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THE SRI-WEFA SOVIET ECONOMETRIC MODEL: PHASE THREE DOCUMENTATION – VOLUME I

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This technical note presents the documentation of the third phase of research in the development of a medium-scale macroeconometric model of the Soviet economy incorporating an input-output component. The accomplishments of the first two phases of research are summarized and the results of the application of SOVMOD II during Phase III to questions of interest to both Soviet specialists and policy planners are presented. The report then details the added capabilities and refinements introduced in developing the SOVMOD III version of the SRI-WEFA Econometric Model, with particular attention devoted

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FOREWORD

The publication of this technical note represents the completion of the third and final phase of development work in the construction of an econometric model of the Soviet Union by the Strategic Studies Center of SRI and the Wharton Econometric Forecasting Associates. This unique undertaking by a team of specialists on the Soviet economy and experienced econometricians is the central component of the SSC's Soviet and Comparative Economics Program. This program is under the direction of Dr. Herbert S. Levine, Professor of Economics at the University of Pennsylvania and Senior Research Consultant at the SSC, and M. Mark Earle, Jr., Assistant Director of the SSC and Co-Director of SRI's Center for Economic Policy Research. Dr. Francis W. Rushing, Senior Economist at the SSC, is the Program Manager.

The authors wish to acknowledge the valuable aid of those who appear as contributors on the title page of this technical note. Appreciation is also expressed for the painstaking efforts of Irene Lesniewski and Jane Misheloff in the preparation of the documentation.

Richard B. Foster
Director
Strategic Studies Center

CONTENTS

V FUTURE DIRECTIONS (Continued)

LIST OF TABLES

LIST OF FIGURES

I THE SRI-WEFA ECONOMETRIC MODEL OF THE SOVIET UNION: AN INTRODUCTION

The SRI-WEFA Econometric Model of the Soviet Union, developed over a three-year period beginning in the fall of 1973, represents a significant development in both econometric modeling and Western analysis of the Soviet economy.[1] Model-building techniques, which had been developed for Western market economies, were for the first time applied in a systematic econometric analysis of a centrally planned economy. The application of these techniques was not mechanistic, but rather was based upon thorough analysis of Soviet economy data and economic institutions. Many of the components of the model constitute original research in applied econometrics on planned economies: labor participation and distribution, investment determination, capital formation, agricultural production, wage determination, consumption and foreign trade. The complete model has been used in important application studies, covering such topics as the 1975 grain harvest failure, technology transfer, the Tenth Five Year Plan, and longrun growth potential through the 1980s. In this introduction, the major accomplishments in the development of the Model will be reviewed and the tasks of consolidation which remain will be outlined.

A. Past Accomplishments Embodied in SOVMOD III

In Phase One of the project, a compact model (SOVMOD I) was developed through a symbiosis of econometric modeling experience and an understanding of the Soviet economic system and Soviet economic data. By restricting the degree of disaggregation, the project was able to focus its resources on the development of consistent specification and structure. A description of this process of specification search and system design,

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[1] Annual reports on the project were submitted; see Green and Higgins, "The SRI-WEFA Soviet Econometric Model: Phase One Documentation," SSC-TN-2970-1, SRI/Strategic Studies Center (March 1975), and Green, Klein and Levine, "The SRI-WEFA Soviet Econometric Model: Phase Two Documentation," SSC-TN-2970-3, SRI/Strategic Studies Center (October 1975).

together with a broader examination of the methodological issues involved in this new approach to comparative economic systems, is now available in a book written by the principal architects of the Model during Phase One of the project.[1]

1. Scope of the SRI-WEFA Model

With the development of SOVMOD III, an appropriate level of disaggregation for a Soviet macromodel appears to have been achieved. In the determination of GNP from the production side, there are presently six sectors of origin with industry disaggregation into twelve branches:

- Aggregate Industry
  - Electroenergy
  - Coal Products
  - Petroleum Products
  - Ferrous Metallurgy
  - Nonferrous Metallurgy
  - Chemicals and Petrochemicals
  - Machine-Building and Metalworking
  - Forest Products
  - Paper and Pulp
  - Construction Materials
  - Soft Goods
  - Processed Foods
- Construction
- Transport and Communciations
- Domestic Trade
- Government and Services
- Agriculture

Within agriculture, there is a further specification of grain production, total crops, animal products and meat.

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[1] Donald W. Green and Christopher I. Higgins, A Macroeconometric Model of the Soviet Union (New York: Crane-Russak, forthcoming 1976).

