings.

7 Morris D. Morris of the ODC and his staff were particularly helpful as were the staff of the D.C. International Labor Organization Office.

8 In a subsequent stage of the project, we envision establishing close working relationships with a number of national statistical offices.

9 1975 values for average caloric intake were not available.

10 However, note that in computing S_h we have allowed for the possibility of crowding (1.2), implying that more than one household could occupy a single dwelling.

11 In addition to noting this fact in the literature (see for example, Morris, 1976) we satisfied ourselves of this by correlating medical service indicators with two indicators of health, infant mortality and life expectancy at birth. There were no really significant relationships.

12 Improvement of the conceptual basis for our N_{ho}, N_{ph} and N_{mp} values is an area to which we will be devoting attention in the coming months. We welcome the suggestions of the readers.

13 Obviously this is a matter of concern since such an index is likely to be highly correlated with GNP/CAPITA. For a brief discussion of the relationship between the composite index SBNI and GNP per capita, see Section 4.

14 To calculate U_t, we have relied presently on the income distribution data provided in Chenery, H. (1975), in order to construct a precise linear approximation of the Lorenz Curve. As time series data is not available, it is necessary to assume that distributions are constant, over time.

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Chapter 13

A 51-SECTOR WORLD INPUT-OUTPUT MODEL

Anthony Bottomley, John Dunworth, Colin Carpenter, Donald Nudds, Reginald King, David Taylor, Martin Curtis, Michael Lloyd, Christine Watts, Lesley Clarke, Alexander Diediw, Faith Orr, Rashmi Patel and Manherlal Mistry

INTRODUCTION

Objectives of the Study

We are building a world model comprising the 51 sectors listed in Appendix A. Work is already in progress to expand this model by seven agricultural sectors. The 51 sectors have already been formed into input-output tables for 126 countries.

Each of our 51 sectors will be connected as exports to other countries by means of world trade flows by origin and destination. These flows will initially be shown as exports of agricultural produce from country A, say, to country B. The ultimate aim, however, is to represent them in matrix form with country A's exports of agricultural produce to country B's food processing industry being specified and so on. Such flows will ultimately comprise a matrix of more than 6426 rows and columns (51 sectors x 126 countries). Such a matrix will encompass more than 40 million elements (6426 rows x 6426 columns). When the agriculture and, perhaps, chemical rows and columns are disaggregated to form 57 or more sectors, the number of elements will rise to circa 60 million. In the meantime, however, we are working on a five-sector world trade matrix only.

Various scenarios for world development through to 1980, 1990 and the year 2000 will be developed on the model. The basic scenarios will comprise UN predicted population growth rates with given per capita GDP changes for each country at these dates. The consequent patterns of demand, trade and employment which these are likely to call forth will then be computed. Resulting unsatisfactory balance of payments and employment effects may thus be recorded with initially unchanged 1970 trade and production coefficients. The nature and consequences of "improved scenarios" will then be explored.

Staffing

The study is staffed by candidates for higher degrees, data processors, a research fellow and several members of the teaching staff at the University of Bradford. All are named as the authors of this paper.*

Data Base

The University of Bradford Input-Output Research Group now has some 300 national input-output table-country-years covering almost 100 different countries (see Appendix B).

Each sector of each table is coded according to the appropriate International Standard Industrial Classification (ISIC), and the UN trade tape data for 1970 are translated from the corresponding Standard Industrial Trade Classification (SITC) into ISIC in accordance with the UN stipulations regarding code equivalence. But this translation is rudimentary and will need marked revision at a later date.

All tables with their corresponding codes are filed on the University of Bradford computer and a 51 x 51 standard format aggregation already exists for them. But the remaining seven agriculture sectors are still in the process of preparation. The ultimate intention is to devise procedures for expanding or contracting each country's table into predetermined sector formats in accordance with their associated ISIC codes. We here describe a 51-sector model.

In addition to the data on computer files, the original tables plus notes are concentrated in box files with one box for each one of the countries in the collection. Each box file contains an index with the information concerning the tables in it as listed in Appendix C.

To this must be added the three-digit SITC computer trade tape for 1970 produced by the UN Statistical Office (UNSO), together with tapes on total output volume and value plus value added for the 48 (out of our 51) sectors contained in UNSO's publication *Growth of World Industry* for 1970. Additional data on country and sector output in agriculture and fertilisers are obtainable in published form and/or on computer tapes from the Food and Agriculture Organization (FAO), together with predictions through to 1990 with respect to some of these totals. Other data are available from a variety of sources, notably UNSO and other world modellers.

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*Richard Darwin, Phillip Williams, Graham Whitehead, Rejat Al-Kamizy, William Mould, Mark Berka, David Cox, Balwinda Uppal, Melanie Brough, Kay Welham and Angela Bradley have since joined the team.

Methodology

The method which the Bradford Input-Output Group is employing in constructing the model can best be understood by reference to the Zambian input-output table for 1969. We may discuss the issues involved under the following headings: original tables, 51-sector tables, and trade flows.

1. ORIGINAL TABLES

These comprise the 87+ most recent national input-output tables currently in the hands of the Bradford Input-Output Group. They are listed in Appendix B. To these must be added some 30 to 40 created tables for countries which have not yet produced an input-output matrix.

In actuality, these tables range in size from less than ten sectors (Rwanda) to 207 (Spain). Most of them are for years prior to our base year of 1970, but some, including all of the EEC countries, the USA and Japan are available for 1970 at least in RAS update, although not necessarily domestic form. None, however, are presented in the 51-sector format required for our model as per Appendix A. Therefore they have been aggregated and disaggregated until they fit this format.

2. FIFTY-ONE SECTOR TABLES

Compiling a 51-sector individual country input-output table for our 1970 base year presents a number of problems. They may be dealt with under the following heads: (a) the third quadrant, (b) the second quadrant (c) the first quadrant, (d) the fourth quadrant, (e) a modified RAS method and (f) table creation.

a) The third quadrant of an input-output table comprises the import row, the value added row and the column totals. As it is very often the only item for which we have any hard data, our method takes the value added row as its starting point.

The value added (VA) row is first updated by taking the *UN Yearbook of National Income Accounts* (NIA) GDP for 1970 in the nine subdivisions given there: Agriculture, Mining, Manufacturing, Construction, Energy and Services (four subdivisions). By taking these subdivisions rather than the total GDP as a starting point for the updating procedure we are able to restrict the effects of, say, a dramatic fall in mining value added to the mining sector alone within the matrix. The items in the NIA "Import Duties" and "Statistical Discrepancy" are shown as Value Added into Domestic Final Demand. "Imputed Bank Service Charges" is subtracted from the Finance Services sector. These nine figures are again subdivided in the proportions of the VA in the original table.

$$\frac{\text{Original Table Sector 10 (Textiles etc.)VA}}{\text{Original Table Manufacturing VA}} \times \text{1970 NIA Manufacturing VA} = \text{1970 (Textiles etc.) VA of 10.87 million kwacha (See Table 1, row 9, column 2).}$$

At this stage however, we have updated VA only for the number of sectors which happen to be in the original table. The VA row must now be made to conform to our standard 51 sectors. Where a disaggregation is involved, this is done according to the UNSO *Growth of World Industry* (GWI) value added proportions. If, for example, the original table sector 10 has to be split between five of our 51 sectors, ISIC 321, 3211, 322, 323 and 324, then each of the GWI value added figures for these ISIC sectors is in turn expressed as a proportion of the sum of the five sectors and these proportions are applied to the updated original table VA figure for sector 10:

$$\frac{\text{GWI 321 VA}}{\text{GWI 321 + 3211 + 322 + 323 + 324 VA}} \times \text{Table Sector 10 VA} = \text{Sector 321 VA of 1.61 million kwacha (See Table 1, row 9, column 4).}$$

Updated column totals (CT) are found by taking the ratio of the original table VA to the original table CT in any particular sector and applying this proportion to the 1970 VA for that sector:

$$\frac{\text{Original Table Sector 10 CT}}{\text{Original Table Sector 10 VA}} \times \text{1970 Sector 10 VA} = \text{1970 Sector 10 CT of 26.89 million kwacha (See Table 1, row 10, column 2).}$$

But this system has the disadvantage of causing all other inputs into sector 10 to rise or fall in the same proportion as value added therein has risen or fallen in relation to their respective sectors. There is no reason to suppose that this would be so, particularly in the case of agriculture and mining where commodity prices are volatile.

Nevertheless, we have now updated CTs for the original table sectors, so in order to make these sectors conform to our 51 sectors, some aggregation and disaggregation will be necessary. Where a disaggregation is required, this is done according to GWI 1970 total output (CT) proportions:

$$\frac{\text{GWI 321 CT}}{\text{GWI 321+3211+322+323+324 CTs}} \times \text{Table Sector 10 CT} = \text{ISIC 321 CT of 5.20 million kwacha (See Table 1, row 10, column 4).}$$

It will be seen that, although the CTs have been updated and standardised, it may be that the final figures have been distorted somewhat as their calculation has been based on VA figures which do not include import duties and statistical discrepancies from the 1970 *UN Yearbook of National Income Accounts* (see VA method above), whereas, in the original table, VA may well have included these items.

Table 1. Sample column Sector 10, textiles, wearing apparel, leather products and footwear from original Zambian input-output table updated and disaggregated into sectors 9 - 13 of the 51-sector table (millions of Zambian kwacha).

	Original Column	Updated Column	%Change (2)/(1)	DISAGGREGATED UPDATED COLUMNS ISIC 321	ISIC 3211	ISIC 322	ISIC 323	ISIC 324	TOTAL	%Change (9)/(2)	RASed DISAGGREGATED UPDATED COLUMNS ISIC 321	ISIC 3211	ISIC 322	ISIC 323	ISIC 324	TOTAL	%Change (16)/(2)	%Change (16)/(1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
1. Farming, Forestry and Fishing	1.16	1.30	+12	0.25	0.13	0.75	0.08	0.08	1.29	-1	0.22	0.14	0.56	0.07	0.07	1.06	-18	-9
2. Other food products	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3. Textiles, wearing apparel and leather products	0.04	0.04	0	0.01	0	0.03	0	0	0.04	0	0.01	0	0.02	0	0	0.03	-25	-25
4. Construction	0.15	0.17	+13	0.03	0.02	0.1	0.01	0.01	0.17	0	0.04	0.03	0.10	0.01	0.01	0.19	+12	+27
5. Government Administra-tion	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6. Other inter-mediate sectors aggregated	3.53	3.95	+12	0.76	0.36	2.29	0.25	0.25	3.91	-1	1.01	0.51	2.34	0.27	0.27	4.40	+11	+25
7. Intermediate column totals	4.88	5.46	+12	1.06	0.53	3.17	0.35	0.35	5.46	0	1.19	0.67	3.04	0.36	0.36	5.62	+3	+15
8. Imports	9.43	10.56	+12	2.04	1.02	6.13	0.68	0.68	10.55	-1	2.24	1.31	5.68	0.69	0.69	10.61	+0.5	+13
9. Value Added	9.71	10.87	+12	1.61	0.48	7.42	0.68	0.68	10.87	0	1.77	0.62	6.89	0.69	0.69	10.66	-2	+10
10. Column Totals	24.02	26.89	+12	5.20	2.60	15.61	1.73	1.73	26.87	-1	5.20	2.60	15.61	1.73	1.73	26.87	-0.1	+12

Imports: The elements in the import row are updated and disaggregated by taking the ratio of the original table import figure to the original table column total in each sector (the import input co-efficient) and applying it to the 1970 CT for that sector. Disaggregation takes place when the ratio of the original table import to the column total for, say, Sector 10 is found and applied to each of the five updated disaggregated column totals in the foregoing examples:

$$\frac{\text{Original Table Sector 10 Imports}}{\text{Original Table Sector 10 CT}} \text{ X ISIC 321 CT 1970=ISIC 321 Imports in 1970 of 2.04 million kwacha (See Table 1, row 8, column 4).}$$

Once the import row has been updated and standardised to the 51 sectors in this way, the sum of this row, plus re-exports from the UNSO trade tapes, is subtracted from the 1970 NIA import total (M) and the difference is taken to represent the figure for imports into domestic final demand. This residual is arbitrary and leads to a different import co-efficient in the DFD column vector from that contained in the original table.

b) The second quadrant of our input-output tables comprises row totals as well as the export column and the domestic final demand column.

Row totals (RT): The values for column totals found for the third quadrant are transferred to the row total vector in the second quadrant.

Domestic final demand (DFD): The 1970 total for domestic final demand in the fourth quadrant is found by the following formula:

GDP 1970 + M 1970 - X 1970 = DFD 1970
(These three totals are obtained from NIA when M represents total imports and X represents total exports, in millions of kwacha in Zambia's case.)

They comprise 1142.8 kwacha (GDP), 470.5 kwacha (M) and 685.4 kwacha (X) to give a DFD column total of 927.9 million kwacha for 1970. From this total must be subtracted VA into DFD + imports into DFD (see method for VA and imports respectively), which go into the fourth quadrant (see below). The remainder is then distributed in the DFD vector in the following way: we take the DFD column vector in the original table and express each element in that vector as a proportion (co-efficient) of the total within the second quadrant only. We then apply these co-efficients to the adjusted DFD total:

$$\frac{\text{Original Table Sector 10 DFD}}{\text{Original Table DFD within the second quadrant}} \text{ X 1970 Second Quadrant DFD=Sector 10 1970 DFD of 39.04 million kwacha (See Table 2, row 2, column 8).}$$

Table 2. Sample row Sector 10, textiles, wearing apparel, leather products and footwear from original Zambian input-output table, updated and disaggregated into sectors 9 - 13 of the 51-sector table (millions of Zambian kwacha).

		Farming, Forestry and Fishing (1)	Other food products (2)	Textiles, wearing apparel and leather products (3)	Construction (4)	Government Administration (5)	Other intermediate sectors aggregated (6)	Intermediate row totals (7)	Domestic final demand (8)	Exports (9)	Row Totals (10)
(1) Original row		0.81	0.01	0.04	0.03	0.3	0	1.19	22.33	0.5	24.02
(2) Updated row		1.00	0.01	0.04	0.04	0.40	0	1.49	39.04	0.4	26.89
(3) % Change (2)/(1)		+23	0	0	+33	+33	0	+25	+75	-20	+12
DISAGGREGATED UPDATED ROWS	ISIC(4) 321	0.19	*0	0.01	0.01	0.08	0	0.29	3.74	0.08	5.2
	ISIC(5) 3211	0.1	*0	0	0	0.04	0	0.14	1.63	0.04	2.6
	ISIC(6) 322	0.58	*0	0.03	0.02	0.23	0	0.87	17.59	0.23	15.61
	ISIC(7) 323	0.06	*0	0	0	0.03	0	0.1	0.34	0.03	1.73
	ISIC(8) 324	0.06	*0	0	0	0.03	0	0.1	4.07	0.03	1.73
	Total(9)	0.99	*0	0.04	0.03	0.41	0	1.5	27.37	0.41	26.87
(10) % Change (9)/(2)		-1	*0	0	-25	+2	0	+1	+43	+2	-0.1
RASed DISAGGREGATED UPDATED ROWS	ISIC(11) 321	0.21	*0	0.01	0.01	0.09	0	0.32	4.06	0.79	5.20
	ISIC(12) 3211	0.12	*0	0.0	0.00	0.05	0	0.17	1.98	0.44	2.6
	ISIC(13) 322	0.45	*0	0.02	0.02	0.18	0	0.66	13.36	1.59	15.61
	ISIC(14) 323	0.15	*0	0.00	0.00	0.07	0	0.22	0.83	0.67	1.73
	ISIC(15) 324	0.02	*0	0.00	0.00	0.01	0	0.04	1.59	0.11	1.73
	Total(16)	0.95	*0	0.03	0.03	0.40	0	1.41	21.84	3.60	26.87
(17) % Change (16)/(2)		-5	*0	-25	-25	0	0	-5	-44	+900	-0.1
(18) % Change (16)/(1)		+17	*0	-25	0	+25	0	+18	-2	+720	+12

* Not available due to rounding error.

Where disaggregation is necessary in order that the vector will conform to the 51 sectors, this is done according to whatever co-efficients may be contained for the required element in the second quadrant of the table of an analogous country, or an average of such countries.

$$\frac{\text{ISIC 321 DFD co-efficient}}{\text{ISIC 321+3211+322+323+324 co-efficients}}$$ X Sector 10 DFD=ISIC 321 DFD of 3.74 million kwacha (See Table 2, row 4, column 8).

These co-efficients are, of course, largely impressionistic since they do not include direct imports into DFD and are therefore not directly related to income-elasticities of demand where such imports occur. Only where these co-efficients are equal to zero because no domestic production is recorded in the GWI for Sector 10 will we be on fairly safe ground.

The export vector is updated to equal the export total from the 1970 NIA so that proportions remain the same as in the original table. The formula is as follows:

$$\frac{\text{Original Table Sector 10 exports}}{\text{Original Table export total}}$$ X NIA 1970 export total

= updated export element for Sector 10 of 0.4 million kwacha (See Table 2, row 2, column 9).

These original table elements are then subdivided in accordance with the proportions which the row totals form within each element. The formula is:

$$\frac{\text{GWI ISIC 321CT}}{\text{GWI 321+3211+322+323+324 CT}}$$ X Sector 10 updated export element = ISIC 321 exports 1970 of 0.08 million kwacha (See Table 2, row 4, column 9).

Eventually, however, we may derive the export vector from the trade tapes which have been obtained from the United Nations Statistical Office and which contain details of trade by commodity between most of the countries with which we are concerned. These tapes have to be translated from SITC Standard International Trade Classification (a system of classification by commodity) to International Standard Industrial Classification (ISIC) codes. Once this translation has been done, the export column vector can be found in two further stages:

First, the export column in the original table will be updated by taking each element of that column in turn, expressing it as a proportion of the export column total and applying that proportion or co-efficient to the 1970 NIA export total, including re-exports.

Second, these updated export elements will be made to conform to our 51 sectors. Where a disaggregation is involved, this will be done according to the proportions which are provided by the export vector in 51 sectors and re-exports derived from the trade tapes.

So, where an original table Sector 12 must be split into sectors ISIC 321, 3211, 322, 323 and 324, the figures for these ISIC codes will be taken from the export vector and each one in turn will be expressed as a proportion of their sum. This proportion will then be applied to the updated export element which must be disaggregated. For the present however, the system of translation from SITC to ISIC leads to some anomalous results.

c) The first quadrant: The inter-industry flows are updated and split up the columns in one operation using column total proportions. If the first quadrant elements for original table Sector 10 must be split between ISIC 321, 3211, 322, 323 and 324, then the column totals for these five are each expressed as a proportion of their sum and these proportions are then applied to each element in turn:

$$\frac{\text{ISIC 321 1970 CT}}{\text{ISIC 321+3211+322+323+324 CT}} \times \text{Inter-industry element 10/10}$$

= original table Sector 10 into industry coded ISIC 321 for 1970 of 0.01 million kwacha (See Table 1, row 3, column 4).

Obviously, where no disaggregation is required, inter-industry elements are updated using the same formula, but with the original table CT being substituted for ISIC 321+3211+322+323+324 CT.

The foregoing only gives us column splits and we see from Table 2 that the original element 10/10 in Table 1 must not only be split up along the columns, but also along the rows. That is why the ISIC 321 column element total of 0.01 million kwacha given above must also be split into rows for ISIC 321, 3211, 322, 323 and 324 in Table 2. Therefore the row totals in Table 2, which are also the column totals, are used to make these row divisions.

Thus, in order to split the inter-industry elements of original table Sector 10 along the rows between ISIC 321, 3211, 322, 323 and 324, the row totals for these five sectors are each expressed as a proportion of their sum and these proportions are applied to each element in turn in exactly the same way as for the column splits. For example:

$$\frac{\text{ISIC 322 RT}}{\text{ISIC 321+3211+322+323+324 RT}} \times \text{Inter-industry element sector 10}$$

= ISIC 322 inter-industry row of 0.03 million kwacha (See Table 2, row 6, column 3).

However, one of the authors, David Taylor, has scanned the whole range of our original domestic and gross input-output tables with a view to regressing co-efficient change against per capita income changes, size of country, etc. at the two-digit ISIC code level. There are, for example, 15 countries with 22 country-years which show ISIC code 13 into ISIC code 34 and all of them give a zero; seemingly, the output of the fishing industry never goes into paper products, printing and publishing. Thus we are able to say that all the elements covered by ISIC 13 into ISIC 34 in the Zambian table are very likely zero and they are so recorded regardless of the results derived from the splitting procedures.

We may, however, decide in the end to let our admittedly imperfect second, third and fourth quadrant inputs stand uncorrected beyond an initial insistence that they conform to national income account totals for imports, value added (GDP), exports and domestic final demand.

Zambia illustrates more than most countries the bizarre results which can arise from RASing all four quadrants at once. Exports increase by an implausibly large amount in the original Sector 10 (Textiles) over a period of only one year. This is almost certainly because copper ore exports dwarf all others. These were presumably maintained in 1970 by drawing down stocks from previous years even more rapidly than in 1969. This meant that the metal ore row total, including exports, exceeded the row total arrived at by updating through the ratio of 1970 metal ore value added to total output, and metal ore exports were artificially reduced at the RASing stage. This was compensated for under the RAS by very large relative increases in the exports of other commodities whose total value was minute by comparison with metal ore (+900 percent for textiles in row 17, column 9 of Table 2). The presumed drawing down of metal ore stocks also distorts the results in the domestic final demand vector (-44 percent in row 17, column 8 of Table 2). This shows as well as anything that we still have a long way to go before these tables can be used with any degree of confidence.

Where gross tables only are available, as they are for 7 of our countries including the USA, then (assumed competing) import columns are distributed in accordance with the row co-efficients and deducted from the gross matrix to arrive at an approximation of the domestic matrix. The import matrix thus derived is then summed down the columns and added to any non-competitive imports along the rows. In the case of the USA, the so-called transferred imports in row 80b of the 1970 RAS update are treated as the competing import column.

d) The fourth quadrant contains seven figures only:
1) VA into DFD as already defined,
2) Imports into DFD as already defined,
3) Imports into exports (re-exports) from code 3 on the UNSO trade tapes,
4) GDP as VA row total (from NIA),
5) Import total (from NIA),
6) DFD total (GDP + M - X) (from NIA), and
7) Export total (from NIA).

e) A modified RAS method: It can be seen that if one sums across the rows of the matrix the totals will not now equal the transferred column totals. In order that the entire matrix shall balance, that row totals will equal column totals and that the NIA totals for VA, imports, DFD and exports will be maintained, the matrix is RASed for all four of its quadrants together rather than for the customary first quadrant only. After RASing has taken place, the intermediate row and column totals can be calculated using the following formulae:

Intermediate Column Total = CT - (Imports + VA)
Intermediate Row Total = RT - (DFD + Exports)

f) Table creation occurs for those countries for which there is no known input-output table. The input co-efficients are averaged for groups of tables for countries within appropriate geographical regions and similar per capita GDPs. Such a group table's co-efficients in all four quadrants can then be applied to the NIA GDP figures in the manner previously described for a particular country which already has a table. The whole process therefore begins with a subdivision of the third quadrant section of VA divided into the nine NIA VA sections. But wherever the growth of world industry data states that one of our sectors does not exist in a particular country, this is entered as a row and column of zero's in the average table and the co-efficients re-computed.

This part of the work has now been completed for the 126 countries, but the trade flows which will make the connections between these domestic input-output tables has not. It is to a description of the methodology which we propose to employ in this respect that we now turn.

3. THE TRADE MATRIX

The trade matrix will connect our 126 countries one with another so that increased imports by country A are reflected in increased exports and, consequently, outputs by country B, which needs then to import more from country C and so on. Such a trade matrix may be built in the following way. Table 4A shows how the total imports given in Table 3 might be derived. It is called the import matrix and we have one for the countries marked in Appendix B. But again, they are not in our ultimately required 51-sector format and we illustrate the process of rendering them in this form by reference to the five sectors which we propose to use in the initial model.

We first take the import row totals corresponding to our five sectors, translated from SITC into ISIC from the Series D computer tapes provided by the UNSO. We then split them into an import matrix in accordance with the rules devised above for the reformulation of a domestic matrix into the required number of sectors. The resulting Table 4A shows that Esperanza imported 20 units (millions of dollars) of agricultural produce from Sector 1 into agriculture itself, 10 units into industry and 20 units into services. In column 1, agriculture used 20 units of imported agricultural production, 10 units of mining imports, 80 units of industrial imports and 16 units of imported transportation services to total 126 units. If these sums are converted into row co-efficients, i.e., element 1/3 showing agricultural imports by industry equals 0.2 (from 10 ÷ the total agricultural imports of 50), then we can obtain what we call the import allocation matrix in Table 4B. This shows the proportion of each one of our 5 sector imports going into each sector, plus final demand, of Esperanza's economy.

Table 3. Import matrices in a two-country model.

SITC	ISIC	SECTORS		ESPERANZA: DOMESTIC MATRIX					MISANTHROPIA: IMPORT MATRIX					Domestic Final Demand		Unallocated Exports	Total Outputs
				1	2	3	4	5	1	2	3	4	5	Esperanza	Misanthropia		
0,1,4	1	Agriculture	1	55	18	42	19	18	1	2	3	4	0	400	0.0	40	600
2,3	2	Mining	2	33	20	52	24	22	0	1	2	1	0	200	0.0	46	400
5,6,7,8,9	3,4,5.	Industry	3	39	24	53	37	46	3	0	2	3	0	250	0.0	42	500
-	7	Transport	4	23	15	33	15	14	0	0	0	0	0	100	0.0	0	250
-	6,8,9.	Services	5	17	8	20	5	0	0	0	0	0	0	250	0.0	200	400
		Agriculture	1	2	0	1	0	2						0.0	1000	100	2000
		Mining	2	2	0	2	0	0						0.0	500	200	1000
				ESPERANZA: IMPORT MATRIX													
		Industry	3	4.9	0.9	1.2	0.6	1.8			MISANTHROPIA:			0.6	600	50	1000
		Transport	4	2	0	0	0	0			DOMESTIC			0.0	300	50	500
		Services	5	0	0	0	0	0			MATRIX			0.0	100	50	200
		Unallocated Imports		115.1	14.1	55.8	9.4	46.2						9.4	100		
		Value Added		307	303	250	140	250									
		Total Inputs		600	400	500	250	400	2000	1000	1000	500	200	1210	2600	775	6850

Table 4. Esperanza's import matrix.

A. MONEY VALUES	1	2	3	4	5	Imports into Domestic Final Demand	Import Row Totals
1	20	0	10	0	20	0	50
2	10	0	10	0	0	0	20
3	80	14	20	10	30	10	164
4	16	0	0	0	0	0	16
5	0	0	10	0	0	0	10
Totals	126	14	50	10	50		
B. ALLOCATION ROW COEFFICIENTS (Elements ÷ Row Totals)							
1	.40	.00	.20	.00	.40	.00	1.0
2	.50	.00	.50	.00	.00	.00	1.0
3	.49	.09	.12	.06	.18	.06	1.0
4	1.00	.00	.00	.00	.00	.00	1.0
5	.00	.00	1.00	.00	.00	.00	1.0

Once the import row contents have been adjusted to conform to our predetermined number of sectors, we will then assume that any country exporting goods in any one of these five sectors to Esperanza will have those goods separated by sector of destination in the same proportion as for the overall import allocation matrix. Thus, if Zambia exports smelted copper as a mining good in Sector 2 of its export row, half of it (0.50 in row 2, column 1 of Table 4B) will be assumed to go into Esperanza agriculture since the major mineral import, crude oil, has that distinction. But clearly this is not likely to be the case with copper as practically all the smelted ore goes into other countries' industries in row 2, notably into non-ferrous metals and electrical goods. This, then is illustrative of the scope for error that will exist in our Mark I model trade matrix, although the 51-sector aggregation given in Appendix A does distinguish non-ferrous metals (32) and electrical machinery (36) and we may be able to devise a method of splitting Zambian copper exports between these even in our original model. Nevertheless, many such problems will remain and will have to be solved in our Mark II model by close consultation with international trade associations, most of which, happily, are located in the United Kingdom.

But be that as it may, we must proceed on the best information currently available to us and here and now this comprises trade matrices for less than half of our 126 countries. Again, we must add "created" imported matrices to the ones which we actually have. These may be devised in the same way as the domestic matrices discussed in Section 2 (f) above, by means of an average country grouping of technical co-efficients for the import matrix itself (i.e., the known 126 in the column total for imports into agriculture in Table 4A might be multiplied by 0.133 (80÷ 600, total input from column 1 of Table 4C) to give the 80 in row 3, column 1 of Table 4A, since 0.13 in Table 4C is the average input co-efficient for this element within Esperanza's country group). Again a technical co-efficient must be yielded for each element of the standard import matrix for each classification of country no matter how doubtful the procedure. Later work on a Mark II model will be designed to improve on this.

But once these import matrices have been extracted from the original data (they will be given either with the original table, or may be obtained by subtracting domestic from gross flow matrices), or created from country group averages, they will have to be made to conform with the updated 1970 51-sector domestic table. This will be done by taking the import total from the NIA for 1970 and distributing it in accordance with the percentage which each element of the 51-sector import matrix forms of the whole. But, as has been said, this will be done in a five-sector aggregation only in the first instance.

Where there are no UNSO Series D trade statistics on a particular country's exports, either in value or destination as with China, we will simply have to aggregate other countries' exports to, and imports from China *et al.*, as recorded in the statistics for those who trade with China. The service export row totals also present a particular problem. They are not given in the UN Series D statistics and must therefore be derived for 1970 from

Table 4C. Column technical co-efficients (elements ÷ column totals).

	1	2	3	4	5	Imports into Domestic Final Demand	Import Row Totals
1	.03	.00	.02	.00	.05		
2	.02	.00	.02	.00	.00		
3	.13	.04	.04	.04	.08	.01	
4	.03	.00	.00	.00	.00		
5	.00	.00	.02	.00	.00		
Column Totals	600	400	500	250	400	1210	
From Table 5							

the appropriate *UN Yearbook of National Accounts* or from the *IMF Yearbook.* Total world exports of services are given therein for most countries. Where they are not given, the updated or created table service export element totals will be used. Average country group service export totals will be assumed for countries for which there is no data at all. In the 51-sector table this service export total will first be apportioned as per service outputs for each one of the five service sectors listed in Appendix A (sectors 47-51). This is, of course, extremely crude and no doubt refinements embodying known tourism origin and destination totals and the like will be embodied in the Mark II model.

If Esperanza exports 200 in service exports, we get its service export total of 200 given in row 5, of the unallocated column of Table 3. If we know that Misanthropia imports 100 of the world's total service imports, none of it from Esperanza (see Table 4), then we can apportion this 100 in accordance with Misanthropia's unallocated row in its import matrix. Since there are no destination data for service exports, all services are assumed to be exported to the unallocated column and imported from the unallocated row so that if Esperanza's GDP increases she will add to the world-wide demand for service exports and this demand will be distributed in accordance with the co-efficients for service exports in the unallocated column. The same will apply to all commodity exports which are not accounted for by the UN Series D trade tapes. The allocation of exports in the export column vector in the updated matrix totalling to the NIA 1970 value will not be matched by the values contained in the Series D data and whatever shortfall, or less likely, excess occurs from Series D will be allocated as a plus or a minus value respectively in the unallocated export column. The same will apply along the import rows.

Once we have filled their import matrices with $US figures at market rates of exchange, we will be in a position to join all 126 countries together in the manner outlined in Table 3. This shows that if Esperanza has an agricultural output of 600, as it does in the bottom row of Table 3, it will import 2 from Misanthropia's mining industry in the form of phosphate rock. Thus, the technical trade co-efficient between a $1 increase in Esperanza agricultural output and consequent f.o.b. export sales from Misanthropia's mining industry is 2÷600 or .0033; i.e., one third of a cent. This assumes, of course, that Series D trade tape exports can be allocated in the same proportion as the row co-efficients for c.i.f. imports in the Esperanza import matrix.

Needless to say, we would be able to make the whole process more realistic if we were able to assume that when Esperanza's GDP increases by $1,000,000 by 1980, regression analysis designed to allocate consequent increases in domestic final demand revealed that agricultural output needed to increase by only $100,000. This amount, when multiplied by a technical co-efficient for f.o.b. imports of Misanthropia's phosphate rock, equals $330 ($100,000 x 0.0033). But we can see also from Table 3 that an increase of $1 in Misanthropic mining output results in further imports of

$0.002 from Esperanza's agriculture (row 1 column 2 of the Misanthropic import matrix of 2+ column total for Sector 2 in Misanthropia of 1,000). Thus the $330 increase in exports of phosphate rock from Misanthropia increases the demand for and, presumed output of, Esperanza's agriculture by a further $0.66 ($330 x .002). This $0.66 requires more phosphate rock and so on, with the impact of Esperanza's increases in agricultural output spreading first throughout its own economy, then to Misanthropia and then throughout the Misanthropic economy, with consequent increased imports and with further spread effects to the rest of the world.

But such a trade matrix will be huge; at least 126 countries each with 51 sectors. As we said at the outset, this makes a matrix of 6426 columns and rows, with over forty million individual elements, each with its own $US value or technical coefficient. Of course, a great many of these elements, particularly in the trade matrices off the main diagonal (which comprises individual country domestic matrices) will be zero. Nevertheless, this input-output matrix will be easily the largest ever produced and the problem of inverting it so that the effects of changes in output anywhere in the world can be shown to be formidable. We have a growing feeling that we may be forced to stick at a five-sector trade matrix with a sixth sector being selected from the list given in Appendix A and added as an extra column and row to each individual country matrix so that we can investigate that sector's world trade on its own.

4. CALIBRATION

We expect that the base year model will be completed sometime in 1980. By this time Series D trade data tapes and *Growth of World Industry* row total data, GDPs from the *UN Yearbook of National Accounts* etc. should be available from the UNSO in New York for 1978. The most recent country data lags about two years behind. We will thus be able to plug the actual changes in GDP for most countries into the 1970 base year model and to predict consequent changes in value added and trade. Initial calibrations may thus be carried out on the years between 1970 and 1978. They may also be undertaken by taking earlier GDP's than those for the 1970 base year and comparing predicted results with those actually realised.

Unfortunately, for any calibration based upon the years from 1970 to 1974, the violent boom of 1972-74 is bound to upset predictions. The exceptional commodity price rises of the early 1970's will cause divergence from predictions based upon 1970 prices. After 1974, however, this is less likely to be the case, except where crude oil is concerned. The first correction which we will have to make in the 1970 base year model if we wish to use it for prediction will, no doubt, be in our sector in Appendix A for petroleum and coal products (Sector 25).

For the rest, the degree to which the model is capable of predicting (or reproducing for earlier years) actual dollar values in all sectors of the world economy will have to be measured. These measures, combined with the sensitivity of the whole system to individual errors, will provide us with criteria for identifying priority areas for further research into data components of the model when we come to prepare the Mark II version.

5. USES OF THE MODEL

The 1970 base year model will be used to work out various scenarios. For example, it has become UN policy to try to work towards a situation in which 25 percent of the world's industrial production is located in developing countries by the year 2000. We may therefore suppose that Misanthropia and other rich states abandon low value added per-worker industries. We have worked out what these are in direct value added (i.e., apparel), from the data contained in the *Growth of World Industry* but not yet with respect to indirect value added (i.e., spinning and weaving) for the corresponding sectors in our 51-sector individual country matrices. On the basis of these estimates, we may transfer part of the Misanthropic textile industry to Esperanza and make similar adjustments elsewhere. The consequences of this in terms of balance of payments and employment (we have related employment to value added from the GWI data) can then be worked out on the basis of varying individual country growth rates within the model.

Once the agricultural sectors have been added to the model, we may also consider how trade in foodstuffs and pressure on land will develop with unchanged technologies as population grows. Such scenarios will indicate what alterations in existing trade patterns and in import combinations or domestic technical coefficients will have to take place. Alternative scenarios incorporating these can be developed and their likely results obtained.

6. CONCLUSIONS

We have not disguised the weaker of our assumptions throughout this exposition. If critics are prepared to trust us in this respect they will be able to proceed directly to telling us how we can improve our methodology, given the data available, rather than concentrating on exposing shortcomings in the model of which we are already well aware.

Our model rarely rises above the impressionistic and sometimes borders on surrealism. Nevertheless, we hope to replace this crude first attempt with improved versions as the years go by. We have already devoted a number of years to gathering and computer filing the input-output data in a systematic form and a decade of work or more may lie ahead before we can hope to produce a model with "acceptable" predictive power.

In the meantime, we have to admit that there are obvious and serious errors in our initial results. It may be that matrices in this detail are simply too large for us to correct even the most glaring errors. Hence, the existence of computer programmes already written which are capable of dealing with different levels of disaggregation, and, more particularly, the relative ease of translating SITC into ISIC at higher levels of aggregation, may lead us in the end to a substantial reduction in the number of sectors which we incorporate in our World model.

APPENDIX A: THE 51-SECTOR FORMAT

		ISIC Code
1.	Agriculture	1
2.	Coal Mining	21
3.	Petroleum and Gas	22
4.	Metal Ore Mining	23
5.	Other Mining	29
6.	Food Products	311/12
7.	Beverages	313
8.	Tobacco	314
9.	Textiles	321
10.	Spinning, Weaving, etc.	3211
11.	Wearing Apparel	322
12.	Leather and Products	323
13.	Footwear	324
14.	Wood Products	331
15.	Furniture and Fixtures	332
16.	Paper and Products	341
17.	Pulp, Paper, etc.	3411
18.	Printing, Publishing	342
19.	Industrial Chemicals	351
20.	Basic Chemicals excl. Fertilizers	3511
21.	Synthetic Resins, etc.	3513
22.	Other Chemical Products	352
23.	Drugs and Medicines	3522
24.	Petroleum Refineries	353
25.	Petroleum, Coal Products	354
26.	Rubber Products	355
27.	Plastic Products nec	356
28.	Pottery, China etc.	361
29.	Glass and Products	362
30.	Non-metal Products nec	369
31.	Iron and Steel	371
32.	Non-ferrous Metals	372
33.	Metal Products	381
34.	Machinery nec	382
35.	Office, Computing, etc.	3825
36.	Electrical Machinery	383
37.	Radio, TV, etc.	3832
38.	Transport Equipment	384
39.	Shipbuilding and Repair	3841
40.	Motor Vehicles	3843
41.	Professional Goods	385
42.	Other Industries	39
43.	Gas and Steam	41
44.	Electricity	4101
45.	Water Works and Supply	42
46.	Construction	5
47.	Wholesale, etc.	6
48.	Transport, Storage, Communication	6
49.	Finance	7
50.	Community, Social and Personal Services	8
51.	Other Services	9

APPENDIX B: LIST OF BRADFORD INPUT-OUTPUT TABLES

Algeria	1963D
Antigua	1963(NOC)
Argentina	1950D 1953DG
Australia	1958-59DG 1962-63DG
Austria	1964D
Belgium	1965DG 1970G
Bolivia	1958DG
Brazil	1959G
Bulgaria	1963D
Cambodia	1966DGM
Cameroun	1959(/VINS) 1969D
Canada	1949D 1961-1970(NOC) + 1971
Ceylon	1963D 1965G 1968G
China	1956G
Colombia	1953(NOC)
Costa Rica	1968DG
Cyprus	1954DG 1957DG
Czechoslovakia	1962DG 1967DM
Denmark	1947D 1949D 1966DG
Ecuador	1963DG
E. Germany	1956D 1959D
Egypt	1954DG
Fiji	1970D 1971D 1972D
Finland	1956D 1959DGM 1963RAS 1965GM
France	1957D 1959G 1962G 1965DG 1966G 1967G 1968G 1969G 1970G 1971(EEC) 1972(EEC)
W. Germany	1953G 1954DG(M) 1955DG(M) 1956DG(M) 1957DG(M) 1958DG(M) 1959DG(M) 1960DG(M) 1961DG(M) 1962DG(M) 1963DG(M) 1964DG(M) 1965DG(M) 1966DG(M) 1967DG(M) 1970DGM
Ghana	1960D 1968G
Greece	1954D 1958DG 1960D 1966G
Guyana	1959D
Hungary	1959G 1971D
India	1951-52G 1953-54G 1955-56G 1959G 1960-61G 1964-65G
Indonesia	1969G
Iran	1965DG
Iraq	1960DG 1961DG 1962DG 1963DG

Ireland	1956D 1960D 1964DG 1968G 1974D
Israel	1968-69DGM
Italy	1953G 1959DGM 1965DG 67DG 69DG 70G 1971(EEC) 1972DM(EEC)
Ivory Coast	1958D 1960D 1962(/VINS) 1963(/VINS)
Jamaica	1958D 1965PROJ 1970PROJ 1975PROJ
Japan	1951G 1954G 1955G 1965G 1970GM
Jordan	1964D 1967D 1969D
Kenya	1967G
Korea	1960DG 1963G 1966DG 1968G 1970DG
Lebanon	1964D 1965D 1966D 1967D 1968D 1969D 1970D
Madagascar	1960G
Malaysia	1960DGM 1965DG(M) 1970DG
Mali	1959D
Malta	1961(NOC) 1962D 1963D 1964(NOC) 1965(NOC) 1966(NOC) 1967(NOC) 1968(NOC) 1969(NOC) 1970D 1971(NOC) 1972(NOC) 1973(NOC) 1974(NOC)
Mexico	1960D
Morocco	1958D 1960D 1964D 1965D 1966D 1969D
Netherlands	1948D 1951D 1952D 1953D 1954D 1955D 1956D 1957D 1965DG 1970DGM(EEC) 1972D(M) 1973(M) 1972(EEC)
Nigeria	1959-60D
N. Ireland	1963G
Norway	1947D 1948D 1950DG 1954DGM 1956G 1959DGM 1964DGM 1973
N. Zealand	1952-53D 1954-55D 1959-60DGM 1965-66D(M) RAS1959-60 D RAS1960-61D RAS1961-62D RAS1962-63D RAS1963-64D RAS1964-65I
Pakistan	1954G 1960-61DG
Peru	1968DG 1969DM
Philippines	1956DG 1961DG 1965DG
Poland	1967G 1969DG 1971G 1972(NOC) 1973(NOC)
Portugal	1959DG 1964GM
Puerto Rico	1962-63(M)
Rhodesia	1965DG
Rwanda	1957D 1970D
S. Africa	1956-57G 1967G
Senegal	1959D
Singapore	1967D
Spain	1954DG 1958DG 1962G 1965G 1966DG
Sri Lanka	1970D
Sudan	1961-62D

Sweden	1964DGM 1968DGM 1969DM
Switzerland	1967G
Syria	1956G 1959-60DG 1963D 1964-65DG
Taiwan	1954G 1961G 1964DG 1966DG 1969DG 1971DGM 1974DM
Tanganyika	1954D 1961D
Tanzania	1969DGM
Thailand	1954G
Togo	1962(NOC)
Trinidad	1959D
Tunisia	1957D 1960D 1962D 1964D 1968G
Turkey	1963G 1967DG
UK	1935D 1948G 1954DG 1963DG 1968DGM 1970DGM 1971(EEC) 1972(EEC)
Upper Volta	1968D
Uruguay	1961DM
USA	1919D 1929D 1939D 1947D 1958G 1961G 1963G 1966G 1967G 1970G
USSR	1959G 1966D
Yugoslavia	1958G 1962DG 1964G 1966DG 1968DG 1970D
Zaire	1957D
Zambia	1965DG 1966DGM 1967DGM 1969DG 1971D

NOTE

(EEC) - TABLE IN EEC FORMAT NOT ON COMPUTER

(M) - IMPORT MATRIX NOT ON COMPUTER

(NOC) - NOT ON COMPUTER

D - DOMESTIC MATRIX ON COMPUTER

G - GROSS MATRIX ON COMPUTER

M - IMPORT MATRIX ON COMPUTER

PROJ - PROJECTION

VINS - UNCLEAR WHETHER DOMESTIC OR GROSS TABLE

IMPORT MATRICES CAN BE CALCULATED WHERE WE HAVE BOTH D and G

APPENDIX C: INFORMATION IN BOX FILES

Country:
No. of Sectors
Valuation:
Source:
Language:
Compiling Agency:

Date Received:
Box File No:

Coded:
Status:
- compiled
- not-compiled

Diagonal:
Notes:
Analysis:

Year:
- Currency:
- Stat. Unit:
  - sitc
  - nace
  - isic
  - industry-
  - commodity-
  - enterprise-
  - mixed-

Imports:
- Valuation of Imports
- fob/cif
- Breakdown of Imports
- (Specify)

File Name(s):

<u>Contents - Final Demand</u>
Consumption-Household
-Government
-Total
Investment -G.F.C.F.
-Stock Change
-Total
Total Domestic
Export column
Total Final Demand
Import Column
Imports to Final Demand

<u>Contents - Primary Inputs</u>
Imports
Indirect Taxes-Domestic
-Customs
-Total
Subsidies/Social Cont.
Net Indirect Taxes less Subsidies
Wages and Salaries
Rents and Interest
Profit/Operating surplus
Depreciation
Total Incomes
Balancing row
Total Value Added

DISCUSSION

Vacca stressed that, in addition to the needs referred to in the paper, there is a definite need for information in the sense of knowledge and understanding, a need not only badly neglected in many parts of the world but also omitted in many studies. Bruckmann added that another factor missing is the right of the individual to play a constructive and appreciated role in society. The neglect of this factor has led to the neglect of the consequences of youth unemployment in affluent societies, which may represent one of the major problems of the years to come.

Richardson underlined that this is a typical example of the necessity to limit oneself - if a list of factors shall remain of practicable size, certain factors necessarily must be left out. One example is the fact that education, as important as it may seem, had to be left out initially. At least in early stages, the emphasis should go mainly on clarity and simplicity. Any indicator system, hence, must remain a mixture of science and art and public relations. Turning to Bottomley, Richardson asked to what extent the present form of the project still addresses the problems posed when it was started several years ago, a question relating to any project of this kind. As an example of the original problem, Bottomley referred to the necessary change in trade coefficients between Bangladesh and the United States in order that the US starts to import clothing from Bangladesh. In reply to another question by Richardson, Bottomley stated that he considers his client anybody who supports his work and asks specific questions; also, the time horizon is determined by the question, e.g., an investigation within which time span goals of the Lima declaration can be achieved.

Carpenter referred to the excessive number of input coefficients (120 countries with a 60 x 60 input/output matrix). Even admitting that many of these are zero, how can one extrapolate or even handle such a high number of coefficients (60 million).

In reply, Bottomley stated that the number reduces to 500,000 coefficients to start with; furthermore, they have tried to identify what are the really important domestic coefficients. Extrapolating these by means of various independent variables has not proven too bad if one excludes great changes (e.g., the introduction of nuclear fusion).

Rademaker asked about the percentage of zeros in the matrices; Dunworth replied that this percentage well exceeds 50%, in particular in less developed countries. Carpenter added that, in the trade matrices, this percentage must be much higher.

Carpenter and Fritsch pointed out that trade relations often depend on meta-economic factors, like property rights or former colonial relationships which might bring all the raw material of a less-developed producer country to one particular industrialized country.

Reichardt wondered to what extent classical methods can be used which distinguish important parts of an input/output table from less important parts. In reply, Bottomley doubted the usefulness of such techniques; on the contrary, even if the trade from Barbados to the United Kingdom were negligible for the United Kingdom, it is of the utmost importance to Barbados. If a world input/output system wishes to be able to answer questions important for Barbados, such techniques seem inapplicable.

Kaya asked about the number of sectors in the original country tables. Bottomley replied that they ranged from about 4 or 5 up to 475 (USA). Bottomley went on to say that, in his opinion, an important synergistic effect could be achieved if the institutions working on international input/output relations were to cooperate more closely.

Chapter 14

ADAPTIVE MECHANISMS IN GLOBAL MODELS*

P.C. Roberts†

There are now enough separate designs of global models for the classifiers and cataloguers to be sorting them out into those more or less disaggregated by region/country or sector within economy, or those with or without trade, and so on. A classification according to the pervasiveness of explicit adaptive mechanisms would, I think, be more illuminating than the particular divisions used to disaggregate. There are, of course, immense numbers of implicit adaptive mechanisms in any global model and indeed in almost any system model devised. For example, in Forrester's World II there is no consideration given to the number of people employed in the manufacturing or in the agricultural sectors. To the question of what happens if there are too few or too many in either sector, the answer must be that the numbers automatically adjust to approximate those totals actually required for the output generated by the quantified capital, i.e., there is an implicit adaptive mechanism present. All modelers confronted with questions of why some particular mechanism has been left implicit are prone to reply that the result would have been the same had they introduced the mechanism explicitly, and therefore it is preferable for reasons of simplicity to omit it. There is no objection to omitting a mechanism provided that indeed there is no difference between inclusion and exclusion. Ideally, the reply to the question of why a given mechanism has been left implicit is that a trial was made of its inclusion and the result did not differ significantly from the case of its absence. For

*The views expressed in this paper are those of the author and do not necessarily coincide with those of the Department of the Environment.

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example, in the case of employment within sectors, the SARU (Systems Analysis Research Unit) model carried a detailed mechanism intended to represent the way in which adaptation occurs:

1 At any time, for a given industry there is a desired labor force which may be higher or lower than the actual labor force. In each simulation time interval, there occurs a fractional change in the labor force tending to diminish the gap between the desired and the actual:

$$\frac{1}{L}\frac{dL}{dt} = \frac{1}{T_1}\left(\frac{\text{marginal revenue of labor}}{\text{marginal cost of labor}} - 1\right)$$

T_1 is a time constant representing the inertia of labor movement (time delays associated with recruitment, wastage, and redundancy).

2 The rise or fall of the labor force in the industry respectively subtracts from or adds to the reservoir of people able to work in the industry. The higher the proportion of this reservoir actually employed in the industry, the higher the wages in that industry relative to the mean wage rate in the economy.

3 There is a movement of people out of the reservoirs with lower-than-average wages into the reservoirs with higher-than-average wages.

$$\frac{1}{n_i}\frac{dn_i}{dt} = \frac{1}{T_2}\left(\frac{W_i}{\sum_j W_j n_i} - 1\right)$$

where n_i is the fraction of the population trained for sector i, W_i is the wages paid in sector i, and T_2 is a time constant representing the delay involved in retraining.

Thus, the planning strategy of the industry's controllers, the response of the labor force to wage differentials, and two sorts of time delays must be taken into account. In the normal operation of SARUM, without any particular stresses applied, the actual labor forces are found to lie close to the optimal labor forces and the wage differentials between industries are small. In other words, there is little difference between modeling output as a function of capital only (Forrester's World II) or following through the signals impinging on producers and on workers, their responses to the signals, the intrinsic delays, the market adjustments, and the final outcome as a continuous search for equilibrium. However, these comments started with the qualification: ".... in the normal operation...." and it is the possibility of non-normal operation that is the justification of modeling the labor adjustment mechanism explicitly. For example, the abrupt onset of a fuel shortage can be thought of as non-normal. The rate at which the labor force can be redeployed in such a situation is significantly affected by the "retraining time constant."

Training personnel in the skills of thermally insulating domestic premises to high standards can be achieved in a matter of weeks, but training sufficient engineers and ancillary technicians to double the pace of a nuclear power plant building program takes years.

Most of the issues raised by global models are related directly or indirectly to the crucialness of the magnitudes of the time constants. Short time constants raise no problems. Who would investigate the "problem" of a shortage of paper money? The time required to print money is so short as not to matter. On the other hand, the time required to train nuclear power plant engineers does matter. Indeed, any time constant of the order of some years or decades is likely to matter and should appear explicitly in the model. From this rule it follows that Forrester's omission of a labor adjustment mechanism was a serious shortcoming. Similarly, the assumption made in IIASA energy reports that the time constant of energy source substitution is necessarily about 60 years (without an underlying explanatory model of the substitution process to justify this estimate) is a shortcoming.

At the other extreme from the very short time constants that do not matter are the very long time constants about which no one is concerned to do anything (and, therefore, they also effectively do not matter). Solar energy influx is likely to stray outside the level needed for the maintenance of life on this planet after a few thousand million years, but this is well beyond our time horizon. However, the same error of confusing orders of magnitude can occur at the high end of the scale. Once again, Forrester's World II provides convenient examples. The natural resource consumption of the inhabitants of World II continues *pro rata* to the industrial and agricultural output through to the bitter end, i.e., the time constant of adaptation to increased difficulty in supplying virgin resources is effectively infinite. Similarly, the time constant of adaptation to rising pollution level is again infinite. Now it may be that some of our human time constants of adaptation are poorly matched to the real world situation; but it is clearly a dubious procedure to restrict all model experiments to the cases where two of the key time constants are fixed at infinity.