Disaggregation on the income and end-use sides of the national accounts also appears to have reached an appropriate level. Nominal annual wages are determined for seven sectors of employment (with a separation between state and collective farms). Total household income includes money wage income, agricultural income-in-kind, and State transfer payments; nonhousehold income is divided into gross profits and amortization in State and collective organizations, and into four revenue categories in the State budget. There are two wholesale industrial prices, two retail prices for the State sector, and a "negotiated" agricultural price which enter in the determination of the consumption price deflator. In the consumption component of the model there are four categories: food, soft goods, durables, and services. Beyond the categories of new capital investment corresponding to sectors of production, there is a category of capital repair and two categories of inventories (domestic trade and nonagricultural). On the expenditure side of the State budget, the model includes categories for financing the national economy, social-cultural expenditures, administration, defense, and a residual category.

In order to focus on model development, the defense sector of the SRI-WEFA Model was at first given limited attention. A simple specification using the official defense budget and a separation of that total figure into personnel and nonpersonnel categories allowed us to avoid the extensive controversy in the West on the appropriate measure of Soviet defense expenditures and concentrate on the development of the macromodel. During Phase Three, we have introduced a generalized specification of the defense sector which has been partially implemented through the addition of a category for State Reserves.[1]

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[1] Donald W. Green, "The Defense Sector in a Soviet Macromodel: A New Specification for the SRI-WEFA Model," Project Working Paper #43, revised version (July 1976).

The final area of disaggregation concerns foreign trade. Four geographical areas are distinguished: CMEA, Developed West, Other Socialist Economies, and Less Developed Countries. Soviet trade with the CMEA and the Developed West is broadly disaggregated by the commodity (raw materials, machinery, food, grain, and other consumer goods). Hard currency liquidity is determined in the model by a consideration of the current account in hard currency, credit repayments and interest, services and transfers, credit drawings and gold transactions.

2. Bureaucratic Response and Administrative Intervention

For the application of econometric methods at the macroeconomic level, it is important that the data one observes are generated by a stable underlying process which is not dominated by nonrandom disturbance or stochastic elements. For models of Western market economies, this assumption of structural invariance is usually based upon technical relationships or the aggregation over rational economic agents operating in competitive markets. A major concern in the development of the Soviet model has been the identification of a third source of structural stability, arising from Soviet administrative regularity in response patterns over a 1-2 year period.

In order to incorporate administrative regularity in our specification of a macromodel, we have identified a small number of signals which quantify the state of the macroeconomy in a given year. These signals convey what we have defined as system contingencies, the departure of important variables from "planned" or anticipated levels. Whereas in market economies information about the state of the economy is typically distributed to independent agents through prices, in a centrally planned economy such as the USSR most information is conveyed administratively through quantity signals or rates of growth. Consequently, we defined most of these contingencies by rates of growth or other dimensionless measures and these terms appear in many equations. The most important contingencies in our macromodel are:

- the proportional deviation of the harvest from potential production, almost entirely a consequence of the weather;
- the rate of growth of real nonpersonnel defense expenditures, determined by an exogenous budget allocation of defense;
- the rate of growth of real gross profits in the national economy, influenced in part by current and past harvest but also by changes in consumer goods inventories;
- the realized rate of growth of nonagricultural capital investment, dependent on the Annual Plan and the first and third contingencies above; and
- hard currency liquidity, defined in terms of hard currency reserves, gold reserves and external debt.

We conceive of the Soviet economic administration responding to such contingencies through either central command or decentralized action by officials sensitive to the preferences of the leadership. System contingencies may in reality be defined differently within the actual Soviet bureaucracy, and they may be defined in terms of variables that are not observable from the outside. We have, however, defined signals which are available from published official sources or Western estimates. If they are adequate proxies for the actual signals, the test of regularity in administrative response is the statistical significance of the reaction coefficient within a fully specified equation.

This conception of bureaucratic response is one of shortrun accommodation to system contingencies and is not meant to explain the longterm structural shifts observed in the past or anticipated in the future. In this sense, the SRI-WEFA Model is rather similar to quarterly forecasting models in the West where inertial guidance dominates performance over a two-year horizon unless certain strategic instruments in the Western economy are changed, e.g., government expenditure and taxation, the money supply, wage and price controls.