REGULATION AND VARIATION

The examples considered here belong to the class of existing regulated systems. The most important property of such systems is that they achieve the attenuation of variation. Just as the thermostat on a refrigerator enables the variation of temperature in the refrigerator to be much smaller in extent than the temperature variation of the surroundings, so the regulatory action of market feedbacks retains the spread of wages across sectors within quite a narrow band. This regulation of variables to remain within restricted ranges is a characteristic of living organisms. Human beings must maintain body temperature within a degree or two on either side of 37 °C, must maintain a food energy input within small margins of 150 watts, oxygen intake in a narrow range, and so on. Movements of these variables towards the limits of acceptability cause discomfort and, *in extremis*, death results. Similarly, the fluctuation of certain key variables applying to entire economies is a matter for concern, e.g., if employment changes by 10 percent in a year, this is a major problem.

Much of the motive for constructing and studying models derives from the value that society places on regulation. This point applies with equal force to regional, national, and global models. Holling's budworm study is much concerned with the strategies by which employment in the lumber industries is saved from fluctuation. The energy modelers do not doubt that substitute energy sources for oil and gas will be found, but they think that there will be a temporary fall-off (a fluctuation) in the flow of energy because of delay in preparation of the substitute.

Sometimes, the cost associated with variation is directly calculable. I recall an instance in an industrial study valuing the associated costs of variation. Figure 1 shows the system diagrammatically. A component processing station is fed a stream of unprocessed components whose mean rate of arrival is equal to the mean rate of processing, but whose arrival rate is subject to fluctuation. In order that the processing machine and operator do not suffer spasmodic idle periods, a queue or buffer of components is present between supply and processor. However, a queue of material represents assets tied up, and hence a cost. The queue length can be controlled to a predetermined level if the processing rate is variable (e.g., by process operators working overtime). Thus, there are three cost elements:

The lost working time when the process operator is idle
The cost of servicing the inventory in the queue
The additional expense of the overtime used to achieve control of queue length

Figure 2 shows the form of the relation among the three elements and the constant cost contours that can be calculated for a given case. There is a unique solution - a minimum cost operating point.

It is not essential to have explicit costs to solve such cases. Individuals trade off sigma against mu without any difficulty. For example, in traveling between two points in central London, I will usually use underground rail rather than bus even though the mean bus travel time may be shorter than the mean underground rail travel time. The reason lies in the fact that the bus travel time variance exceeds the rail travel time variance and the penalty function for lateness that I use predisposes me to select reduced sigma in exchange for greater mu.

Though individuals can perform such judgments with ease (or at any rate without regret) and managers in industrial enterprises can trade sigma against mu with alacrity because costs are ascertainable, the equivalent problems posed for governments are less easily soluble. Holling avoids the problem of the value to be placed on stability of employment in the lumber industries. In

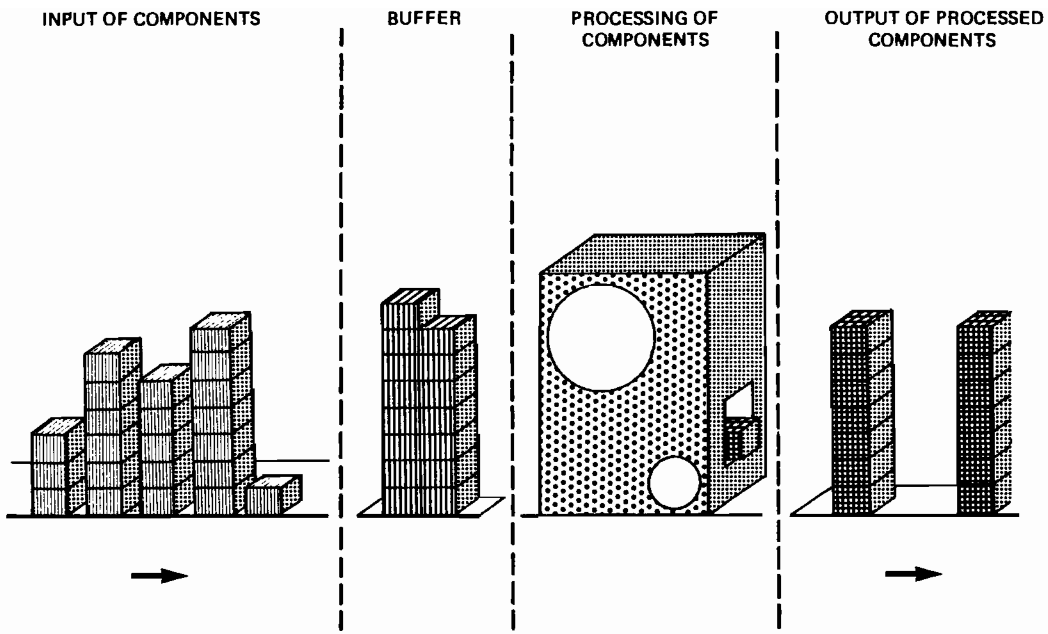

Figure 1. A diagram of the flow of components in an industry.

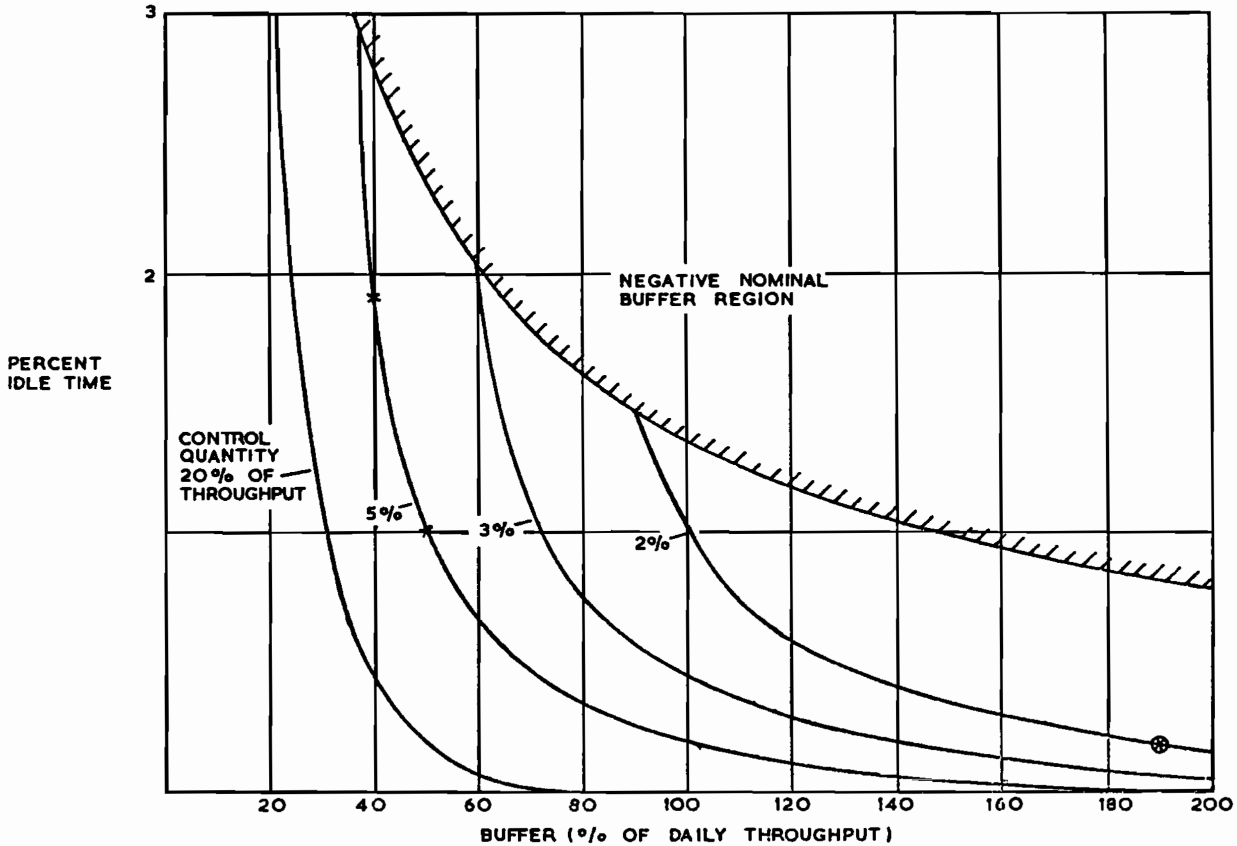

Figure 2a. The relationship between buffer, idle time, and control.

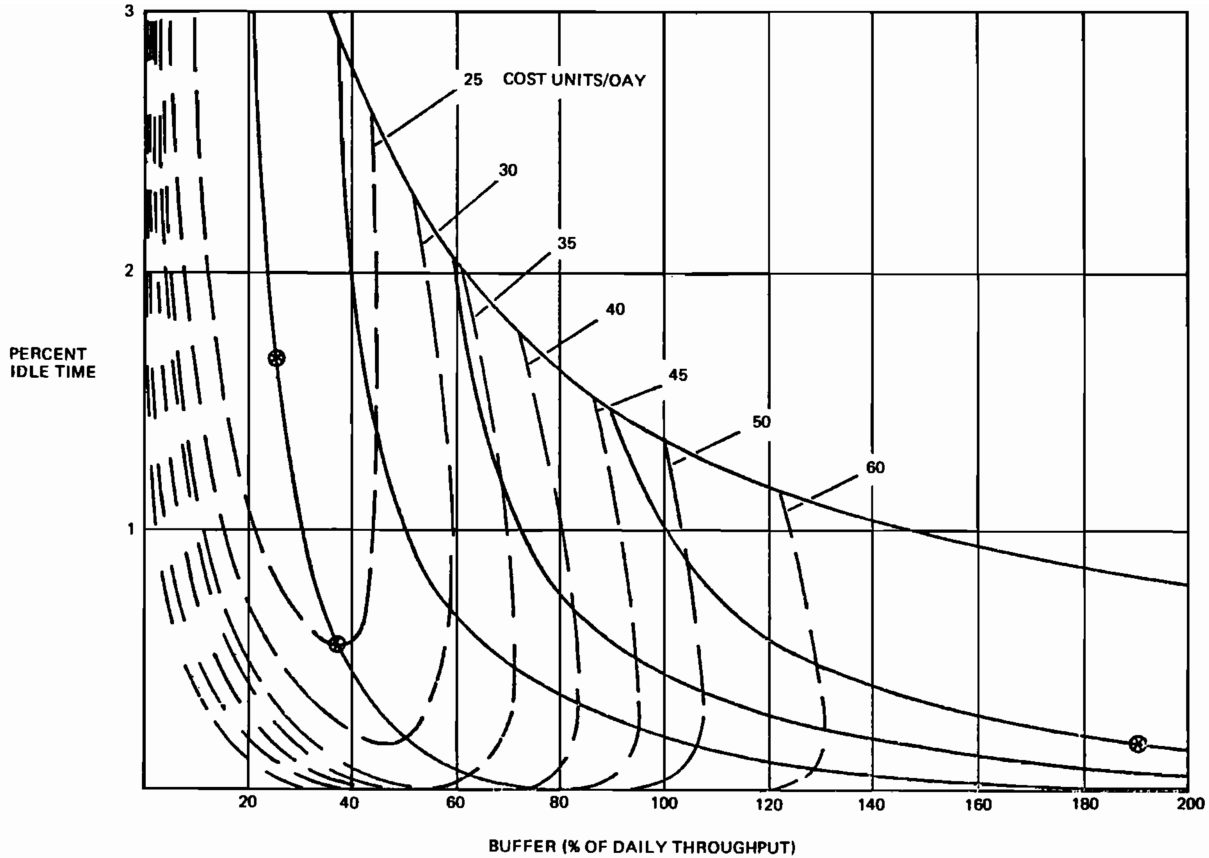

Figure 2b. Cost contours.

fact, all political judgments are subject to the same intrinsic difficulty of applying weightings that are supposed to reflect some sort of group preference, the nature of which is not directly ascertainable. The consequent arbitrariness of political judgments worries the purists, but it is not, in my opinion, of great consequence. To worry about the intrinsically unknowable is misguided. There is another dimension of the system that warrants more attention - the virtue in fluctuation itself.

HETEROGENEITY

In the industrial example given earlier, the cost of the operator's idle time, of the operator's overtime, and of inventory carrying cost were shown to be interrelated, and the possibility of seeking optimal operation was indicated. Let us consider a fourth element in this system - the source of the cost analysis, i.e., the visualization of the three-element cost factor relation - indeed, the authorship of the analysis. Authorship of this sort lies outside of the occupations necessary for the functioning of the subsystems. It arises from a "slack" in the organization - the spare-time musing of a manager or some spare money spent on consultancy. If the equivalent of this slack is sought through other systems, natural and man-made, it is found not to be a luxury but an essential element of the totality. The simplest form of the slack is mere heterogeneity.

The experiments on prey/predator systems using populations of simple organisms in a closed flask usually show a rapid extinction, but even a small degree of heterogeneity will allow the avoidance of extinction. Systems of separate vessels and thin connecting tubes have been devised to supply the heterogeneity. More simply, the ability of the prey to cling to the vessel wall can be sufficient to permit the two populations to persist through time.

A natural population exhibits variation in its gene pool, so that when the environmental conditions change, the potential is present for the population (over successive generations) to select for those features well suited to the new conditions. Moreover, the genetic variation is not lost in the course of this adaptation but remains available for a subsequent reverse shift if the environmental conditions should return to the initial state. This means of adaptation could be termed "drawing on a reservoir of variety."

The essential requirement for a source of variety to be available in learning to regulate throughout the emergence of novel conditions was demonstrated by Ashby in the operation of his homeostat. The homeostat is of a higher order than the error-controlled regulator because its successful functioning depends not only on the operation of negative feedback loops maintaining key variables within prescribed ranges, but also on the power to change the parameters of the feedback loops through random searching. The random element in the search process is essential for the homeostat to achieve overall equilibrium of its parts in response to the "changed environment."

RECOGNITION OF THE ROLE OF HETEROGENEITY

There are examples of the explicit identification of the role of heterogeneity - attempts are being made in several institutions to build up seed banks so that the tremendous horticultural variety that has been generated in the course of some three thousand million years of evolution should be preserved in spite of the heavy erosion of wilderness which is happening. This is overt recognition of the expectation that there will be novel sorts of challenge arising, to which the only victorious response will come from the availability of a rich gene pool.

The concept of the "seed" sector that was introduced into SARUM contains an underlying assumption of the existence of heterogeneity. It was presumed that a host of possible ways of producing food/energy/materials exists and that choices will be made (other things being equal) on the basis of minimum cost. The reason for inventing the seed sector idea was to explore the adaptive role that such seeds could have in response to changing conditions. The actual example of the flowering of a single cell protein industry in response to the rising cost of alternative animal feed was used as an experimental demonstration of seed sector adaptive response. The demonstration was of practicability, given the emergence of the seed - nothing was said of the seed's origin, though clearly if such seeds fail to emerge then the future looks very different.

"Seeds" and heterogeneity and the "quality of adaptiveness" are closely associated - in a sense they are facets of the same entity. Ashby showed that adaptiveness - rigorously defined - can be present in any system, animate or inanimate, dispersed or centrally coordinated, because ultimately it is an outcome of the topology of the system, and not of the nature of the elements comprising the system. It is legitimate to compare the adaptive powers of single organisms, species, ecosystems, institutions, and economies. Furthermore, the enhancement or erosion of adaptive power is in some cases demonstrable.

Ecosystems manifest strong powers of adaptation for the reasons given previously. Parts of economic systems display adaptiveness. But here arises a conflict between, on the one hand, the claim of efficiency (which in general requires the reduction of heterogeneity) and, on the other, the ultimate need for that variety which permits adaptiveness and thence survival. A field of wheat is an efficient production unit, but as an ecosystem it has poor power of adaptation. The conflict can be considered in the context of economics: how much is lost if some of your adaptiveness is destroyed (e.g., a part of your brain rendered useless)? The use of a wide-spectrum insecticide (in the interests of efficiency) erodes adaptive power. If the officers within an organization are schooled to perform their individual tasks with the highest efficiency, preprogrammed as it were, then the capacity of the organization to adapt will be low.

WORLD MODELS AND WORLD ADAPTIVENESS

The paradox of efficiency seeking (which tends to lower heterogeneity) and adaptiveness (which relies on the existence of heterogeneity) has been noted previously. There is paradox and there is conflict - and the conflict is becoming more severe with the passing of time. Adaptation is a more pressing requirement than it was because limits of various sorts are beginning to obtrude; but the power to adapt is being eroded through a crushing load of homogeneity exported by industrial man.

The "normal" operation of systems involving production, consumption, capital equipment, investment, wages, prices, markets, and raw materials can be modeled satisfactorily. The power of such systems to persist in the face of perturbations is, in a sense, demonstrable because little more than low-order, error-controlled regulators are required. The modeling of reaction to novel threats has scarcely been tackled. The seed sector concept in SARUM suggests a possible manner of approach, but it does not come to grips with the learning process itself.

It is important to progress to this new modeling development because current modeling lacks a dimension. The early world models were rife with doom and calamity because they were assembled without adaptive machinery. The recent world models are, one suspects, a little too reassuring because adaptation can be assumed always to work effectively. What is needed now is the modeling of the adaptive process itself and the ways in which adaptive power is changed (enhanced or eroded). This does not mean dissecting the world for those aspects of its operation that are familiar, well-learned, and reliable - like the self-stabilizing properties of markets. Adaptation in the face of novel threats is the matter for concern. The pattern is:

Threat → associated emission of signals revealing threat → perception of signals → interpretation of signals → decision process → action to eliminate or neutralize threat.

Obvious striking examples of this pattern in recent times have arisen from the threat posed by novel toxic substances like thalidomide. In this case, the signals are strong, the perception is swift, the interpretation correct, the decision immediate, and the action fully effective. Cases of threats that are less clear-cut can be listed: fuel starvation, over population, and climate disturbance. It will be agreed that though the disbenefit arising from materialization of the threat in each of these three examples is of uncertain magnitude, the desirability of strong signals, acute perception, sound interpretation, and ameliorative action is clear. Although perception and interpretation are essential elements in the adaptive process, there have often been manifested delays and distortions in the transmission of threat information so that the necessary detection and diagnosis is much more difficult than otherwise and, consequentially, action is delayed or ineffective. Thus, it is apparent that whereas the familiar well-learned feedbacks (Adam Smith's "Invisible Hand") suffice well enough most of the time, the power of successful adaptation to novel threats should not be assumed to be an inevitable component of existing systems. Indeed, it may be that the network of institutions coming into being is actually less adaptive than heretofore. This is a question of great importance, and closely allied to it is the concept of discovering those aspects of systems that directly affect the power of adaptation. There is the necessary element of heterogeneity that has received mention earlier and other more familiar systems measures like redundancy and connectivity. In principle, modeling the adaptive process has been done; Ashby's *Design for a Brain* demonstrates explicitly, through the homeostat, what the functional properties are that must be present for adaptation to occur. The question now arises of the feasibility of mapping the homeostat's functions on to the "societal organism."

The plea that modelers should consider this task as the next in the sequence of evolving world models derives from the following considerations:

1 The current generation of models points strongly towards the view that for global human society, technological ability does not represent a barrier. Given adaptive societies, even current technical knowledge is adequate.

2 The early models containing virtually no adaptive mechanisms tended towards collapse. Some recent models particularly (SARUM) are very robust and resistant to collapse, and this robustness derives from a wealth of inbuilt adaptive mechanisms.

3 It seems quite possible that the form of development pursued for the last few centuries has been eroding the adaptive power of the global societal complex.

There is no point in building further models that either collapse because they lack adaptiveness or that refuse to collapse because they have been made pervasively adaptive. There is little to be gained by refining estimates of the "limits," i.e., the amount of cultivable land, the quantity of fossil fuels left, the level of heat dissipation at which climate regimes will be disrupted, and so on. Chasing precision in the delineation of limits is just displacement activity - because even an extra order of magnitude of any resource subject to erosion at 5 percent increase per year, buys less than 50 years of time. The limits exist and what matters is our ability to live within them. Thus, the area of research should now become the adaptive process itself.

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Chapter 15

THE USE OF INPUT-OUTPUT TECHNIQUES IN AN ENERGY-ORIENTED MODEL

Bruno Fritsch*, René Codoni* and Bernard Saugy+

(1) ALTERNATIVE SCENARIOS OF ECONOMIC GROWTH AND ENERGY REQUIREMENTS

Some Political and Economic Considerations

As long as economic growth is related to activities representing the transformation and/or the transport of matter, there will always be a positive correlation between economic growth and demand for energy, i.e. the use of power. In addition, the necessity to bridge the temperature differentials between the natural environments as determined by climatological conditions and the artificial subsystems of human civilization, induces an additional demand for either heating or cooling, hence an additional demand for energy. Under the present rules applied for measuring national income, a partial decoupling of economic growth from the requirements for energy can only be achieved in the following ways:

- by changing the ratio of non-energy requiring activities, such as services, to energy-requiring activities, such as industrial production (a shift towards a higher proportion of services),
- by increasing the efficiency of energy use, and
- by energy conservation.

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All three factors are exhaustible, which means that we can never achieve a full decoupling of economic growth and the requirements for energy. The degree to which an economy can squeeze energy-using activities and extend the non-energy using type of services - factor one - is limited. The second factor - increased efficiency of energy use - is also clearly limited by economic, and, even more so, by technical and physical laws. Energy conservation, finally, can certainly play an important role; once all wasteful activities have been eliminated - which, in part, also depends on our capability to tolerate inconveniences - however, the procedure can not be repeated. The conservation potential is thus clearly limited. On the other hand, there are physically no limits of energy potentially available for economic use. It is the complex set of other - non-physical - factors which limits the speed with which the economic system can generate and absorb energy. Some of these factors are listed below.

Factors Limiting Growth Capacity	Extension Possibilities
Scarcity of renewable resources.	Recycling.
Finite stock of non-renewable resources (e.g. fossil fuels).	Substitution by other energy sources: solar, nuclear, hydro, geothermal, wind, tides, etc.
Agricultural area.	Land reclamation, productivity increase via fertilizers, mechanization, high yield varieties, water management, desalination of sea water.
Pollution.	Abatement technologies, environmental protection.

All extensions require more energy. In addition, increased requirements for housing, transport and communication, increased industrialization etc. in conjunction with increased growth rates in the less developed countries (ldc's) require an overproportional extension of the energy system both in industrial countries and in the ldc's. This in turn implies an increased investment ratio from today's 20 to at least 40 percent of GDP. This follows from the fact that, at any given technology, any energy generating and transformation system, even at a stationary state, will itself use up energy in two ways. First, energy is directly absorbed in the transformation of one form of energy into another. Secondly, energy is indirectly absorbed by the system through the energy required to produce materials needed for reinvestment. In a growing economy with increasing total consumption of primary energy, the long lead times of investment make the energy generating and transformation systems absorb even more energy. Thus, even with physically unlimited energy resources, the growth rates of the two systems, the energy generating and transformation system and the non-energy production system of the economy, are mutually interdependent: one system can not outgrow the other. This situation is visualized in Fig.1.

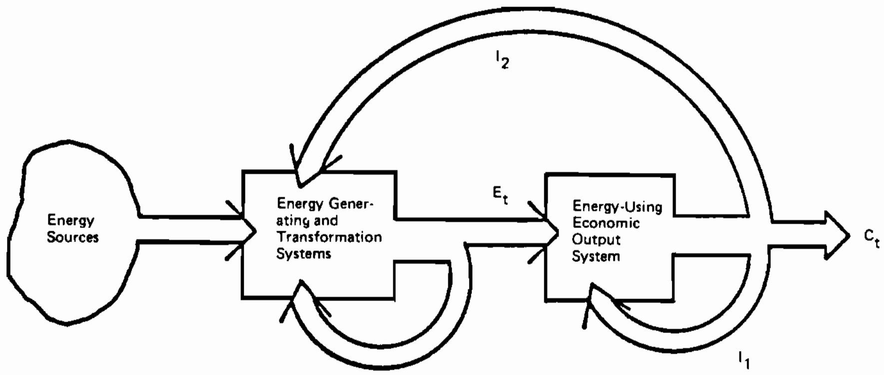

Fig.1 Interdependence of Energy and Economic Systems

Energy Production/Total Consumption Ratio. Given the following variables

- Y_0 initial income,
- Y_t income at period t,
- C_t consumption at period t,
- I total investment, whereby $I = I_1 + I_2$,
- I_1 investment in the energy system,
- I_2 investment in the non-energy production system,
- E_t energy production at period t,
- r growth rate of the economy,
- r' rate of technical progress,
- k lead time of investment,
- α fraction of income spent on consumption,
- λ fraction of non-consumed income going into the energy system, and
- σ productivity of investment in the energy system,

the ratio E_t/C_t can be determined using the following definitions and relationships:

$$C_t = \alpha Y_o e^{rt}$$

$$C_{t-k} = \alpha Y_o e^{r(t-k)}$$

$$I_2 = \lambda(1-\alpha) Y_o e^{r(t-k)}$$

$$E_t = \sigma_t I_2$$

$$\sigma_t = \sigma_o e^{r't}$$

$$\frac{E_t}{C_t} = \frac{\sigma_o e^{r't} \lambda(1-\alpha) Y_o e^{r(t-k)}}{\alpha Y_o e^{rt}} = \frac{\sigma_o e^{r't} (1-\alpha)}{\alpha e^{rk}}$$

Thus, the fraction of production going into the energy system, together with σ, the growth rate of the economy, and the lead time of investment, determines the ratio E_t/C_t. Since both λ and σ, among other factors, depend upon the technology available, the most important parameters influencing the ratio E_t/C_t are the rate of technical progress and the growth rate of the economy. Assuming that there is a positive correlation between the growth rate of the economy and technical progress, and assuming that λ is a decreasing and σ an increasing function of technical progress, one could envisage an equilibrium position between the growing demand for energy in a growing economy and the increased efficiency of the energy generation and transformation processes, thus keeping the net share of investment going into the expansion of the energy system, as a percentage of total investment, constant. For the time being, we are still far from achieving such a dynamic equilibrium.

The strategic factors determining the feasible growth rate of the two systems are therefore the following:

- the investment rate,
- the productivity of investment (capital/output ratio),
- technical progress,
- the proportion of investment going into the energy system,
- the lead time of investment,
- the efficiency of energy use (W/$)

  (offsetting factors: increase in efficiency vs. increasing share of industrial production in the ldc's),
- energy conservation,
- the relation between attainable and expected increase of disposable income (social discount rate).

In order to solve their own economic problems, such as unemployment, inflation, resource availability, etc., and in order to achieve an improvement in the intra- as well as in the international distribution of income, the industrial countries of the West (market economies) have to continue growing. However, whereas growth may ease some of the short-run problems, it causes, at the same time, in the long run, additional problems such as resource scarcities and hence price increases - which, by no means, are always offset by a corresponding increase in productivity - environmental disruptions, energy shortages, and the like.

Five reference scenarios (cf. Table 1) - not to be mistaken for forecasts - reflect some of the magnitudes involved in various assumptions about growth rates of population (POP) and gross national product (GNP) within a time horizon of year 2020. These scenarios are presented against the background of our present situation, which is given by $4*10^9$ for POP, $5.3*10^{12}$ for GNP (in US$), and $7.6*10^{12}$W (or 7.6 Tera Watt (TW)), and by historical growth rates of two percent per annum for population, and of four to five percent for gross national product in real terms.

Scenario A reflects United Nations' estimates and targets proposed in various UN publications. The target growth rate for GNP is a weighted average rate composed of the target rates of various world regions. The point I wish to make here refers to the implications of such target values. If population is assumed to stabilize somewhere between nine and ten billion people by year 2020 (which is the figure given most frequently), and if the GNP growth rate envisaged should really reach four percent per annum (the historical rate), we then would arrive, in 2020, at a world GNP of $31*10^{12}$ US$, and, at the given efficiency of energy use of 1.43 Watt per $ of output, at an energy requirement of 44.3 TW, which is nearly six times the present energy consumption. There is no question that such power can not be provided by classical fossil fuels anymore; definitely, new energy sources must be made available. This, in turn, requires additional investment capital, which has to be generated within the developed industrial countries. 1/

Scenario B refers to the estimates resulting from the Bariloche Model, which is a world model presented by a group of scientists from Latin America. 2/ This model is based upon the above-mentioned definitions of basic needs. It is normative and redistribution-oriented, but still requires economic growth.

1/ Estimates of future capital requirements of alternative energy strategies were presented by this author at the 5th World Congress of the International Economic Association, August 29-September 3, 1977, at Tokyo, and will be reprinted as B. Fritsch, "Future Capital Requirements of Alternative Energy Strategies: Global Perspectives", in the respective Conference Proceedings.

2/ A.O.Herrera, H.D.Scolnik, Catastrophe or New Society? A Latin American World Model, International Development Research Center, Ottawa, 1976.

YEAR	WORLD POPULATION (in Billions)	WORLD GNP (at 1975 prices) in US $	WORLD ENERGY CONSUMPTION (in TW = 10^{12}W at 1.43 W/$)	PER CAPITA ENERGY CONSUMPTION (in kWh)
1975	4,0	$5,3 * 10^{12}$	7,6	1,9
2020 REFERENCE SCENARIOS:				
A Various UN-estimates and targets, e.g. GNP-growth rate of 4 % p.a. and POP growth rate of less than 1,9 % p.a.	9,0	$31 * 10^{12}$	44,3	4,92
B The Bariloche Model	9,3	$13,4 * 10^{12}$	19,2	2,06
C With 3 % growth rates p.a. for POP and GNP	15,1	$20,0 * 10^{12}$	28,6	1,9
D With 2 % growth rates p.a. for POP and GNP	9,7	$12,9 * 10^{12}$	18,5	1,9
E With 3% growth rate for GNP, 2% growth rate for ENCON, 1,5% growth rate for POP	7,8	$20 * 10^{12}$	18,5	2,4
		increase in efficiency from 1,43 to 0,93 W/$		

Table 1. Reference Scenarios for Year 2020

The implicit energy requirements of this scenario amount to 19.2 TW by year 2020, i.e. to more than two-and-a-half times the present energy consumption.

Scenarios C and D simply show what values for GNP and POP would result if growth rates of three and two percent would be assumed for these two variables, respectively, and what - at historical efficiency rates - the corresponding energy requirements are. Again, even at a GNP growth rate of only two percent, which will certainly be insufficient to absorb the growing number of people looking for jobs, we are faced with an increase in total energy requirements of 2.43 times the amount of our present energy consumption.

Scenario E, finally, represents the most unlikely case - though it might be viewed as a most desirable scenario - since it assumes an increase in the efficiency of energy use by more than fifty percent, and an increase in population of only one-and-a-half percent per annum. Even here, with a three percent GNP growth, we are confronted with the same increase in total energy requirements.

Conclusions

It is evident that something must give way: either the growth rate of GNP, and/or the efficiency of energy use (expressed by the W/$ ratio) must drastically increase, and/or private consumption expenditure must be curtailed while the investment rate goes up.

In this context, the following concepts are important:

- rising cost of foregone opportunities (threshold values, trajectories)
- the 'quantum jump' of postindustrial societies, and
- the learning capacity of complex societal systems (catalytic crisis): the price of learning.

The ultimate scarce goods therefore are:

- time,
- options,
- the capability to adjust values, and
- the capital formation capability.

The relationship between growth, employment, inflation, and the distribution and use of resources is determined by a set of complex economic interactions which can not be easily evaded without profound change of the existing economic and political system. Considering Europe's weak energy resource position - little indigenous oil and uranium compared to the reserves of the United States and the Soviet Union - the only feasible way to achieve a certain degree of independence seems to be the speedy development of a fast breeder reactor capacity with the lowest possible doubling time. In this context, the development of advanced fuels becomes the focus of research, whereas the availability of sufficiently large reserves of plutonium represents a formidable strategic factor.

If the feasible growth rate of the two systems - the energy-generating and the energy-using system - will satisfy the political constraints set to the alternative combinations of inflation and unemployment, then, the advanced market economies will be able to participate in the global burden-sharing exercise and play a constructive role in the ongoing North-South dialogue. If, on the other hand, the industrial countries of the West should fail to achieve higher employment, less inflation and a considerably higher investment rate - i.e. the quantum jump -, and if they should fail to remain at the same time within the boundaries of the overall ecological equilibrium, then social unrest will follow and the chances for a peaceful solution of the pressing world problems will be foregone for ever.

(2) AN INPUT-OUTPUT SYSTEM FOR ENERGY-ECONOMY MODELING (Project ZENCAP)

On the occasion of the IIASA workshop on energy ("Energy Strategies - Conceptions and Embedding") at Laxenburg earlier this year (May 17-19, 1977), a progress report on the joint project was given. 3/ In line with the different orientation of the present workshop, the focus of today's presentation will

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3/ "Structural Change in Energy Production and its Impact on Capital Requirements: An Empirical Model", by Peter Staub, reprinted together with papers by Saugy et al., Becker et al., and Kappel in the IIASA Proceedings of the respective workshop.

be on the global modeling dimensions of the joint project. Aside from this shift in emphasis, the present progress report will differ from its earlier variant by concentrating on problems which occur when using input-output techniques together with other model approaches (e.g. an energy mesh, and a macroeconomic simulation model).

Project ZENCAP attempts to estimate the capital requirements of alternative future energy production strategies, its focus being on transition strategies. Transition mainly characterizes the fact that, based on today's known energy reserves (both fossil and non-fossil), energy supply some twenty to forty years hence can only be secured through the development of new sources of energy, and of new energy production techniques. Area-wise, the aim of Project ZENCAP is a coverage of major consumers of world energy. Geographically, the project starts out with European OECD countries. As yet, no decision has been made as to how country models and findings are to be linked (e.g. via aggregation of basic data, or via linking of country models).

Project ZENCAP makes use of a simulation model, which comprises an energy model (supplying exogenous information), an economic model (containing endogenous variables and parameters), and a political decision model (providing instrument variables). The simulation model produces transition paths, viz. alternative outcomes, which permit a judgement on the feasibility of certain energy strategies, given economic and political constraints (e.g. the capital formation capacity) of any country or country grouping considered.

What has just been characterized as the economic model part of the project may best be viewed as an input-output core to the simulation model. In a very summary fashion, this fact is depicted in the lower half of Fig.2. In addition, Fig.2 also shows the major links of the ZENCAP approach with the energy technology work of the SYSTEN group to be discussed below. The embedding of the input-output core in the simulation model framework is represented in some more detail in Fig.3. As the present progress report will focus on problems

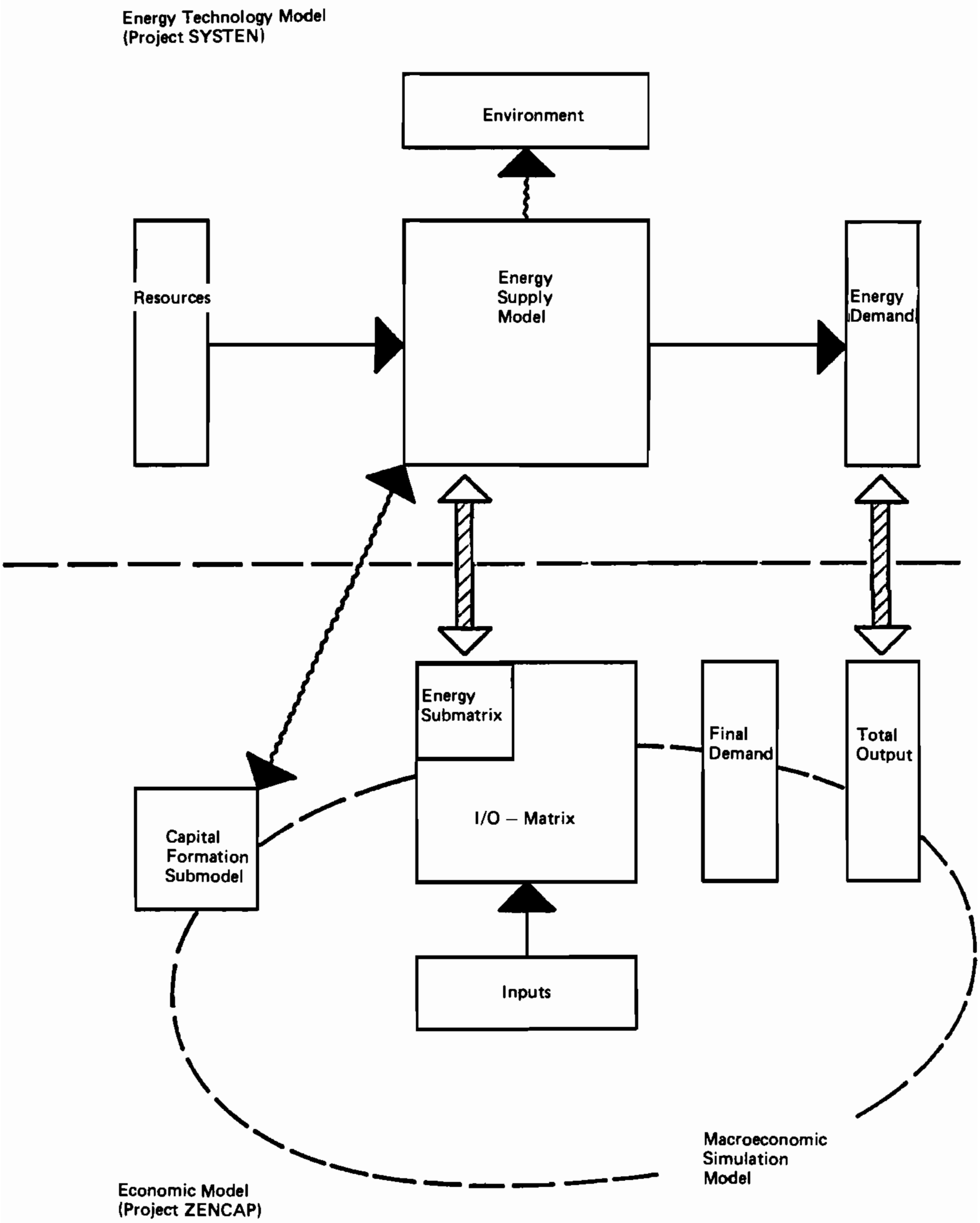

Fig.2 Interaction of the Energy Technology and the Economic Model

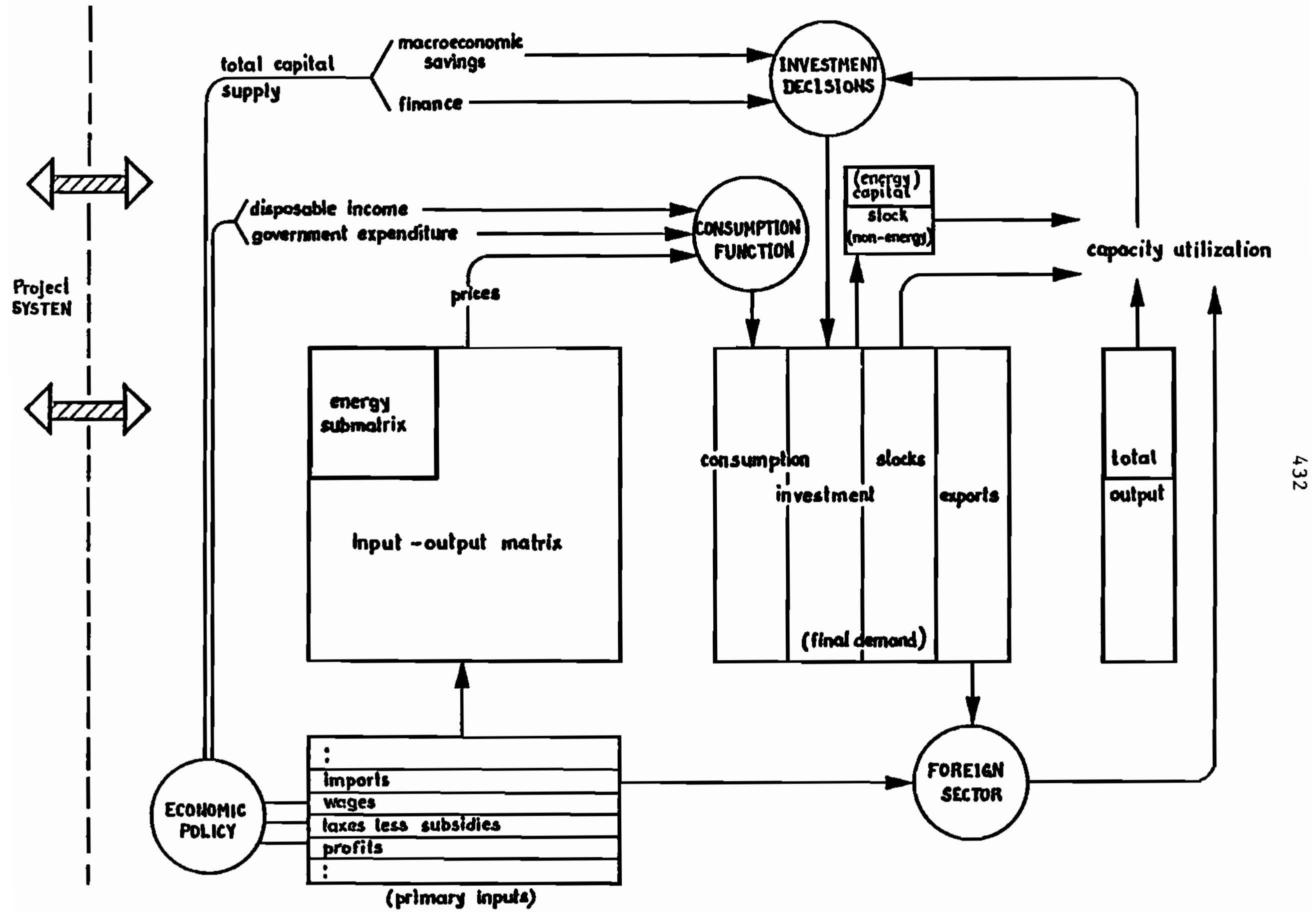

Fig.3 The Economic Model (Project ZENCAP)

of designing and implementing an energy-oriented input-output system, we abstain from further elaboration on the simulation model. 4/

The system consists of an input-output matrix (including primary inputs and final uses, respectively) and of a capital investment matrix. It contains 26 sectors, ten of which are energy sectors. The energy sector data of the input-output matrix (ten rows, over all 26 columns) are alternatively in physical units - tons of coal equivalent, or tce - and in domestic currency monetary units. In a pilot study, the input-output system has been implemented for the case of the Federal Republic of Germany (data for 1970).

Both to empirical economists and to the more theory-oriented members of the profession, the brief description of the system just given immediately raises a host of issues. In the following, we will attempt to be somewhat systematic in going through the major points.

The classification of the 26 sectors of the input-output matrix is given in Table 2. The ten energy sectors have been singled out. The fact that some of these sectors look rather uncommon to industrial economists is explained by the focus of the study: In order to satisfactorily account for requirements stemming from energy production technology analysis and from economic analysis, a classification criteria compromise had to be achieved. More on that will be said below.

Classification, as a problem of standardization, directly points to the data base. Whereas the classification scheme must meet both technological and economic criteria, data sources, in turn, should ideally be in a standard form for all countries to be considered. In other words, a study of the kind presented here can not start from full individual country input-output data and energy statistics, but should attempt to get reduced, internationally comparable and consistent data for the countries.

Both for the input-output tables and for energy statistics, such sources did exist in roughly the detail required. For input-output tables, the source

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4/ Cf. Rolf Kappel, "A Macroeconomics Simulation Model: The Theoretical Framework", reprinted in Staub, op.cit.

Table 2. An Energy-Oriented Input-Output System.
List of Economic Sectors.

Energy	Industrial
	I1. Mining nes.
	I2. Steel
	I3. Non-Ferrous Metals
E1. Hydrocarbons	I4. Plastic and Rubber
E2. Coke	I5. Chemicals
E3. Gas	I6. Construction
E4. Solid Fossil Fuels	I7. Machine Building
E5. Heating Oil	I8. Motor Vehicles
E6. Transportation Oil	I9. Transport Machinery nes.
E7. Electricity	I10. Electrical Engineering Products
E8. Low Temperature Thermal Energy	I11. Metal Products nes.
E9. High Temperature Thermal Energy	I12. Non-Metal Products
E10. Miscellaneous	I13. Food and Agricultural Products
	I14. Rail and Road Transport
	I15. Air and Ship Transport
	I16. Services nes.

is the Statistical Office of the European Communities, which publishes input-output tables under a system called 'NACE-CLIO R-44'; for energy statistics, the source is the OECD's 'Energy Balances of OECD Countries'. As there is no standard international source on capital formation, data for the capital investment matrix must be gathered from individual national sources.

As already mentioned, the input-output system has been implemented for the case of the Federal Republic of Germany (for 1970). The study has been laid out as a pilot study in several respects. For one thing, problems of conversion - from the standard sources to the energy-oriented input-output system - had to be solved. Second, given the very detailed national energy statistics for that country, an idea of the goodness of energy data conversions from OECD sources could be obtained. Finally, again given extensive capital formation data for Germany, some experience could be gathered on capital investment matrices.

Yet, the implementation for the Federal Republic of Germany is also a pilot study from a model formulation viewpoint. The way in which the input-output system is embedded in the economic (simulation) model is depicted in Figs. 2 and 3. What is labeled 'capital formation submodel' in Fig.2 has been spelt out in more detail in that study. Though not yet extended to a full scale simulation model, some of the more explicit links around capital demand (Fig.3) have been incorporated. The financing of the energy sector investments being the subject of a separate study presently in progress, the capital supply side has been left out for the time being.

Capital demand, in the present model version, is determined by a complex of relations around capacity utilization and capital stock. As yet, the mechanism is more of a capacity check/planning type than of a demand/price (or: interest rate) type.

Two issues of the project briefly mentioned so far, but definitely of interest to the topic of this conference, finally deserve a closer look. Both issues address linkage problems: the first that of the energy technology model and the energy submatrix, the second that of the individual country models.

The energy submatrix of the input-output system is so constructed as to allow a tracing back of entries in an energy technology system. That energy technology system essentially contains three parts: primary energy sectors, transformation sectors, and secondary energy sectors. The input-output energy submatrix represents a condensed, or reduced, version of that system. The advantage of this procedure is that changes in the energy submatrix (at the data or at the coefficient level) can be followed back into a full scale energy technology system, or, vice versa, that changes in energy technologies can directly be translated into energy submatrix coefficient changes. This may not be particularly spectacular from a theoretical viewpoint; in practical interpretation of results or translation of changes, respectively, however, such a model property is indeed of great help.

As said before, no decision has yet been taken on the linkage of individual country models. Evidence from large model building exercises, however, - the United Nations' Leontief Study (as presented at this conference by

Professor Petri), and the work of the Bradford Group (presented here by Professor Bottomley) may serve as random reference points - to the authors of the joint project, makes a strong point to treat the linkage problem with great care. Without necessarily implying a critique of the studies in question, neither the foreign sector pool of the Leontief Group, nor the sector-by-sector input-output table link of the Bradford Group, seem particularly suited for our purpose. An energy trade model, similar to the mini-link model of IMF's Project LINK, 5/ very likely may be the alternative to be adopted.

(3) ESTIMATING CHANGES IN INPUT-OUTPUT COEFFICIENTS THROUGH A TECHNOLOGICAL MODEL (Project SYSTEN)

When developing a comprehensive technological model on energy strategy assessment, it becomes necessary to also account for economic dimensions of the problem. In practice, however, an incorporation of the main properties of economic models into a technological approach has proven difficult for two reasons: First, the two approaches have different levels of aggregation, second, they differ with respect to the time horizon of the analysis.

Formulated from the viewpoint of technological energy models, economic model approaches are not sufficiently (or: suitably) disaggregated, nor are they able to describe a sufficiently long time span. From an economic model viewpoint, on the other hand, the technological approach creates similar problems of correspondence. The aim of a joint project, such as this one, must be to interlink a technological model (like that of Project SYSTEN) and an economic model approach (ZENCAP) without destroying the basic properties of either approach.

5/ By Grant B. Taplin, in: R.J.Ball (ed.), The International Linkage of National Economic Models, Amsterdam &c. (North-Holland), 1973.

Scenario and Time Scale

Simplifying somewhat, the technology approach basically distinguishes between three types of energy scenarios, viz.

- a development scenario, centering on nuclear resources,
- a stabilization scenario, centering on a better use of coal and oil, and
- an austerity scenario, centering on renewable resources.

There is increasing consensus that, if actual energy consumption patterns and present economic structure were extrapolated into the future, future energy demand could only be satisfied by a fast development of all known resources. Such a development, however, is likely to have serious political repercussions; from recent experience, one may conclude that it will not be an acceptable proposition unless a satisfactory explanation for that need be offered, or, alternatively, undue force is exerted. In other words, an investigation of changes in the structure of energy demand becomes imperative.

On the energy supply side, time factors affect the actual availability of new energy production technologies in a variety of ways. In sequential order, they are:

- the development of a technology to the point of commercial interest,
- investment in industrial productive capacity to produce such a technology,
- actual production of that technology, and
- application of that technology at a significant scale.

In this, it should be noted, it is assumed that the time required for implementation, as compared to the lifetime of a technology, is sufficiently long not to produce a gap between initial demand and replacement demand.

Conventionally, the industrial use, or implementation, of a technology is said to be at a 'significant scale' if half the saturation level of that technology is reached. From experience, the time span involved is about once the lifetime of that technology for existing technologies, and about twice its lifetime for new technologies. For energy technologies and housing technologies, the time span for an implementation at a significant scale is in the range of some twenty to fifty years.

Main Links Between the Models

There are three major links between the economic model described above and the technological model (cf. Fig.2). These links are between

- capital formation (Project ZENCAP) and capital requirements of the energy supply model of Project SYSTEN,
- the energy submatrix of the input-output system and the energy supply model, and
- total output and energy demand.

From the technological model, such links can be established not just for energy, but for any limited resource, such as e.g. water or a specific raw material. The technological model is thus able to 'physically' trace the impact of any scarce resource. In turn, this information is used in the economic model. In the following, the problems of linking technological and economic information are discussed by main link item.

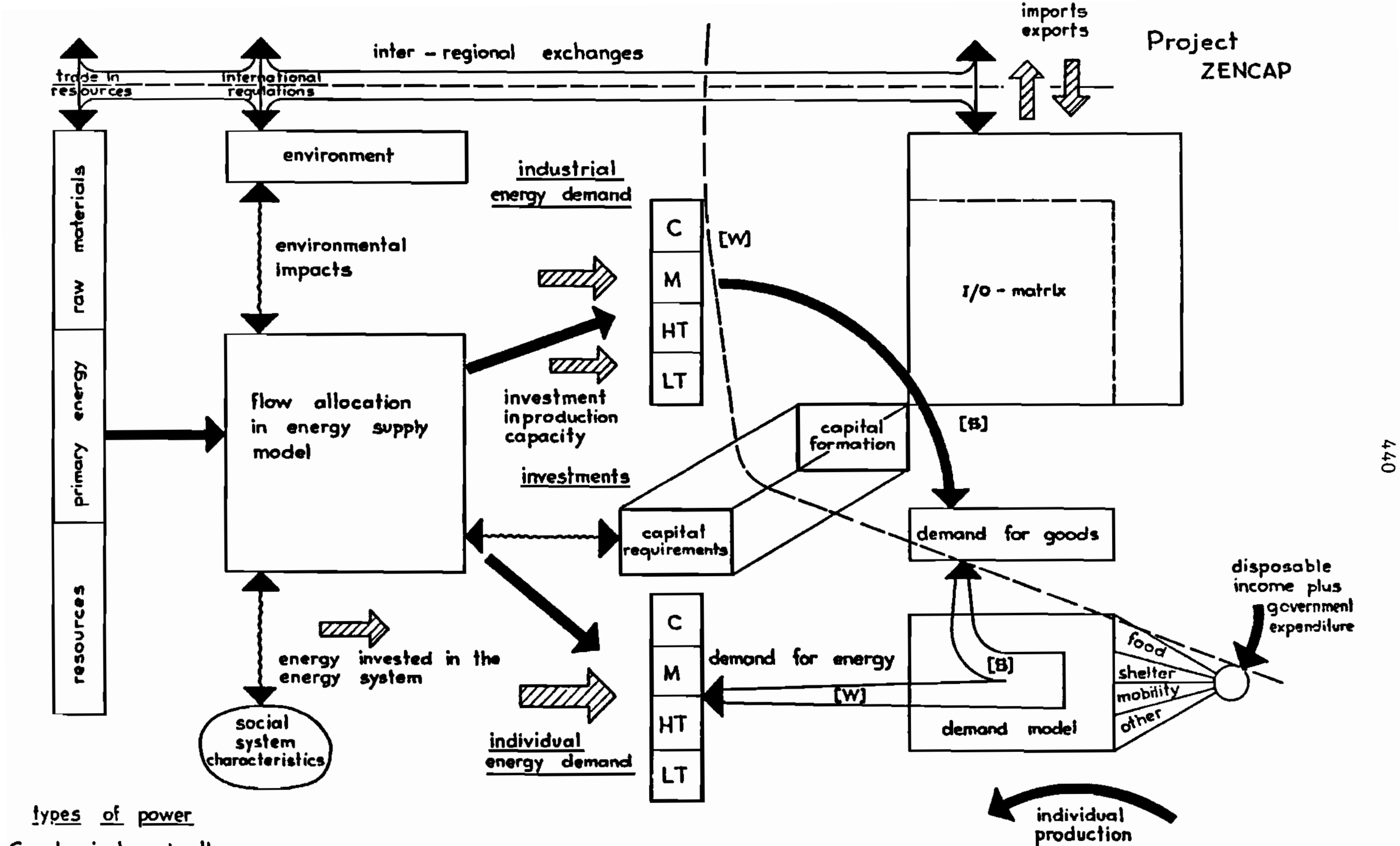
Capital Requirement. For any technology, there are data on specific capital cost. For a given energy mix, the total capital requirements of production increases can be calculated; at the same time, total goods required are determined by individual sectors. These figures are directly comparable to parameters of the economic model.

Energy Submatrix. The subdivision of energy sectors, though simple from a theoretical viewpoint, does present considerable problems at the operational level. For the economic model part, the sector classification represents a compromise between energy production technology analysis and economic analysis. In the case of the technological model, however, the energy submatrix is simply a condensed version of the energy mesh, of which resource and demand sectors only are retained. More difficulties are encountered the other way around, i.e. when the industrial sectors of the economic model are to supply information to the technological model. At present, the industrial sector classification does not conform with the resource and demand aggregates of the technological model, though an effort is made to reconcile the concepts.

Energy Demand. If expressed in terms of energy carriers (e.g. oil, electricity), demand for energy is highly sensitive to energy technology choices. In such a case, future demand for electricity, for example, strongly depends on the technological choice between, say, coal district heating and electric space heating. In terms of basic demand types, however, either variant should be expressed as demand for low temperature heat. Such demand would thus clearly depend on a given (or: assumed) way of life, standard of comfort, and the like, but definitely less on technological change or on energy technology choices. For that reason, i.e. a certain invariance to technology choices, demand for energy is aggregated into three major types of energy, viz. heat (high and low temperature), mechanical power, and special processes.

One way of connecting the energy technology model with the economic model is via disposable income (cf. Fig.4). At that level, budget allocation is between basic need categories such as food, shelter, mobility and health. These needs can be satisfied through various combinations of goods and energy, for which total individual demand for goods and energy can be calculated. From the energy content of goods, direct industrial demand for energy can be determined. Finally, indirect industrial demand for energy can be calculated from the energy content of investment goods and from investments into the energy system.

The results from this rather intuitive approach to calculating overall energy demand need to be compared and adjusted to econometric energy demand forecasts. The advantage of such a procedure, however, is that it is able to account for individual production of services, which may



types of power
C chemical and other
M mechanical
HT high temp. thermal
LT low temp. thermal

Fig.4 The Energy Technology Model (Project SYSTEN) have a sizable effect on the standard of living (via an improved quality of services), but which is normally largely neglected in standard economic approaches.

Processing the Technological Model

The properties of the energy technology model have already been described in detail at a previous IIASA workshop. 6/ For the sake of completeness of this presentation, its main characteristics will again be summarized.

For any given run, energy technologies to be considered are organized in an energy system network, which describes all technical options capable of satisfying energy demand from a given set of resources (cf. Fig.5). Tests are applied to check for completeness and coherence of the network. Storage and transportation characteristics of technologies are derived from the network representation. Technical, environmental and economic characteristics of technologies are stored in data bank CARTEN.

In a second step, energy technology mix is determined. This implies calculating the energy flows through each technology, i.e. the contribution of each energy technology in matching demand and resources. Linear programming offers an algorithm to generate an optimal solution, or an optimal combination of technology contributions, such as e.g. program DESOM of Brookhaven National Laboratory. For three reasons, we do not use the linear programming algorithm. First, it is close to impossible to satisfactorily define an overall objective function accounting for cost, environmental and technical characteristics. Second, the identification of a damage function containing all parameters is considered impossible for practical as well as for theoretical reasons. Finally, the concept of optimal solution optimizes individual production processes rather than optimally matching resources and demand.

6/ Saugy et al., "Energy Strategies: A Technical Assessment", in: Staub, op.cit.

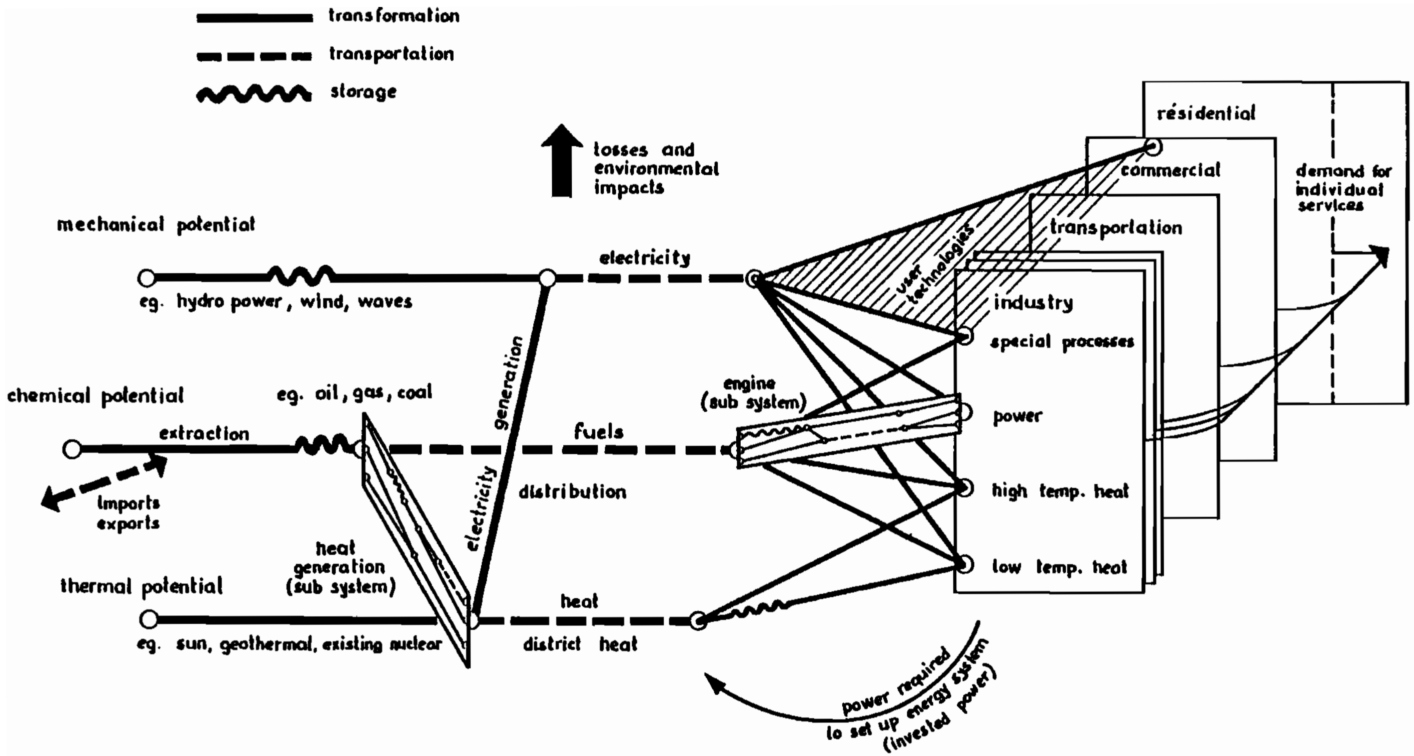


Fig.5 Rules on Building a Reticulated System

The algorithm adopted instead of the linear programming approach is that of proportionate allocation. The attractiveness of a technology can be defined as the inverse of cost, or thermal pollution, or be expressed by any objective function adequately accounting for the various technology characteristics. The algorithm allows for specifications such as "the more attractive a technology, the more it is used", or "the most attractive technology chain is used". This algorithm, of course, will not produce a unique solution.

When considering alternative energy technology mix-variants, a profile is established for each variant, which consists of a set of indicators such as investment requirements, chemical or nuclear pollution, land use, and social impacts (cf. Fig.6). The profile is established on the basis of the information stored in the technology data bank. From such assessments emerges a limited number of 'acceptable' solutions, which are subject to further analysis. To each solution corresponds a set of energy sector input-output coefficients; similarly, energy sector coefficients of the respective capital investment matrix can be calculated. Developed out of the energy technology approach, these coefficients are successively introduced into the economic model. There, they allow an assessment of the economic impacts of any given energy strategy, e.g. on capital formation and on growth potential.

Extension to Trade Coefficients

The proportionate allocation algorithm is comparable to finite element methods in mechanical engineering. One property of that algorithm is its ability to handle freely structured networks, and thus also interlinked national or regional energy networks. Runs where the mesh for one region is given in detail, while other regions, except perhaps for oil imports, are represented by a highly aggregated network, are also possible.

The concept of interfacing regional energy systems through energy balances of subsystems (cf. Fig.7) represents a compromise between a pool approach

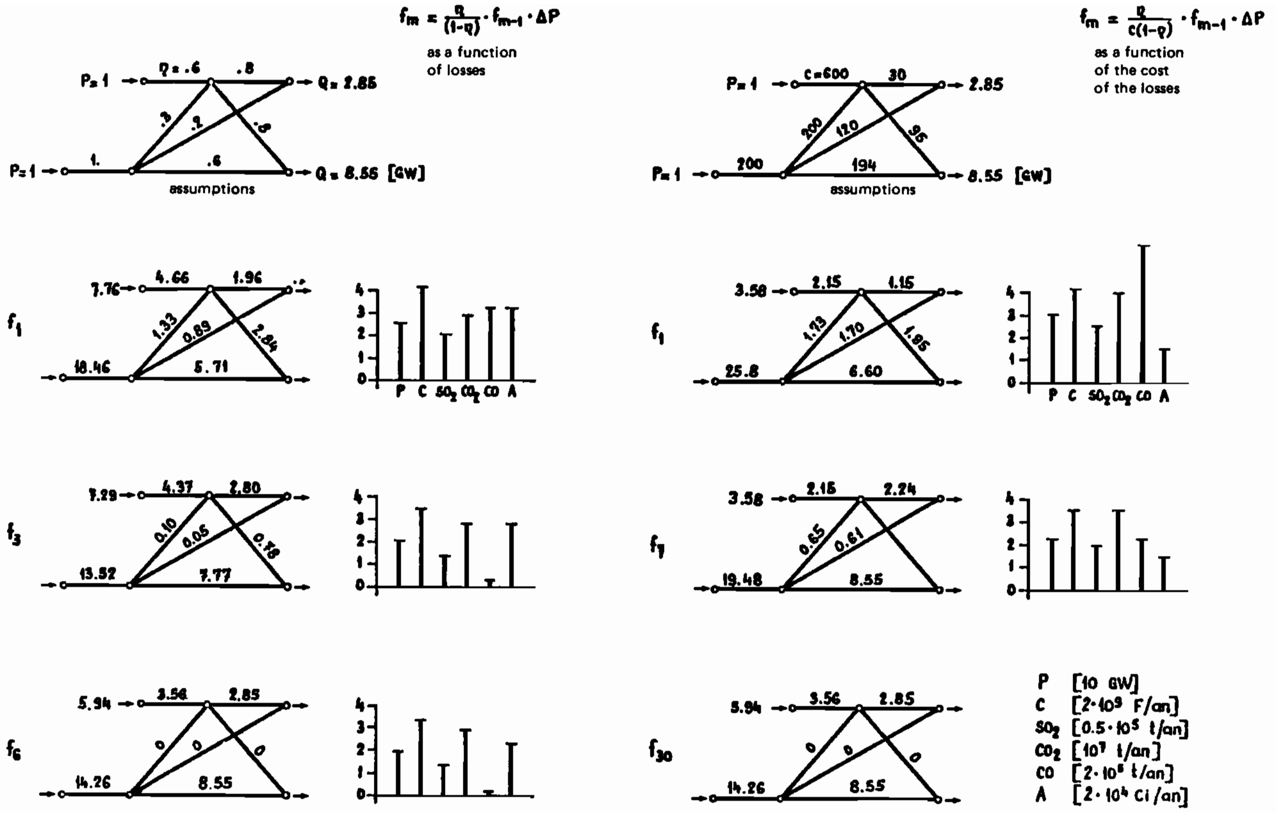


Fig.6 Allocation Examples

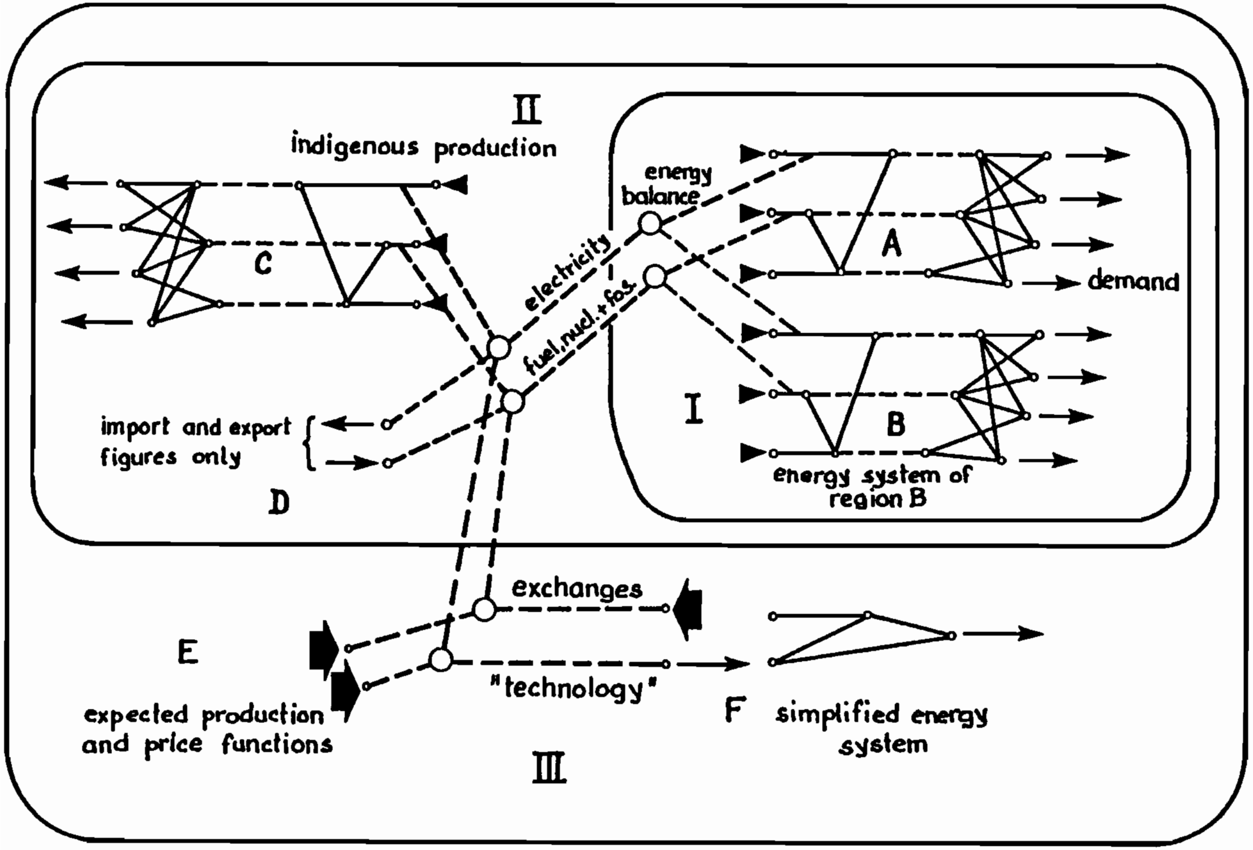


Fig.7 Interfacing Regional Energy Systems Through Energy Balances of Sub-Systems

to world trade and a full international trade matrix. Through such interfacing, any national exchange with regions is retained, while intra-regional exchanges are suppressed. In the light of data availability, such selectivity is indeed a welcome property of the algorithm.

Energy imports and exports are treated like the energy transportation technology; subsequently, they can be characterized by attractivities. Due to the lack of information on true production cost (in the case of imports) and final use (for exports), respectively, political and economic judgement is regularly required in estimating these figures. From such model analysis, energy sector import-export coefficients corresponding to alternative energy strategies can be calculated.

Conclusions

Interfacing economic and technical model approaches to the energy system makes it possible to study long-term structural changes in that system at a world level. In particular, the methodology developed conserves the main fundamental qualities of the individual approaches.

DISCUSSION

Bruckmann pointed out that the analysis, interesting as it may be, seems to lack important factors that should not be omitted in a systematic study: the ecological problems on one side, the sociopolitical problems on the other side, associated with the switch from a 7.5-terawatt society to a 35- or 55-terawatt society. Many ecologists are convinced that not only the problem of CO_2-concentration, but the problem of thermal pollution at large of a 55-terawatt society would simply be prohibitive; the same may be true of the sociopolitical aspects of an all nuclear society.

In reply, Fritsch stressed that, unfortunately, science is not yet able to give an operational answer; he hopes very much that future cooperation with IIASA will yield fruitful results. Saugy added that the concerns expressed by Bruckmann were the reason for one of their scenarios; this can certainly be elaborated further.

Bottomley said that the model should differentiate more clearly between different types of energy and their (partial) substitutability. Condoni replied that, the more detailed the model, the less workable it becomes. Substantial difficulties were associated with converting the detailed German energy data to an input-output system. A trade model on energy to supplement the information would be more important than to go into more detail within energy itself.

Richardson raised the general question whether the policy models designed so far are really directed towards answering the kind of questions that policy makers are used to asking. Policy makers usually are not interested in a large number of scenarios and free policy parameters, but rather in clear-cut concrete policy actions to be taken now (or in the immediate future) and the results likely to be derived from them. Unless model builders are prepared to answer such clear-cut questions in a very clear-cut way, without many reservations and limitations, their models will remain of no impact. If Fritsch were to give, on the basis of his model, a concrete policy recommendation, how would this look? In reply, Fritsch referred to the different (even contradictory) answers that the big global models have given (Limits to Growth, Pestel/Mesarovic, Leontief); the same holds true on the national level - different models give different answers.

Chapter 16

A VALUE-DRIVEN, REGIONALIZED WORLD MODEL

Frederick Kile*
Arnold Rabehl*

INTRODUCTION

Regional World III (RW III) has successfully replicated several aspects of socioeconomic activity within the limits of available data. We have now designed a successor model, RW IV, which will improve on RW III in two major ways:

1) RW IV will be capable of tracking heretofore elusive socioeconomic events and trends by disaggregating many previously lumped parameters.
2) RW IV will require the user to *state* value assumptions which were formerly overlooked or clouded by the lack of distinctions among social or economic categories. The value basis of RW IV will be developed until we can reasonably assert that the model is value-driven. We anticipate that this *modus operandi* will influence users to acknowledge the value-driven aspects of our present socioeconomic decision mechanisms and to demand that future modeling efforts be explicitly value-driven.

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The paper is divided into two chief parts: A description of RW III and an explication of the specific improvements incorporated in RW IV. (Note: RW IV is presently being programmed and will not be tested until late 1977.)

PART I: A DESCRIPTION OF RW III

FUNCTIONAL DESCRIPTION

Regional World III is:

1) A dynamic, difference equation model
2) Written in FORTRAN
3) Regionalized by nations and groupings of nations according to political and economic spheres (see Table 1).

INTRA-REGIONAL CALCULATIONS

The model is sectorized to reflect separate production figures for:

1) Grain equivalent food production
2) Animal protein equivalent protein levels per capita
3) Petroleum production
4) Coal production
5) Credit balances
6) Industrial production which is further subdivided:
    a) Industrial Base (factories, machinery, etc.)
    b) Agricultural Equipment
    c) Advanced Technological Equipment
    d) Overhead (consumables, clothing, chemicals, paper, etc.)
    e) Industrial Exports
    f) Other (a general capital goods sector including non-industrial buildings, railways, air transport equipment, housing, military, etc.)

TABLE I

REGIONS

1 UNITED STATES

2 CANADA

3 UNITED KINGDOM

4 INDIA, NEPAL, SRI LANKA, BHUTAN

5 FEDERAL REPUBLIC OF GERMANY

6 USSR, MONGOLIA

7 BRAZIL

8 CHINA, NORTH KOREA

9 FRANCE

10 JAPAN

11 INDONESIA

12 BANGLADESH

13 PAKISTAN

14 NIGERIA

15 MALAYSIA, THAILAND, BURMA, SINGAPORE

16 BLACK AFRICA, MALAGASY REPUBLIC, MAURITIUS

17 ALGERIA, IRAQ, SAUDI ARABIA, KUWAIT, OMAN, EMIRATES, LEBANON, SYRIA, JORDAN, MOROCCO, LIBYA, SUDAN, MAURITANIA, TUNISIA, EGYPT, YEMEN

18 SPANISH LATIN AMERICA

19 BULGARIA, HUNGARY, ALBANIA, CZECHOSLOVAKIA, GERMAN DEMOCRATIC REPUBLIC, POLAND, ROMANIA

20 WESTERN EUROPE (EXCEPT UNITED KINGDOM, FRANCE, FEDERAL REPUBLIC OF GERMANY; INCLUDING ICELAND, ISRAEL, MALTA, CYPRUS)

21 AUSTRALIA, NEW ZEALAND

22 VIETNAM (INCLUDING LAOS), CAMBODIA

23 PHILIPPINES, SOUTH KOREA, TAIWAN

24 TURKEY

25 IRAN

26 SOUTH AFRICA, RHODESIA

RW III also contains a population-based model including (by region):

1) Population

2) Nutrition level

3) Birth rate

4) Death rate

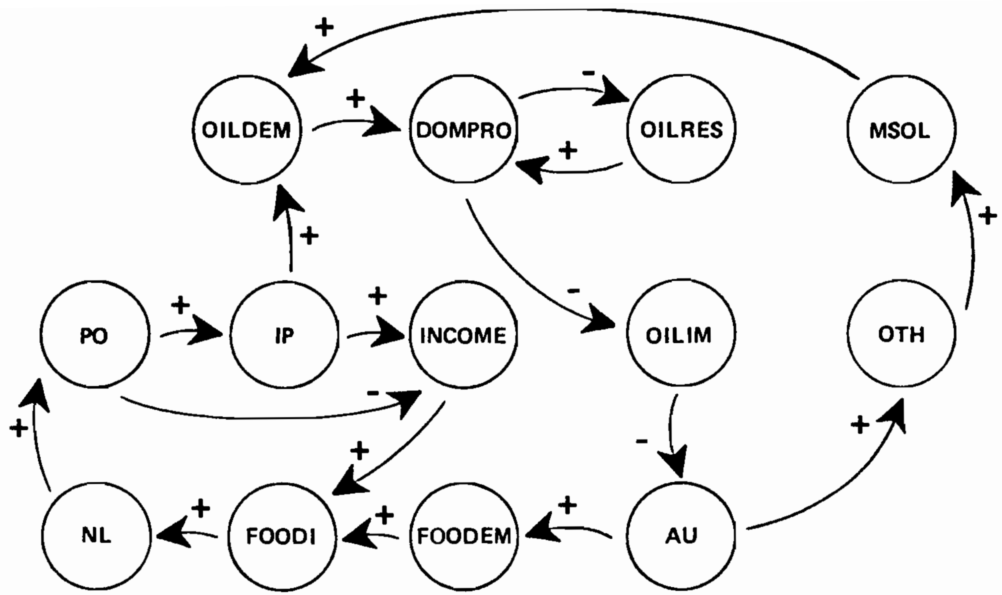
INTER-REGIONAL CALCULATIONS

After intra-regional calculations determine each region's need for food, raw materials, and manufactured goods as well as materials of all types which are available for export, these availabilities and demands are compared and materials are imported by regions which have sufficient available credit. Regions queue for imports according to per capita income. This follows from the observation that when goods are scarce, the rich usually buy before the poor. Note that the opportunity for ethical intervention here is great; a later section in this paper describes tests simulating a prototype international market allocation system.

Exports are made from regions on a pro rata basis, e.g., if only 90 percent of the world's available supply of a certain commodity is imported, it is assumed that each potential exporter sold 90 percent of its goods, retaining the remainder as surplus. Should manufactured goods available for export not be purchased, industrial production calculations are adjusted to reflect idle industrial capacity.

CAUSAL LINKAGES

Figure 1 shows a large causal loop together with some subloops linking petroleum production, credit, material standard of living, food demand, population, industrial production and income to illustrate the design of the model. Note that a particular link is not completed until a new calculation is made for the next element in the loop based on the value calculated for the previous element. In some cases, this may mean that signal



Key to Acronyms

OILDEM	Oil Demand	MSOL	Material Standard of Living
DOMPRO	Domestic Production	PO	Population
OILRES	Oil Reserves	IP	Industrial Production
OILIM	Oil Imports	INCOME	Income Per Capita
AU	Available Utiles (a measure of credit)	FOODI	Food Imports
		NL	Nutrition Level
OTH	Other (consumption of goods linked with 'MSOL')	FOODEM	Food Demand

Figure 1. A causal loop linking petroleum production, credit, material standard of living, food demand, population, industrial production, and income per capita.

flow around a feedback loop is not completed until several model time cycles have elapsed. Since the cycle time for RW III is one year, the reader should be well aware of the time-dependent character of the loop structure.

EXAMINATION OF THE CONSEQUENCES OF ASSUMPTIONS IN FIGURE 1

The complexity indicated by the very minimal causal diagram of Figure 1 suggests that any of a number of factors lying outside the main loop shown might act as a constraint on some aspect of system behavior and be determinative of model output. For example, doubling known oil reserves of Region A might increase production and available utiles, permitting adequate food imports to continue at a time when world supplies of exportable food are shrinking. This scenario would transfer the social burden of a lower nutritional level and higher death rate to another region (say Region B). Conversely, an early desire on the part of Region A to build a large trade surplus might lead to faster depletion of domestic petroleum reserves together with a higher standard of living at an early date, followed by greater dependence on oil imports, lowered purchasing power, a lessened nutrition level, and a higher death rate in Region A at some later date.

MODEL TESTS

TEST ASSUMPTIONS

Using 1968 as the base year, our tests typically run for 15 - 35 years based on the following two assumptions:

1) Short range effects (five years or less) are best simulated by other means.
2) Decision makers are unlikely to undertake policies whose primary effects will not be felt during this century (year 2000 = model year 32).

POLICY TESTS

Each policy test is based on the modelers' judgment that the projected policy is either a reasonable option open to decision makers or that decision makers might seriously consider a policy of that type if test results demonstrated its desirability. After baseline test values are established, a policy variable is incremented (or decremented) in successive stages to demonstrate the effects of the selected policy option. In special cases, several parameters are varied simultaneously to demonstrate the combined effects of a coherent policy intended to achieve a specific socioeconomic goal.

Test results are compared with baseline results both in tabular form and as computer output plots.

Most policy tests yield changes across a broad range of output variables. Output from policy tests is examined according to two criteria:

1) How well did the test policy achieve its objectives?
2) What significant changes occurred in output variables which would remain unchanged under optimum conditions (that is, if the test policy affected only the target output variable and no other outputs)?

The next two sections of this report focus on recent tests of RW III to illustrate its use in achieving goals of the project.

EFFECTS OF LESSENED DEPENDENCE ON PETROLEUM (REGION 1)

In Figure 2 the solid line indicates foreign exchange deficits (one utile = one 1968 dollar) expected to build up beginning about year 22 (1990) if the present level of petroleum dependence in Region 1 continues. It is unlikely that world credit structures would support a Region 1

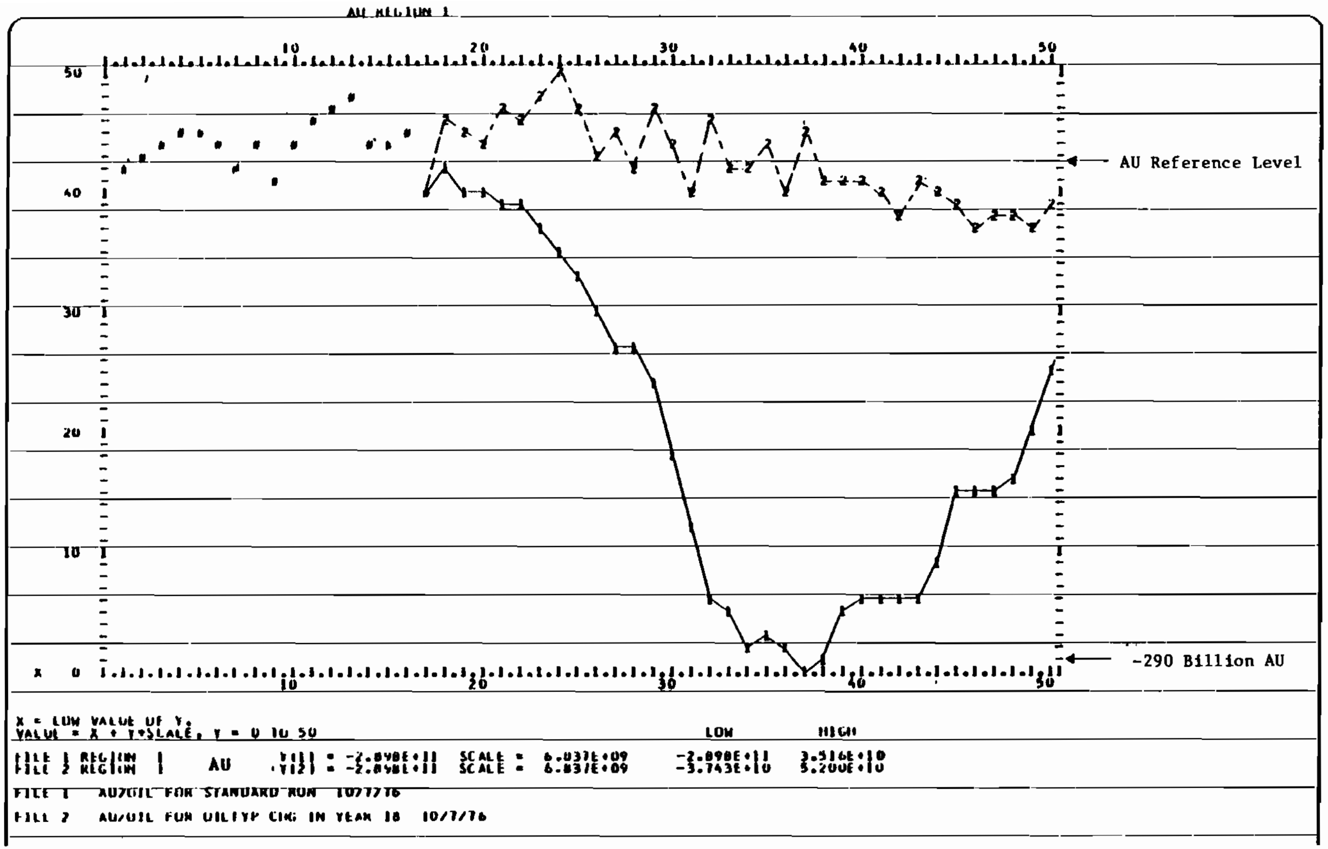


Figure 2. Foreign exchange credits/debts if present level of petroleum dependence in Region 1 continues (solid line) and under policies for low petroleum dependence beginning in 1986 (dashed line).

cumulative deficit of this magnitude. The strain of this growing deficit would very likely have one of the following effects:

1) Repeated devaluation of the U.S. dollar with attendant social unrest.
2) Attempts to raise grain prices for exports would lead to greater starvation in weak regions with little additional revenue for Region 1.

The dashed plot in Figure 2 indicates rough parity of foreign exchange credits/debits for the same period if internal policy dictates a change from medium petroleum dependence to low petroleum dependence beginning in year 18 (1986). The annual levels of petroleum imports which correspond to these two Region 1 petroleum dependence options are shown on Figure 3 (solid = medium petroleum dependence, dashed = low petroleum dependence).

The death rate curves (Figure 4) for Region 12 (Bangladesh) indicate consistently lower values following initiation (dashed line) of a low petroleum dependence policy in Region 1, further demonstrating the close relationship of ethical values and political/economic/social decisions. Unfortunately, death rates continue a gradual climb in Region 12 under either policy option. Further testing must be done to suggest coherent combined policy options which will lead to level or (more desirably) decreasing death rates in Region 12.

VALUE-BASED POLICY TESTS

The computer output plots shown in Figures 5 - 7 demonstrate the impact of value-based policy. Tests portrayed in these figures were run at a different phase of model development than those depicted in Figures 2 - 3 and thus the baseline values in Figure 5 differ from those in Figure 3.

Figure 5 compares anticipated levels of petroleum imports for Region 1 (USA) (solid line) with expected levels of petroleum exports from

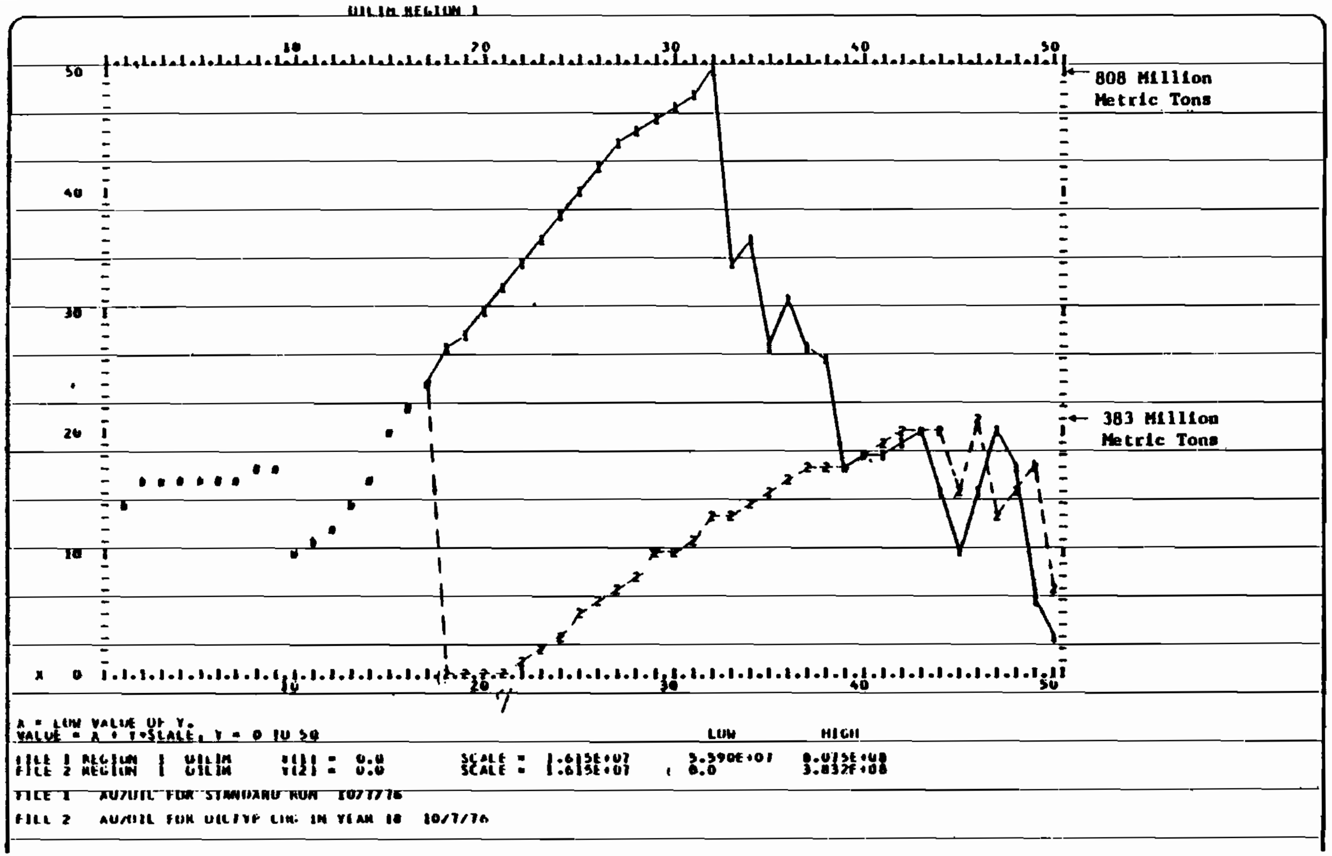


Figure 3. Petroleum imports by Region 1 under policies for medium (solid line) and low (dashed line) petroleum dependence.

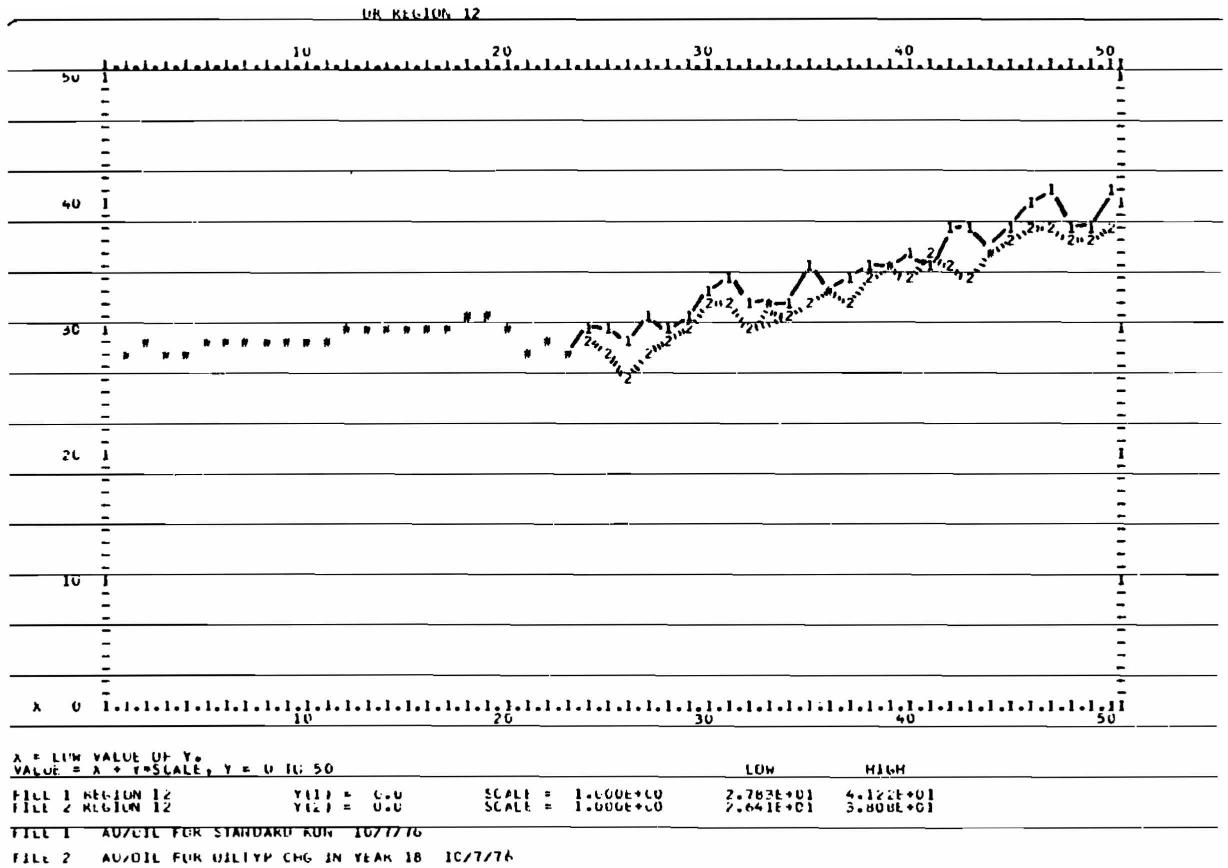
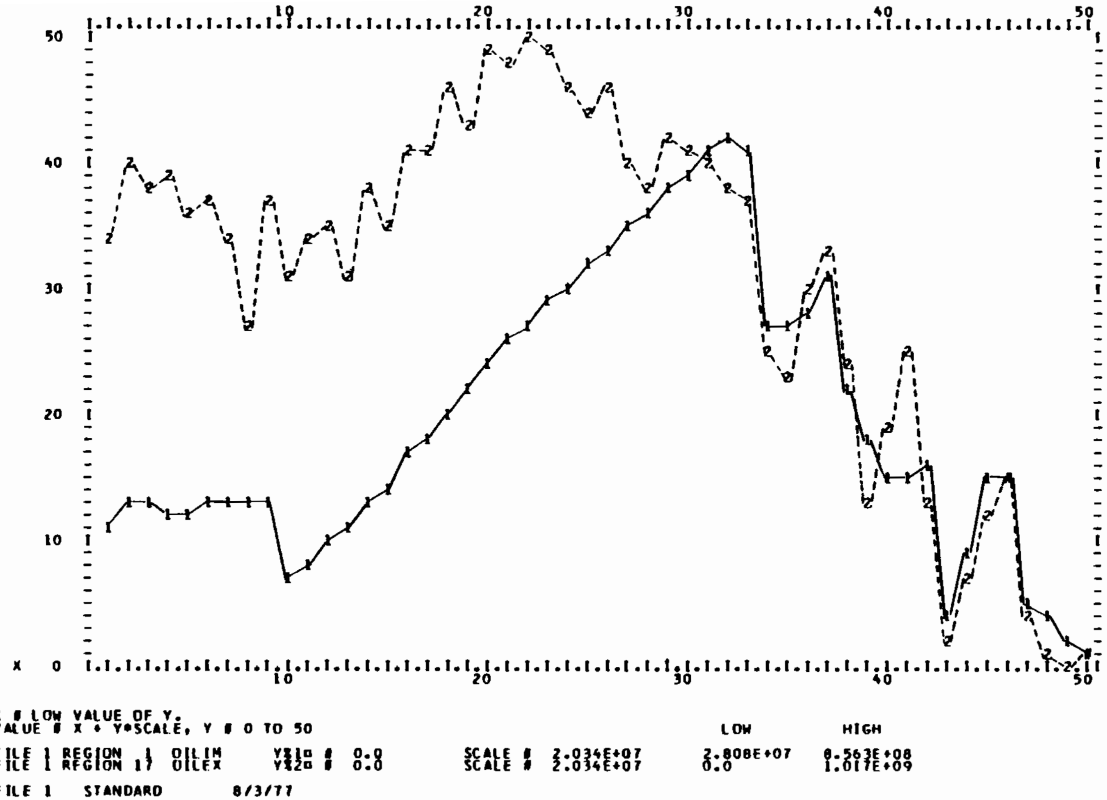


Figure 4. Death rates in Region 12 under low (dashed line) and high (solid line) petroleum dependence in Region 1.



Figures 5-7. Petroleum imports by Region 1 (solid line) and exports from region 17 (dashed line).
Figure 5. Countries may import all they need on the first pass and queue in order of per capita income.

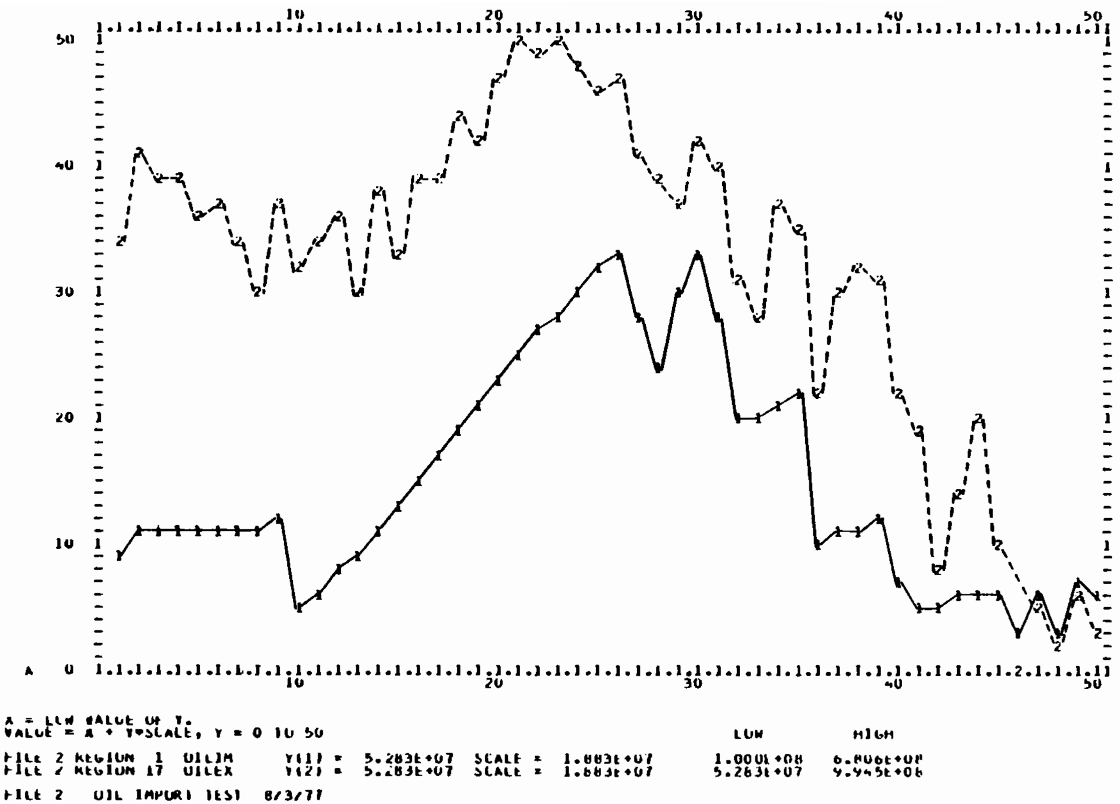


Figure 6. Countries may import half of what they need on first pass and queue in order of per capita imcome.

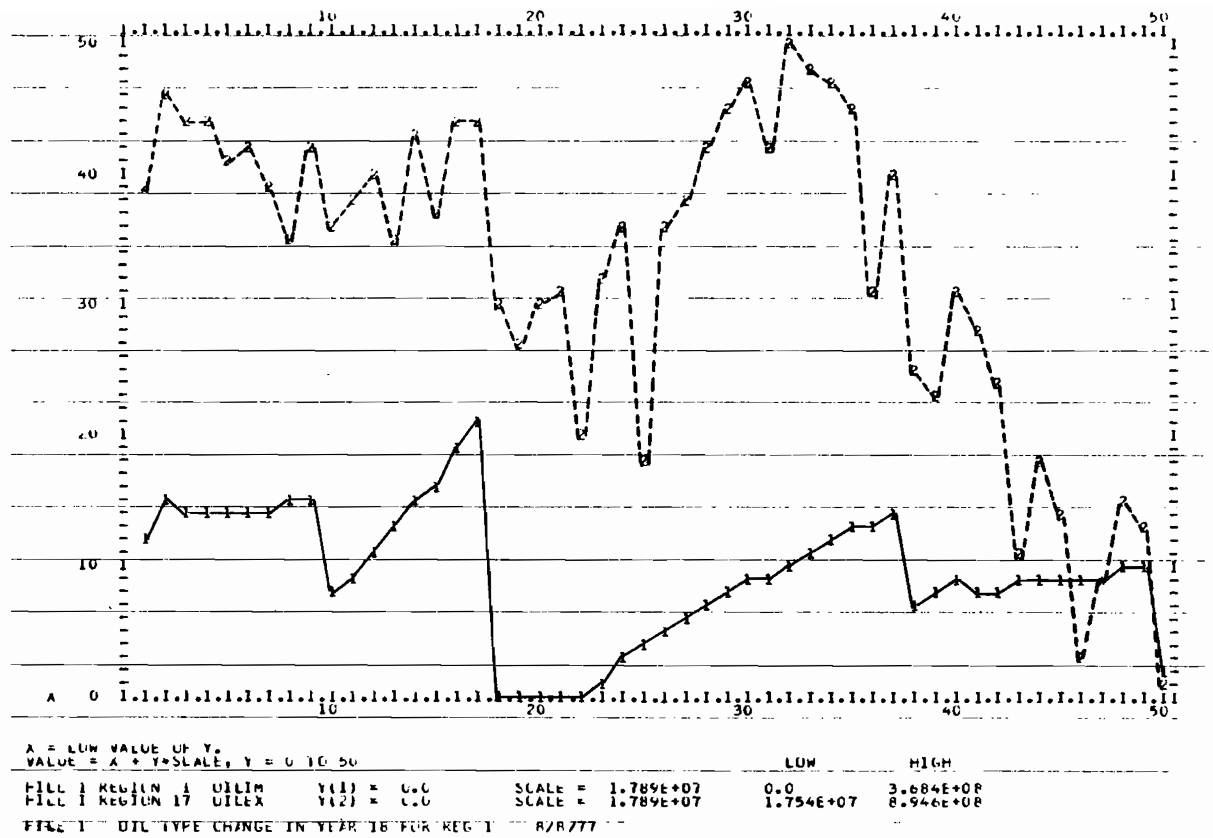


Figure 7. Countries may import half of what they need on the first pass and Region 1 adopts a strict oil conservation program in 1986.

Region 17 (Arab nations) (dashed line). This test was run under the basic assumption that the region with the highest per capita income may buy oil on the open market until its import demands are satisfied and then the region with the next highest per capita income is permitted to make purchases. This simple assumption gives no weight to ethical, political, military, or other attendant economic considerations.

Even though the model operates under this very loose constraint, the petroleum import demand for Region 1 (consistently highest in per capita income) is not met after 2000 (year 32), largely because by that date Region 17 has begun to decrease its exports to conserve reserves for its own anticipated future demand. Exports from other regions have virtually ceased by 2000 (year 32).

Obviously, however, petroleum allocation based on preference to buyers with highest income will be politically unsustainable in the face of pressures from other regions which are denied needed supplies although the situation may be altered sooner by the declining value of the U.S. dollar under the pressure of large balance of payments deficits.

Figure 6 shows petroleum imports by Region 1 and petroleum exports by Region 17 under a different market allocation assumption. In this test, regions queue to purchase petroleum in order of per capita income, but purchasing is done in two passes with each region allowed to purchase only .5 of its import demand on the first pass. This permits lower income regions access to the petroleum market for *at least some* of their needs for about sixteen additional years, extending the time during which these regions must shift from dependence on petroleum either to a lower energy economy or to new sources of energy.

Figure 7 also shows petroleum imports by Region 1 and petroleum exports by Region 17 under the same constraints governing the test in Figure 6 with the additional proviso that Region 1 adopts a strict petroleum conservation program in 1986 (year 18). This set of constraints generates a scenario which permits about 25 years beyond the present for worldwide phaseout of dependence on petroleum-based energy. These constraints are sufficient to yield a reasonably stable balance of payments history for Region 1 (not shown), thus averting the unsettling effects of repeated devaluations of the U.S. dollar.

PART II: SPECIFIC IMPROVEMENTS IN RW IV TO PROMOTE VALUE-BASED SCENARIO GENERATION

PRIOR EXPERIENCE WITH VALUE ASSUMPTIONS

The scenarios of Figures 5 - 7 were generated by a three-step approach to the value implications of a world market (in this case, petroleum). In the first step, we assumed straightforward allocation of economic power to obtain desired goods or services.

Computer output plots suggested that petroleum allocation by economic power might fail in the face of a politically unsettling imbalance in world petroleum trade, so we experimented with a second market mechanism. This mechanism was based on application of two *values* to world petroleum marketing: First, *conflict avoidance* by tension resolution, second, *distribution* of the discomfort or suffering pursuant to a worldwide petroleum shortage by a very simple *rationing* procedure. This rationing procedure, which was described in Part 1 of this paper, may be refined to achieve any desired degree of distribution simply by decreasing the allocation the model permits queued petroleum importers in each pass through the purchasing loop and increasing the number of passes accordingly.

Since petroleum pricing is based in part on the demand/supply ratio, the simple *rationing* method generated another scenario dependent on the purchasing ability of each region, because continued high demand resulted in high prices; thus, poorer regions passed their turns in the buying queue when they ran out of foreign exchange credits.

Dissatisfaction with the second scenario led us to develop a third scenario based on voluntary limiting of petroleum demand in Region 1, the largest importer, thus decreasing demand and price. The two values which motivate this policy assumption are: 1) *Sharing* resources in a finite world; 2) *maintaining supplies for the future* by conservation in the present.

MORAL IMPERATIVES AND STRUCTURAL DISAGGREGATION IN MODEL DESIGN

The sequence of petroleum market scenarios discussed in the preceding paragraph led us to infer that inclusion of value assumptions in a model design requires *specific* value-based policy mechanisms. Vague or general policy application is not feasible in a computer-based socioeconomic model.

MORAL IMPERATIVES IN MODEL DESIGN

The model designer must anticipate a range of value-questions which will arise in model testing and policy simulation. The designer is then obliged to construct the model in a way which *further obliges the user* to consider the value implications of policy assumptions. Finally, the designer must oblige the user to *state* the *value choices* which he makes in a policy test. In turn, these value choices act as a driving impetus for the policy test.

The moral imperatives of a design which requires the user to state his value choices are integral to the holistic modeling approach. Future models may progress beyond this stage by incorporating simulations of a value choice mechanism, but the first step in this direction is to require either the decision maker or his surrogate to interact with the model.

Any approach which completely bypasses the social decision domain is too mechanistic, too linked to observation of *past* social data and structure to warrant serious pursuit in solving policy dilemmas for the future.

DISAGGREGATION AS A VEHICLE FOR STATING VALUE ASSUMPTIONS

To satisfy *both* the moral imperatives requiring value inclusion in model design *and* the requirement for methodological consistency, and thus provide the requisite variety for a credible simulation, the model designer must disaggregate model structure as well as data in several domains including:

1) Geopolitical Groupings
2) Population
3) Agricultural Production
4) Industrial Production
5) Resource Reserves
6) Policy Selection

The goal of this disaggregation is to produce a model which generates credible simulations by meeting at least three performance criteria:

1) The model must be subject to validation testing in each output area.
2) Testing options must be available to identify which changes in output are traceable to which changes in data, model structure, and value-based policy assumptions. This criterion is especially difficult to satisfy and may require generation of a succession of scenarios which gradually step the model through a series of changes. If several changes are introduced at one time, identification of cause/effect relationship is difficult.
3) The model must provide the user with linked value and policy alternatives

which simulate the sociopolitical alternatives afforded the decision maker who will be the end-user of the model.

THE UNIQUE VALUE CHALLENGE OF RW IV

In most models the user is confronted with a finished model which generates a baseline scenario and then the user is asked if he would like to test any policy alternatives to generate comparison scenarios.

This methodology is beginning to reach the limits of its usefulness and thus we are designing RW IV with a substantial array of mandatory choices to be made by the user. The choices are inferred by various sets of questions:

What will we emphasize:

1) Conservation for future generations?
2) Aid to poorer regions?
3) Investment in technology?

What will we *de*emphasize:

1) Consumer comfort and convenience?
2) A buildup of industrial production capacity?
3) Military preparedness?

These questions are meaningful in a model test if the answers to the questions become coefficients or connection paths in loops which define model structure.

RW IV is being designed to include specific quantitative decision options through which the user's on-the-spot decisions actually become part of model structure. This enhancement of user value choices is an important step toward a modeling and decision process in which the end-user will demand that his value choices play at least an equal role with the prior structural and analytical decisions of the model designer.

We expect to encounter a typical series of temporary dead-end paths in our progress toward a viable model, but we have enhanced chances of success by disaggregating the computer program as well as the socioeconomic structure, affording a pliable structure for development in as many dimensions as possible.

We will report on early results from this developmental effort at various meetings in 1978.

DISCUSSION

In reply to a question by Bottomley, Kile stressed the difference between a (usual) economic discount rate and the social discount rates that he used. Bottomley then brought the discussion to the connection between prices and the growth of consumption, which can also be negative. Kile replied that this problem must be seen in a systemic way. He cited as an example the fact that the five Great Lakes in North America contain something like 25% of the world's available reserves of fresh water which were not "priced": the asbestos pollution of Lake Superior has forced the people near Lake Superior to drink filtered water; the cartons in which drinking water is now handled, in turn, require for their production additional pollution of water. Bottomley replied that also the contrary can be stated: if the level of production rises to a certain point one can also pay for the pollution-eliminating procedures. Bruckmann stressed that the problem lies elsewhere: it seems necessary to differentiate between "discounting problems" which are solvable (problems where solution mechanisms do exist) and discounting problems where no easy straightforward solution mechanism is in sight. Pollution problems within industrialized nations may belong to the first class, the erosion of tropical forests to the second class. The increasing population pressure requires the use of more and more firewood resulting necessarily in increasing desertification. Apparently, solution mechanisms developed for our problems do not apply in this case.

Pirogov asked for more information on the structure of the value model, and how parameters in the model are being estimated. Furthermore, he asked what happens if the inflation rate exceeds the social discount rate. Kile replied that his model, as compared to other models, is based much more strongly on the finitude of resources of our ecosystem than on economic artifacts like "inflation rates". The structure of the value model is going to be a number of parameters that are accessible directly to the intuition of the modeler; later on, some feedback shall be introduced which might also be referred to as "endogenously generated priorities", depending on levels reached.

With reference to the negative difference between discount rates, Bottomley underlined that many people will even accept a negative interest rate if it at least minimizes their losses over the period in which they wish to hold their savings.

To a question by Bruckmann, Kile responded that the model is essentially a dynamic difference equation model, similar to the systems dynamics approach by Forrester, but not using DYNAMO.

Roberts, excusing himself for this question, asked what confidence there is as to the degree to which the model actually resembles real world relationships. In reply, Kile stated that his confidence is higher for some parts and lower for other parts of the model: he has much confidence in the demographic model where his projections proved to correspond exactly with (later published) UN statistics.

Pestel stressed that, increasingly, value changes should be incorporated into models; even if such value changes are implicitly reflected in the past periods which form the data base, it cannot be claimed that they are sufficiently reflected in the future. In this respect, the presentation by Kile should be considered a challenge to all other modelers.

Part Four

OTHER MODELING WORK

Chapter 17

PROBLEMS IN MODELING MACROECONOMIC GROWTH RATES IN INFORMATION SYSTEMS FOR CENTRAL PLANNING IN POLAND

A. Dabkowski

The use of computer science in planning processes, particularly central planning, is one of the most interesting and most difficult fields of computerization of management. However, all experience in computer science in our country indicates that computer science yields the best economic effects in planning and management at the central level and in the management of big economic organizations. Management information systems, apart from object-oriented systems for enterprises and big complex associations, have been realized from that point of view for a few years. The systems are looked upon as tools supporting central level decision-making processes through their direct inclusion in the varying processes of control of functioning of the economy. The tasks of these systems may also depend on collecting and processing of mass data pertaining to socioeconomic processes in order to meet the needs of a big or selected number of users at the central and local administration level. At the primary stage of working out government computer systems of that kind, it was possible to elaborate overall concepts only in the form of a collection of internally consistent hypotheses. Because of the process of system designing and technology of implementation, government systems were divided into subsystems which improved the separate functions for a user of a complex government system.

The division into subsystems and further into blocks comprising specified computerized problems and technological groups of operations, calculations, and models, results from the concept of designing government computer systems in a kind of evolutionary sequence, in which designing and implementation of definite blocks and subsystems is realized in parallel with work on continually developing the whole system. This facilitated an internal compactness of government systems and verification through experiences in the general concept of each system. We ignore here those government systems whose purpose is to improve the functioning of collecting and processing of mass data, i.e. the systems concerned with the field of state statistics, financial recording, population census and scientific, technical, and organizational information. Instead it can be ascertained that the government system of central planning is helped to a large extent by the above-mentioned information systems and their mutual coherence is secured by ensuring:

- the structural coherence of data bases;
- the acceptance of files at the level of magnetic tape;
- the comparability of model estimation; and
- the uniform conceptual interpretation of applied socioeconomic categories.

We now pass to further consideration of the central planning computer system (CENPLAN). This system enables the central level authorities:

- to construct planning proposals independently, first in the sphere of macroproportions;
- to detect trends and deviations and make diagnoses of their reasons;
- to precisely determine the degree of future engagement of the economy and what has direct bearing on the definition of the sphere of unconstrained decisions on a given horizon of the plan;
- to make prognoses for a wide range of socioeconomic phenomena;
- to make analyses and estimations of planning projects of units at a lower level from the point of view of macroeconomic and social criteria; and
- to make regional and spatial analyses of environmental development within the function of the socioeconomic development of the country.

Consideration must be given to the additional systematization made according to the kind of questions and problems of central planning as well as to the divisibility of methods and models subject to the time-horizon of the plan for which they are applied. In particular, consideration must be given to whether they are used for the formation and choice of strategy or the layout of programs that realize selected strategies, or for current control of economic functioning. The following problem areas can then be distinguished:

- A comprehensive approach to macro-dependence at the scale of the national economy.

- A comprehensive approach to the entire means and activity conditions in the main spheres of the central plan.

- A problem oriented programming.

- A regional and spatial approach to the central plan, (including spatial multilevel plans of environment development).

- The branch and line problems of development and functioning.

- The forming of premises and grounds for current control.

From the point of view of computer system requirements, the system of central planning was considered as a set of interrelated spheres of the plan, differentiated with respect to information needs as well as models and procedures by the use of which specific problems of the planning process can be solved.

Thus the following spheres of the plan can be distinguished:

- Final, material elementary needs.

- Nonproductive services, social welfare and other common needs.

- Renewing of property resources and investment processes.

- Foreign trade and other aspects of the share in the international division of labor.

- Production, supply, and demand coherence and determining factors.

It results in a fairly comprehensive multilevel scheme of problem areas of central planning differentiated with respect to the time-horizon as well as branch and line regional and spatial structures in the framework of which complex goals and the activities of the main spheres of the central plan are exposed.

This set is then analyzed in the computer system by means of various methods, models, and procedures applicable to individual spheres of the plan, time-horizon, and data representation, and, to a certain extent, to formalization of individual analyses and calculations. Taking into account the availability of suitable analytical, balance, simulation, economic, prognostic, and optimizing models, the first phase of the work on CENPLAN determined which of the spheres of the central plan and problems of central planning should be accepted as the subject of data processing.

For these analyses and initial work, and for the realization and implementation of individual subsystems into the five-year and one-year plans, it was agreed initially that as part of the work on CENPLAN, the following subsystems will be realized:

- Economy-wide rates of growth (KORPLAN).
- The realization of the plan in the main fields and branches and in selected economic organizations.
- Renewing of resources and investment processes.
- Long-range planning (perspective planning), regional and spatial (macroregional and regional scale).
- Local planning (provinces, groups of regions, and special regions).

This allowed for the gradual introduction of modern planning techniques and for much earlier application of subsystems than was possible with simultaneous designing of all components of CENPLAN.

It was assumed that the main goal of the first of the above subsystems would be dynamic simulation of changes in macroeconomic rates of growth and initial concepts of socioeconomic plans of the country's development. The main problems being solved by the use of this subsystem are assessment of growth and structural macrorates, assessment of the degree of economic equilibrium, and the acquisition of economy-wide premises for estimation of the effectiveness of resource utilization.

This reasoning necessitates division of subsystems into blocks some of which can solve independently some classes of self-contained substantial problems; others can solve system problems of technological and computer techniques. The first group of blocks are called problem blocks and the second system blocks. In turn, these blocks are divided into sectors and procedure groups, which for organizational and technological reasons are divided into procedures, computer programs, subroutines, etc.

It was assumed that a subsystem aids the creation of concepts and variants of the plan projects including simulation of the course of different kinds of socioeconomic processes in a differentiated time-horizon. The problem and functioning division is then to be understood as an ability to estimate individual fragmentary indices and relations from the point of view of their influence on economy-wide proportions with the simultaneous possibility of making interperiod comparative analysis. This illustrates the degree of disturbances resulting from the influence of changes in fragmentary indices and relations on the achievement of required economy-wide rates. The problem block SIMULATOR with its classes of simulation models and a model of economy-wide growth rates consisting of sectors--general and structural proportions--are very important. The sector of general rates performs linkage functions in close connection with interbranch analysis of structural changes. Organizational and branch balances make a bridge between a structural branch section and the organizational section (departmental or regional).

The problem block BALANCES balances production on the scale of the one-year and five-year plan in structural and regional configurations (i.e. divided into ministries and associations, and regions and provinces). This block contains in addition to traditional balances of organizational and branch analyses, modified models of input-output analyses based on the Victor, Cumberland, and Daly-Isard model (analyses of multilevel environmental system and balancing of exploitation of areas), balances of market and investment equilibrium, and models that are a transition to the block IMPEXOR (connected with the balance of payments of the country and with detailed foreign turnover analysis with elements of effectiveness calculus in foreign trade).

BALANCES is connected with the block RELATOR containing analyses of living standards and providing the basis for balancing supply and demand and for modeling structural changes of consumption demand. The aim of the block is interactive simulation of integrated elements of the consumption model of the population.

A slightly different sector is the simulator of price changes which at the initial stage helps to simulate consequences of exogenously generated price fluctuation resulting from continual variation of prices for raw materials in the world markets. In a developed phase this sector enables the analysis and simulation of regulation processes of goods and money market relations through structural changes of market prices, linking different elements of analysis.

The KOORDYNATOR block contains a part of the classic coordinating growth rates and comparative accounts of planned rates of individual economic sectors (ministries and other economic units, and regional and spatial systems) with the structural division resulting from economy-wide growth rates.

System blocks represent independent technological modules linking all problem blocks in a uniform package of application programs used in interactive cooperation of a user and the computer. By the use of a BASIC LANGUAGE and DATA BASE, they enable a unique interpretation of all dimension definitions and procedures realized in the subsystem within individual models.

System blocks also include a sector called TABLE GENERATOR which facilitates interactive generation of planning tables together with the possibility of performing a number of statistical and logic-combinatorial analyses on the tables and their elements. Another block called ARCHIVES contains variants of the plan (and is a package preventing unauthorized access) and specialized conversational language for updating integrating procedures of individual models; the block PLAN INFORMER contains a current set of procedures for supplying active and passive information on the current version of the one-year, five-year, and long-range plans.

Other blocks introduce changes into the plan or initiate an interactive flow of processes.

As mentioned, the problem block SIMULATOR has a certain superior and linking function in the subsystem. This implies two features. The first allows for application of those forms of modeling which make possible active imitation of behavior, recreated by means of a model of real processes. The essential function in imitating reality is the ability to observe the behavior of the scheme as a consequence of socioeconomic decisions already taken, and possibilities of recreating the scheme itself by the use of a model of selected features and by means of successive experiments in the model.

In practice, out of all possible forms of simulation applied in the problem block SIMULATOR, the most essential ones proved to be those imitating real macroeconomic processes of growth rates and their changes as a function of directive socioeconomic decisions. On the other hand, the problem block SIMULATOR is understood to be a set of simulation models making as a whole a simulation tool of macroeconomic growth, to which simulation models for segmentary problems are subordinated and well-chosen econometric and prognostic models. These models are aided by a set of other problem blocks in such a way as to secure a thorough analysis of features of simulation models or to secure their mutual coherence and internal coordination.

The basic simulation model of economy-wide growth rates is based on an interactive simulation of the scheme facilitating examination and estimation of possible ways of reaching the fastest rate of meeting population needs, i.e. nationwide elementary and consumption goals. Account must be taken of specific requirements concerning mutual relations between different categories of needs.

The model helps to determine the main conditions necessary to realize the goal of meeting the population's needs to a maximum extent and to determine the degree of improvement of these conditions and what it depends on. The simulation model of economy-wide growth in its algorithm form makes a closed logical string of several hundred procedures grouped in two basic sectors, namely:

- a sector of general rates employing concepts and dimensions concerning the entire national economy, and

- a sector of structural rates including expanded calculations of structural correlation between different sectors of the national economy including among others regional and spatial analyses. (These analyses are connected with detailed models of estimation of localized capacity, models of spatial environmental systems, and problem models of energy utilization, environmental pollution, etc.)

In the sector of general proportions the simulation model answers two questions:

- Is the stipulated average rate of growth of wages and real income, and consequently the rate of individual consumption, possible to reach in view of other stipulated rates?

- What is the difference between supply and demand on production investments?

Indirect links of the model are procedures which on the basis of correlation of economic phenomena can calculate other economic effects and necessary expenditures of direct and materialized labor, such as: national income generated and to be distributed, elements of distributed national income, resources of productive fixed assets, employment divided into spheres, efficiency of labor, capital equipment per head, productivity of fixed assets, effectiveness of labor.

In the sector of structural growth rates the model performs a comparison of internally coherent general rates with the assumptions accepted for individual economic subjects (branches of the economy or economic organizations, and regions and provinces) in consideration of defined structural correlations between different sectors of the national economy.

The logic of the construction of the simulation model of economy-wide growth rates and linkage schemes of its particular procedures enabled, after writing programs for the model in three versions, its interactive exploitation according to a set of outlines and parameterized variants of exogenous planning information.

In practice, the versions of the model comprise both applied programming languages, i.e. DYNAMO, DYSPLAN, SIMULA, FORTRAN, ASSEMBLER, GPSS, as well as the ways of linking the model with system blocks, such as BASIC LANGUAGE/CATALOGUE OF ECONOMIC CATEGORIES and CATALOGUE OF PROCEDURES and blocks: ACCESSIBILITY FILTER and CONVERSATIONAL LANGUAGE for changing the outline and variants. Individual variants afford possibilities for not only simple interference with the simulation process, but when the calculated and assumed rate of efficiency growth are not being balanced, the model "presents" to the user rates of changes of parameters according to a given key of weights of importance and variable exogenous decisions.

Outputs of the model in the form of planning tables for five or ten years are the basis for further sectoral and problem analysis and help to prepare initial concepts of projects of plans and their comparison from the point of view of macro and economy-wide criteria.

A similar class of simulation models covers the problems of long-range planning in a general way and particularly the model of raw material management, development of individual motorization, rural and food economy, programs of regional and spatial development of the country, and shaping of the human environment. These models also have links and feedbacks with analyses carried out on the whole Central European scale including, among others, models of environment development in the regions of the Carpathian Mountains and the Baltic Sea up to 1990.

Most models of the problem block SIMULATOR are verified by the estimation of the degree of "sensitiveness" of the exogenous variables and by the correctness of model construction through a class of econometric models called KP-3, W-3, etc.

Links of simulation models with the block of medium- and long-term forecasts and verification of the essential construction of the model with theoretical models of "balanced growth" should be emphasized here.

Undoubtedly this class of models permits the variation and simulation of initial concepts of projects of the plan, and at the same time enables the analysis of effects and impacts of external decisions on long-term and prospective plans. It also helps to determine the direction of the economy in the future and by means of indirect blocks it allows the balancing of the national economy together with both an analysis of trends and deviations and the diagnosis of reasons.

The whole subsystem allows better recognition and analysis of the main problems of development strategy, current functioning of the economy and more flexible use of instruments for the socioeconomic policy both in the approach to complex macrorates and in the branch, regional, and spatial arrangement.

DISCUSSION

In reply to a question by Menshikov, Dabkowski explained that the term "foreign trade efficiency" is more oriented towards import efficiency.

Roberts asked whether an example could be given of a "surprising" result, i.e., a result that could not have been deduced by common sense. Dabkowski replied that the answer can be given indirectly: first, a normative picture of a set of goals to be achieved is being elaborated; second, the model is used to display the consequences to be expected for the five-year plan of the decision taken in earlier plans. As a result of this confrontation, he is being asked by the policy makers to elaborate more detailed analyses.

To a question by Pirogov, Dabkowski replied that his work is basically built upon the Polish econometric model called "KP 3"; in the nearer future, other models will also be used.

Asked by Gottwald about the choice of computer language, Dabkowski replied that, after having tried different available languages, it turned out that "WISCIN" (developed by the University of Wisconsin) proved best suited for their particular needs.

Chapter 18

SOFTWARE CONCEPTS FOR SECOND-GENERATION MODELING

Siegfried Dickhoven*

RECENT TRENDS IN MODELING

Regarding recent activities in the modeling scene, it may be stated that a "new generation of models" [1] is arising. Though this expression was originally used for models covering very long time horizons, I would like to apply it to a broader spectrum of new modeling activities. This new kind of modeling is going in two main directions. The first and more experimental direction can be described by the following characteristics:

The trend towards enormous dimensions: Growing size, of course, is one of the main characteristics in global modeling, combined with a tendency towards sectoral and regional modularization [2,11,28].

The use of more sophisticated methods: This is a tendency to be observed in the field of experimental modeling in pure scientific environments. The development of more sophisticated modeling tools is highly correlated (but time lagged) to this trend. Sometimes, however, sophistication in modeling seems to be a substitute for problem solving.

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The application of optimization techniques: There have been several experiments in applying optimization techniques for econometric and system dynamics models using OR techniques as well as principles of control theory [3,29,30].

The combining (linking) of different approaches (eclectic approach): Though the microanalytic modeling approach [4] has been combined with econometric modeling nearly from its beginning, the eclectic approach has become more important only in the last few years (for example, in Project Independence [5]). But there still exist severe methodological problems with this approach [6].

The second direction in second-generation modeling, often combined with experimental modeling activities, leads towards consolidation (to make modeling more a science and less an art) and can be highlighted by slogans like model evaluation, review, and comparison; user (decision maker) participation (education); and development of test (implementation) methodologies. Such consolidation-oriented activities, including systematic surveys on modeling and strategies for the management and standardization of models, have been discussed recently in a workshop held at the U.S. National Bureau of Standards [7].

If we compare these trends in modeling with the existing software tools [8], it becomes evident that many activities, and especially those that require the transfer of models (or modeling tools) cannot be performed without severe technical problems. To overcome these problems, the modeling tools have to be extended in the spectrum of different modeling tasks (from scenario generation through construction, estimation, systematic run specification, presenting and analyzing of results, and information management) as well as in the spectrum of different modeling approaches.

In regard to our running project "Model Base System" (MBS) [9], the development of such a multitask and multiapproach modeling tool for the government of the Federal Republic of Germany, we think that the three concepts of modularization, software interfaces, and wide-range processors are most important for an improvement of transfer and adaptability of models because they are suppositions for making models a transferable product. While modularization is understood here as a concept to characterize the transferable good (the models) and not a concept to develop the modeling tool, the other two concepts refer to output (or input) characteristics of the modeling tools and to their performance requirements.

The topic will be discussed separately, though there are many trade-offs between them. They are also discussed in relation to our current activity, the development of the Model Base System that is to be produced for two federal ministries, the needs of which regarding MBS are to some extent quite different (more consolidation oriented) from those of pure scientific environments.

MODULARIZATION

With the increasing scale and number of socioeconomic models, the application of modularization techniques becomes more and more apparent. This well-approved technique to manage large and complex systems is already used in the field of modeling, to some extent.

Well-known applications of this technique, like the Mesarovic/Pestel World Model (having regional and sectoral modules combined with a hierarchical layer-concept of interactions) [10], the Project LINK [11] or the INFORUM approach [12] (regional modules), or extreme applications like the Formula Bank Project [13] and the MEBA-Specification-Stock [14] (both holding single and "well-tested econometric specifications to set up models à la carte) use the modularization concept primarily in a substantive way. This, of course, is the right and probably the most important way to control model complexity by model builders as well as by model users. But without a formal and software-oriented concept of modularization, most of the technical transfer problems are not overcome unless the transfer takes place in the same software system, or at least in the same methodology.

With this substantive concept, for example, it will be quite convenient to combine complementary model parts or to compare similar model parts (modules), which are written in the same language (e.g., DYNAMO) and belong to the same methodology. But there will arise severe technical problems of respecification, translation, and manual data transfer if the modules to be combined or compared are of different types or languages, as they will be rather often in second-generation modeling (e.g., the intended dynamic linkage of the different models in project FUGI, mentioned in this conference [15]), whether experiment or consolidation oriented.

To avoid these unnecessary technical problems, it is often assumed to be obvious that one can create a new language or modeling system that combines the advantages of all (or some) different systems and methodologies and meets all their different needs. Though some modeling systems that we have analyzed actually started with this pretension (or presumption), this way either leads to a general-purpose language like FORTRAN or PL1 (and is completely useless) or it fails; and even software giants could not produce such a system in the modeling scene.

In order to find a better way to overcome these technical difficulties with second-generation modeling activities, we considered a concept that integrates some already-existing modeling languages of different methodology and that retains all capabilities and conventions of approved modeling systems, including reporting and running specification, if it is needed by its users. Only new capabilities like linking and scenario generation are very homogeneous, and facilities to be extended, like reporting, documenting, and analyzing, get a new and largely uniform kind of use. The realization of that concept in our Model Base System is roughly as follows [16]:

The basic elements (elementary modules) of socioeconomic models, so-called "partial simulation operators," which generally are time dependent, are a special form of a general operator that transforms a set of input quantities according to its transformation prescriptions into a set of output quantities for one and only one (time) step. This reduces the building process of models to the construction of the model "core" (or the model structure). General tasks like data transfer and run- and time-loop-control are performed by a central simulation processor.

These elementary modules are generated by special precompilers of MBS from the runtime packages of socioeconomic models produced in modeling systems like DYNAMO III-F [17], the econometric systems IAS [18] (developed by the Institute for Advanced Studies, Vienna, and also used for project LINK at Bonn University) and MEBA [19] (used in the Federal Ministry for the Economy (Bundesministerium fuer Wirtschaft) of the FRG), a microanalytic system like MASS, and the general purpose language FORTRAN IV. FORTRAN-modules, however, have to be prepared according to some formal prescriptions before their adaptation by the MBS system [15]. In this adaptation process, a user information block is also generated which is called *Kommunikationsteil* and contains

A name and brief description of the module
A list of control variables
A description of the module's data interface for the meta-construction (e.g., linking) level

The *Kommunikationsteil* of each module is produced under the control of the MBS user, who defines, among other things, the list and (new) names of variables for the meta-construction level.

On this meta-construction level, the modules can be linked together, with special reporting (or analyzing) modules or with data elements of a data base. Special model runs, including conditions and systematic search, may also be specified on this level. (This second level is quite appropriate for second-generation modeling activities.)

This formal concept of modularization preserves the approved construction environment of experienced model builders and provides capabilities for the computer-aided transfer of models (and models of different approaches). By providing a largely uniform manner of meta-construction and run specification (especially for "productive runs"), we hope that MBS will contribute at least a little to better user participation and to more know-how transfer between model-builder groups.

Software Interfaces

To improve the transfer of models, the modularization concept, leading to more formal uniformity of model builders' products, is the obvious and direct way. There is another way to promote model (know-how) transfer: a better transfer of modeling tools. Looking at the vast variety of modeling software systems (and probably we only know about the tip of the iceberg) the impression arises that much effort is wasted in a manifold re-inventing of wheels. This phenomenon is quite common in almost every new and rapidly growing area of data processing (see for example the rather short history of data base systems); but the conditions are ripening for a consolidation in the development of modeling tools, too.

The software interfaces concept, of course, cannot be the concept for consolidation in this area, but it is a possible first step towards consolidation. The linking of different modeling tools, especially of central tools (construction systems) with peripheral instruments like data base systems, report generators, or analysis packages, within one computer (or operating system) environment does not create severe problems for a computer scientist. For a model builder, however, it is really a great problem and therefore very seldom applied. Through the development of interface (bridge) programs, the situation would become much better.

Two kinds of such interfaces are possible, and each is related to a kind of linking:

Direct interfaces between modeling instruments: This kind of linking is more important for combinations of central (construction) systems with peripheral tools, like report generators, because most central modeling systems are rather poor in these peripheral (post-processing) tasks. This direct interfacing has been done, for example, by the Urban Institute in Washington, D.C., which has linked its microanalytic modeling system MASH for analysis purposes with the time series package TSP of the Brookings Institution and with the report generator TPL of the U.S. Department of Labor to produce tables ready for printing [20]. This Table Producing Language again is based on an already-existing data base system and linked with the statistical package SOUPAC from the University of Illinois [21].

Interfaces in a general-purpose, high-level (HL) language: Though direct interfaces are also possible between central modeling tools, they are not recommendable for these purposes. While interfaces between central and peripheral systems only have to provide (numerical) data transfer between different instruments, an interface between central systems generally has to transfer programs. This makes it much more complicated and too expensive for only one connection. The detour into high-level languages like FORTRAN has the advantage here that the produced outputs can also be used by those people who work with this high-level language as their modeling tool. This kind of interface can be developed either as an Input Interface (able to adopt programs of that HL language) or as an Output Interface (producing HL language programs), or as both. Applications of this interface type exist for example for the DYNAMO-F language (type: Input-Interface) and for the Viennese econometric system IAS (type: Output-Interface), both having FORTRAN interfaces.

We think that efforts in this direction will also increase the model builder's impetus towards standardizing in this field, because the use of linked modeling tools will lead to many more technical transfer problems, which may be overcome by the setting of interface standards.

WIDE-RANGE PROCESSORS

Wide-range processors are understood here as modeling instruments that support the set-up and processing of models constructed with different methodological approaches; for example, system dynamics *and* econometric models or microanalytic *and* econometric models. The linking of one central with one or several peripheral modeling tools is *not* such an instrument, though it broadens the spectrum of working with models (but only with models of *one* approach). This rather new type of modeling software will become quite important for almost all second-generation activities.

Besides some microanalytic systems like MASH [20] and MOVE [22] that have been combined with econometric modeling almost from their beginning, there exist only a few rudimentary systems like SIMA [23] or RSYST [24]. While SIMA is one of the systems that has created an overall concept for econometric and system dynamics models, the RSYST System is composed of different but newly developed subsystems for each approach. The Model Base System is similar to RSYST, but it provides more and already existing subsystems for the different approaches. It also has a two-level concept that makes clear the differences between elementary construction (first-generation activities) and metaconstruction (second-generation activities). Such multilevel processors for modeling activities, including additional levels for the writing of methods by its users, will become the modeling tool of the future, as is indicated by experimental systems like the Consistent System [25] or the KARAMBA Concept [26].

As second-generation modeling often deals with models developed by others, and as wide-range processors are the specific tools for this kind of modeling activity, they will enforce the transfer of models and accelerate the process of consolidation and experimentation in modeling. They will also contribute to standardization in modeling and to a harmonizing of software development for modeling purposes because they will meet more technical difficulties with the adaptation of models and because they are rather expensive. While the technical problems will reinforce the users' wish for standardization, the high barrier of development costs will automatically lead to concentration in the development of such modeling tools.

CONCLUSION

The three software concepts mentioned here involve a collection of other but more special software requirements, like information management, design of user interface or programming and documentation standards, which will also contribute to an improvement of model transfer and adaptability, but which I have not discussed here. I will only mention the use of graphics for the recognition of the underlying model structure as well as for the presentation of results [27] and the application of structured programming that would make, for example, FORTRAN-modules easier to read for non-FORTRAN-programmers.

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DISCUSSION

Bottomley came back to an earlier suggestion of his concerning closer cooperation between modeling units. In particular, his input/output work could be useful for many other modeling efforts. He recognized that this requires a lot of preparatory time, of negotiation, of cooperation at great distances. Could Dickhoven's institute, maybe, assume the role of a clearing house for all the data and efforts available worldwide? Dickhoven replied that, in principle, he could imagine the assumption of such a clearing house function within a well-planned division of labor; he has already assumed such a function within the Federal Republic of Germany, rendering services to groups working on modeling software. He also has already established contacts at the National Bureau of Standards of the United States. If a similar task were set up in the United States and linked with his group, a sufficiently broad basis for fruitful cooperation might be created.

Straszak stressed that models are so different as to make documentation and standardization of models practically impossible; even within the United States it would be extremely difficult to comment on and describe the hundreds of existing models in a comparable way; poor documentation is not the only reason for this.

Richardson took a less negative attitude. So far, maybe 95% of modeling efforts have been directed to development and 5% to dissemination, whereas the correct percentages should be around 80% and 20%. If a coordinating effort were started, maybe 15% should be devoted to the development of software and about 85% to integrative activities of the kind envisaged by Bottomley. Turning to Dickhoven, he asked what had been the respective percentages in his work? Dickhoven replied that maybe 20 to 30% were devoted to integration and the rest to development. As soon as the software frame has been established one could change to 80% and 15% maintenance - only referring to the FRG situation. His present forces, however, are too limited to carry out this job for the entire world; he can only strive for a link with similar deliberations in other countries in the field of documentation of modeling. Documentation may be very expensive but will certainly be worth its money.

Bottomley expressed doubt whether such cooperation is likely to be implemented, as nobody seems to be capable of taking the lead and bearing the cost involved. Dickhoven was more confident; an implementation within the Federal Republic of Germany might have some impact on international cooperation.

Chapter 19
GENERAL EVALUATION

Bruckmann, from the chair, recalled that, during earlier phases of the conference, it had been decided to set certain topics aside for the general evaluation. These are, in particular, the notion of "fuzziness", the role of uncertainty, and Olaf Helmer's remark that elements of stochasticity should be introduced into global modeling. To lay a basis for the discussion, Bruckmann proceeded to give an introductory statement:

If, in a model based on different equations one applies a standard deviation of 5% to each of the variables, it can be easily shown that, after 15 time periods, the outcome becomes entirely meaningless. This does not prove, however, that running a model beyond 15 time periods makes no sense; what is necessary is to distinguish between prediction and explanation: it is certainly not possible to "predict" a certain future after 15 time periods, and this should also not be considered the job of a global model. If, however, the goal of global modeling is to shed some light into existing interrelationships, this explanatory task would be obscured by the introduction of stochastic elements. The same holds for an investigation of the likely outcomes of different policy options: again, a comparison of their consequences would be obscured by introducing too strong a stochastic element into the model. There is little use in pointing out that the introduction of stochastic elements corresponds more closely to reality than does their omission.

Kile stressed the importance of distinguishing between the introduction of some arbitrary random element and the deliberate variation of certain variables to test how sensitively the model will react upon variations of this particular variable. Richardson considered it worth making a distinction between the introduction of stochastic elements on parameters of a model which define what we intend and parameters of a model which define what we hope we know but may not be certain about. In earlier models, there has been much discussion about the need for sensitivity analysis; the use of stochastic processes to do sensitivity analysis is highly desirable for certain parameters, but it would be less appropriate to apply it to policy variables.

Chant defended the usefulness of quantifying uncertainties, in particular if a model should be applied by a policy maker it is important for him to know what the range of uncertainties is, as a consequence of certain policy decisions.

Rademaker added that, even in policy analysis, the situation is different whether the outcome of certain "yes/no-decisions" shall be tested, or if one wishes to investigate the achievement of certain goals by means of a feedback structure, where the feedback structure may be stronger than the variation of certain policy variables. The outcome of a model often depends more strongly upon the underlying relations than on a variation of the initial values. Furthermore, sensitivity analysis is of particular value when the question of crossing certain threshold values arises.

Bremer argued strongly in favour of an introduction of uncertainty into models. First, the data upon which the models are built are subject to a great deal of uncertainty. Second, not introducing uncertainty into parameters tacitly assumes them all to be equally certain. Third, the introduction of uncertainty is also important for an analysis of the outcome of different policy options; the decision maker should be given the probable outcome of each option plus some probability distribution around it. If these distributions do not overlap one may be quite certain that the policy results will be robust; if, however, they overlap a great deal we should be honest enough to tell the policy maker that it does not seem to make too much difference which policy is chosen. Fourth, although the introduction of uncertainty will create problems in the short run, in the long run it will help us to understand better which areas we need to know more about, where uncertainties can be more easily tolerated than elsewhere.

Chant pointed out that, even if the outcomes of various policy options do overlap, there is still information to be obtained as to why one policy should be preferred over another.

Hartog pointed out that the decision maker might have a certain attitude towards risks; this is another aspect of why it is important to incorporate uncertainties into a model.

Kile underlined the importance of introducing a stochastic element into agricultural models where the annual crop depends largely on conditions which can be considered stochastic. Bruckmann recalled that, during the discussion of the MOIRA model, he had suggested introducing some "standard disturbance", e.g., a major crop failure in two consecutive years, in order to study the impact such a "standard disturbance" might have on the other variables of the model.

Chapter 20

ON THE METHODOLOGY OF GLOBAL MODELING

Onno Rademaker

INTRODUCTION

From a methodological point of view, a number of immature aspects of global modeling are beginning to become clear. If global modeling aspires to become a grown-up discipline, in the usual scientific sense, then it must do something about them. The four points to be discussed below are not restricted to *global* modeling, for they apply to modeling projects for social systems as well. The first two concern the underdeveloped state of two *reverse activities* that ought to receive ample attention in any model-based analysis: model analysis and dequantification. The others concern the interface between modelers and their clients, and the use of several models instead of just one.

MODEL ANALYSIS

In a stylized way, such a systems analysis may be depicted as in Figure 1. In short, a problem is defined, a model is formulated and then simulated, and conclusions are drawn, after which the team either hurries to develop yet another "better" model or to tackle another problem.

Modelers tend to be proud of the "complexity" of their models. Many do not seem to realize that - in most cases - the more equations, variables, and coefficients a model contains, the more "dead matter" must be included: variables that might be replaced by constants, thus making a number of equations, coefficients, and so on superfluous. Worse still, most modelers seem to have no idea *which* of their many model parts are of dominant importance, and which play only a secondary or even less important part. This is a serious scientific inadequacy in a variety of ways, and will be so obvious once one comes to think of it that we need not dwell

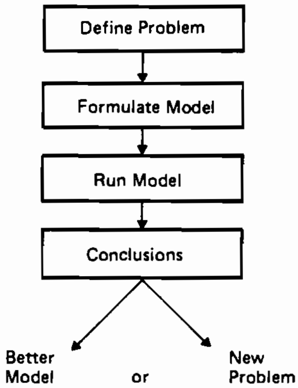

Figure 1. Schematic diagram of a systems analysis.

on it extensively. He who has no clear idea which of the many coefficients, terms, and equations do the real work in a model will miss a lot of opportunities. For example, he is not able to focus his attention and efforts on the equations that really matter, and, consequently, has to dissipate attention and energy evenly over all parts of the model, irrespective of their importance.

The point I want to make in this section is that a kind of *reverse activity, model analysis*, has to be inserted between the activities "run model" and "conclusions" in the first figure. This means using the results of simulations and so forth to *analyze how the model works internally and why it behaves the way it does.* The rewards are *understanding* and *insight*: you learn how your equations really work, what the effects of your assumptions are; you learn that parts that have cost you much mental energy and are still bothering your conscience are not really important, whereas other interrelations turn out to be unexpectedly predominant - and in need of closer attention. In short, you learn to distinguish between interrelations that are of prime importance and others - and that is the beginning of understanding and insight.

The most difficult intellectual process involved here, because it amounts to a mental quantum jump, is the recognition that model analysis - in order to gain understanding and insight into the model - is of crucial importance; once this is recognized, any intelligent mind can easily think of ways to gain such understanding and insight. Perhaps it is useful to add one observation in connection with this. Many people with an academic background tend to regard *general* methods as superior to methods exploiting the special features of the problem under consideration. This may be one of the reasons why universities are sometimes accused of turing out "learned fools" instead of clever people. In any case, I think it is fundamentally wrong to look down upon methods exploiting the special problem features in a clever way, particularly when dealing with complicated models.

In my experience, model analysis, i.e., finding out how a model really works, what the effects of various assumptions and simplifications are, and so on, brings with it a variety of benefits; for example:

Understanding of and insight into the inner working of the model; from this follows the other benefits

A simpler model, because superfluous details can be eliminated

A better model, because the attention is drawn towards the most important parts

A better policy analysis, because if you understand *why* a model behaves in a way you do not like, you can pinpoint the most effective and desirable changes to improve its behavior (for example: the policy recommendations by the Meadows team are unnecessarily far-reaching; see publications by W.A.H. Thissen in the July 1976 issue and in forthcoming issue(s) of *IEEE Transactions on Systems, Man and Cybernetics*)

A better, easier-to-grasp, and more convincing explanation of the model, the simulation results, the insight gained, and the resulting policy recommendations, and hence better communication and a better chance for a successful modeling effort

DEQUANTIFICATION

While the preceding "reverse activity" was one of *analysis*, dequantification is one of *synthesis*. The mental processes of problem definition and model formulation are *quantification* processes. What cannot be quantified has to be left out (what can only be poorly quantified may sometimes be retained in the form of one or more constraints or other side conditions). But we know all too well the importance of imponderables. Hence, what was left out in the initial problem and system analysis phase *must* be reincluded in the synthesis phase when conclusions are formulated; that is, in the synthesis phase a *dequantification* process must take place. The errors introduced during the initial quantification and analysis phase must be compensated for as well as possible during the final synthesis of the conclusions in which imponderables have to be pondered again.

Again, the explicit recognition that this reverse activity is of vital importance is the principal step, amounting to a mental quantum jump. Once this jump has been made, ideas about how to do it come relatively easily.

At this point, it is useful to call attention to the fact that both reverse activities have a strong mental component. Hence the picture given earlier can be improved, as shown in Figure 2.

This leads us to look at modeling efforts from another angle. A lot of intuition, judgment, and plain guesses go into models.

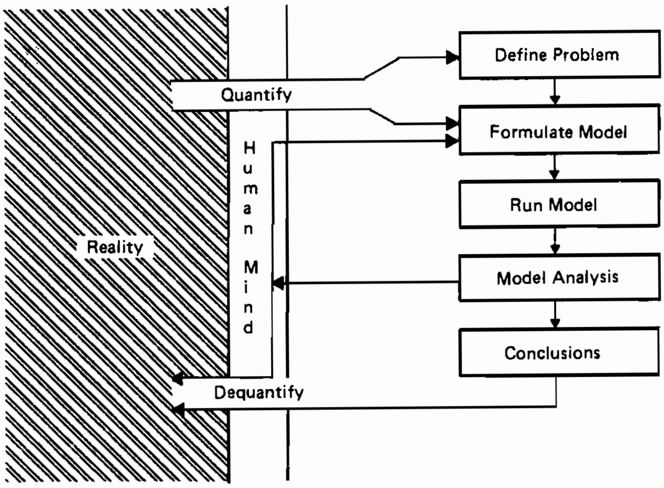

Figure 2. Improved diagram of a systems analysis.

There is, in principle, nothing against that,

Provided it is unavoidable
Provided one does not cover up the fact that it is done
Provided all possible measures are taken to reduce the probability of undesirable consequences

This, again, emphasizes that it is not only undesirable but even dangerous to use models as machines that are cranked and spew out masses of numbers and graphs, and that both *model analysis* and *dequantification* are indispensible as means for reducing the hazards of modeling social systems in the face of uncertainty.

PRESENTATION OF MODELING EFFORTS

This is a weak point of our profession. Apparently, we find it very difficult to provide others with a clear *picture* of what we are thinking about. This symposium provided clear examples of groups having done admirable jobs, yet being unable to communicate the quintessence of their models in a clear and condensed form, without unnecessary complications, in the time available. The word *picture* is used on purpose here: what has to be communicated is not a sequence of words and sentences, or computer instructions, but a *Gestalt* (a whole), like a picture.

It would be much better to use diagrams and tables, and by distinguishing between the principal interactions and the vast number of less important mechanisms. For example, it has been made clear that I/O-tables contain a lot of zeros. Presumably, they also contain numerous coefficients that, in model analysis, will prove to be of minor significance. This means that relatively few coefficients do most of the work, that any I/O-table has a certain structure that probably can be understood to a large extent in physical terms. Yet, we have been told very little about this and, hence, an I/O-table remains a black-box machine that is cranked and spews out numbers.

More examples might be given, but the general point will be clear enough, namely, that better presentation is needed, not only of models, but also of results and insight gained, and of policy recommendations, and above all, more clear *explanations* have to be included in the presentations.

The main reason for emphasizing this so strongly is that effective *embedding* of model-based systems analysis in the decision-making process is necessary, otherwise the work is bound to be useless. Modeling is the easiest part of the job. Detecting the right questions and delivering the desired answers in the right language at the right moment is far more difficult.

If the modeling is not integrated into the blood vessels and the nerve system of the client organization, if it is not actually taking part in the central processes, then it is liable to remain a mere pastime. The integration of modeling activities into the decision-making process is at the same time the most important and the most difficult problem.

GENERAL STRATEGY OF PROBLEM SOLVING

In my opinion, there is a tendency to raise certain wrong questions time and again, such as: How can we model a system as completely as possible? How large should a model be? How can we make a model as endogenous as possible? Such questions are wrong, or at least misleading, because a model is nothing but a tool for helping us think; models are only stepping stones for our minds, and unwieldy ones at that.

A more sensible question is, *What is the best way to divide the tasks that have to be done between human experts and computers?* An answer might be as follows: let routine slave work, which can be specified with confidence, be done by the computer, and let experts deal with the difficult parts of the real system, the tricky questions and ill-defined problems, and make them handle all key data themselves so as to be conscious of what is going on. When one follows this line of thought, one arrives at partial models, as in the Brandeis/U.N. approach, not primarily to model the world but to unburden the minds of the experts as much as possible.

The logical next step is *a variety of separate models*, each helping a team of experts to think better about a certain area of concern. From a model-oriented point of view, one might say that the expert team serves to interconnect the separate models, but it may make more sense to look at this set-up from a problem-oriented point of view, and regard it as a team of experts, each backed up by one or more models. I think that this is the best way of promoting fruitful cooperation among experts from different disciplines. Also, it may be the best way to ensure that the actual integration of the various contributions is done by the team, and not by one or a few team members, as seems to happen so often in monolithic modeling.

Consider, by way of illustration, how a new process is developed in an industry. A chemist will work out the kinetics of certain reactions in his laboratory using his kind of model. Then he hands over his results to a chemical engineer, who designs a reactor process using another kind of model. He provides his colleague, a mechanical design engineer, with the data needed for the design of the reactor vessel and auxiliary components using several other kinds of models. Subsequently, an economist or operations research man takes a look at the resulting design and concludes, on the basis of his own model, that the plant would become far too expensive. Then the four experts sit together and work out a better design, each using his own model(s) when necessary. Note that the critical issues and subjects of potential conflict remain explicit and within the field of view of the experts. The strategy described above works quite well in the chemical industry; as a matter of fact, it would be considered unwise to attempt to force all the different models into one monolithic supermodel.

I understand that a similar approach is used in the planning of the Novosibirsk region, where different experts have developed separate models for different subregions and for different sectors in the region. It is well known that many of the major difficulties arise at the interfaces between subregions and sectors and, unless superior algorithms are available, it is better to let experts face the problems jointly than to hide the difficulties and their "solution" in a computer.

If one looks at model-based systems analysis starting from the question, what is the best way to divide the tasks between a variety of experts and computer models?, it is simply amazing that everybody still seems to think almost exclusively in terms of monolithic models.

Such models certainly do not provide the best possibilities to get the best contributions from demographers, sociologists, political scientists, educators, health care specialists, and so on and so forth. So let us stop forcing everything into one model.

DISCUSSION

Richardson, following up Prof. Rademaker's remarks, suggested that, before we begin to explore the need to understand social institutions we should devote some thought to the institutional structure within which models themselves are presented.

Menshikov, speaking on behalf of all participants, expressed warm words of gratitude for the secretarial assistance that had contributed so greatly to making this conference a success.

Summarizing, Bruckmann thanked all participants for their active contributions and announced that a sixth global modeling conference will be held in a year's time. This sixth conference will be different in format and scope; it is intended to be a cross-cutting assessment of the state of the art, oriented toward laying a common basis for future-oriented global modeling work.

APPENDIXES

Appendix 1

Agenda

Monday, 26 September 1977

08.30-09.30	Registration at Hotel Gutenbrunn	
09.30-09.45	Welcome	Levien
09.45-10.00	Introduction to the Conference	Bruckmann

Chairman: Bruckmann

10.30-12.00	THE FUTURE OF THE WORLD ECONOMY An Introduction to the Structure and Application of the United Nations World Model	Petri

Chairman: Parikh

14.00-15.00	Using the Global Input-Output Model for Long-Term Projections	Menshikov
15.30-16.15	Modification of the World Economy Model: Optimization and Equilibrium	Granberg
16.15-17.45	The INFORUM International System of Input-Output Models and Bilateral Trade Flows	Almon

Tuesday, 27 September 1977

Chairman: Helmer

09.00-09.30	FUGI - FUTURE OF GLOBAL INTERDEPENDENCE Introduction to Project FUGI	Kaya
09.30-12.30	Global Macro-Economic Model	Onishi

Chairman: Keyzer

14.30-16.00	Global Input-Output Model	Kaya Ishitani
16.30-18.00	Global Metallic Resources Model	Suzuki
18.00-18.10	Global Models are Changing	Masini

Wednesday, 28 September 1977

Chairman: Bruckmann

	OTHER INPUT-OUTPUT MODELS	
09.00-10.00	Input-Output Modelling in the USSR	Klokov, Pirogov, Tsygichko
10.00-10.30	The Satisfaction of Basic Needs Index (SBNI), a Progress Report	Richardson
11.00-12.30	A Fifty-One Sector World Input-Output Model	Bottomley & Group
12.30-13.00	Adaptive Mechanisms in Global Models	Roberts

Chairman: Pestel

15.00-16.00	The Use of Input-Output Techniques in an Energy-Oriented Model	Fritsch & Group
16.30-18.00	A Value-Driven, Regionalized World Model	Kile

Thursday, 29 September 1977

Chairman: Straszak

	OTHER MODELING WORK	
09.00-09.30	Problems in Modeling Macroeconomic Growth Rates in Information Systems for Central Planning in Poland	Dabkowski
09.30-10.00	Software Concepts for 2nd Generation Modeling	Dickhoven
10.00-10.30	Problems of Fuzzy Modelling--Control and Forecasting of Time Series and Some Aspects of Systems Evolution	Peschel
11.00-12.00	The Process Dictionary--An Application of a Systems Approach to Production Function Theory	Page

Chairman: Bruckmann

14.30-15.00	The Impact of Tariff Policies on World Trade Welfare: Some Results from a General Equilibrium Model of the World Economy	Waelbroeck
15.00-16.00	Sectoral Production Functions and Structural Forecasts	Millendorfer

16.30-17.00	The Simulation of Social Actors: Information Processing, Orientation, Deduction Processes, and Goal Change	Gruber
17.00-17.30	On the Methodology of Global Modelling	Rademaker
17.30-18.00	General Evaluation	

Appendix 2

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INPUT—OUTPUT APPROACHES IN GLOBAL MODELING
Proceedings of the Fifth IIASA Symposium on Global Modeling,
September 26—29, 1977
Gerhart Bruckmann, Editor

Since 1974, the International Institute for Applied Systems Analysis has been monitoring developments in the field of global modeling. The IIASA conferences on global modeling are intended to serve as a forum for exchanging information among modeling groups. Five conferences have been held; the first four focused on one or two major global models approaching completion: the Pestel—Mesarovic Model, the Bariloche Model, the MOIRA Model, and the SARUM and MRI Models. The fifth conference deviated from the scheme because it focused on a methodology; the models discussed were all constructed with input—output techniques.

The main part of the conference was devoted to the Leontief Model, "The Future of the World Economy," and FUGI, Future of Global Interdependence, a model developed by a group of Japanese scientists. FUGI includes a global input—output model, a global macroeconomic model, and a global metallic resources model, and is published here in full for the first time in English. Reports on other input—output models include a survey of work in the USSR, as well as examples of work in progress in the FRG, the United Kingdom, Poland, and the United States.

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