In addition to the accommodating system of bureaucratic response, the SRI-WEFA Model was developed with considerable attention to administrative intervention, i.e., exogenous shifts in key parameters or in system structure, represented by dummy variables. Since the Soviet economy is a highly politicized economic system, it is not surprising that a Soviet macromodel exhibits a higher percentage of dummy variables than a macromodel of a Western market economy. In SOVMOD I, for example, nearly 15 percent of the variables in the model were dummy variables. Two-thirds of these dealt only with shifts in financial flows and nominal wage/price levels, but the others represented important administrative interventions in the allocation of factors and the disposition of product.

Acknowledging the various technical issues involved, we tended toward a liberal use of dummy variables for two major reasons. First, by incorporating such "events" in the specification of the Soviet model, they become documented in model equations though certainly not explained. These anomalies do not evaporate with the pattern of estimation residuals but remain as subjects for future historical and econometric research. Second, we have sought to predict administrative response rather than intervention, and have employed dummy variables to capture the latter in the interest of "better" estimates for parameters of technical and behavioral regularity.

B. The Integration of an Input-Output Component Within a Macromodel of the Soviet Union

Input-output data, although scarce in comparison to the availability of national income and product data, are an important source of industry detail that can be used to construct links between the supply side and the production side of the macroeconometric model. These data provide a consistent accounting framework, tracing the flow of intermediate inputs through the economy and the distribution of products among alternative categories of final demand. The transactions table can be translated into an input matrix, containing direct input coefficients, which describe the input requirements of each sector per unit of gross output; or an allocation matrix containing direct allocation coefficients which describe the distribution of products among the producing sectors and categories of end use per unit of gross output. In either case these matrices of coefficients can be interpreted as general descriptions of the underlying technology of the economy which was used to produce material products for both intermediate and final use. In turn, the macromodel provides information on factor allocation and the composition of output which serve to move input-output coefficients and capacity constraints over time.

1. Partial Integration Accomplished in SOVMOD II

The principal task in this aspect of Phase Two was the determination of a sequence of a balanced I-0 tables over the period 1959-72. The basis for this derivation is provided by actual Soviet Input-Output Tables for 1959, 1966, and 1972 in current producers' prices, the last table being a preliminary version made available in June 1975.[1]

During Phase Two, this sequence of I-0 tables was balanced in current prices rather than in constant prices. Our objective was to derive a plausible movement of the material requirements matrix, the A Matrix, for unobserved years. Using the actual Tables and time-series for gross value of output and value-added by sector in current prices, intervening tables were determined by a modified RAS technique using a weighted minimization algorithm for coefficient movement. A particular problem was posed by the 1967 Price Reform. It was handled by revaluing the 1966 Table in postreform prices. This revalued 1966 Table was then used in the interpolation between 1966 and 1972.[2]

In Phase One we gained some experience with the use of Input-Output in the determination of end-use categories. Further development in that direction depends upon the reconstruction of the end-use quadrant of the reconstructed 1972 Table. Consequently, we chose to focus upon application of I-0 in the determination of intersectoral deliveries during Phase Two. Our objective was to use such information in an iterative determination of a consistent vector of gross outputs. From the current price series for gross value of output and value added, we derived series for material inputs and entered those in our specifications of production functions for branches of industry. In SOVMOD III, improved estimates of Soviet prices are used to deflate current price material inputs.

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1 We wish to thank Professor Vladimir G. Treml and analysts at the Foreign Demographic Division of the Department of Commerce for making available this preliminary version of the table to facilitate our research.

2 Gene D. Guill, "The RAS Method of Coefficient Adjustment and Soviet Input-Output Data," Working Paper #34 (September 1975).

There are several ways in which the Input-Output Tables may be used to provide the macromodel with the feature of sectoral interdependence present in the actual economy. When the macromodel departs from the actual historical path, the Input-Output framework enables the model to restrict itself to consistent vectors of gross output. We have programmed three different procedures to determine gross outputs consistent with material inputs, using sequences of input requirement matrices (A matrices) and allocational matrices (B matrices) derived from the balanced tables:

- <u>B Matrix allocation</u>: The flow table is regarded as an allocation scheme where purchases by each column sector are a function only of the production levels (or availabilities) of each row sector. Coefficients in the B matrix are defined as $b_{ij} \equiv x_{ij}/X_i$. Gross outputs from the macromodel are multiplied across the rows of the B matrix to establish a simulated flow table.

- <u>A Matrix requirements with B Matrix distribution of excess demands</u>: In this scheme the flow table is regarded as a representation of technological relationships where the inputs purchased by each sector are determined solely by the level of output of that sector. Elements in the A matrix are defined as $a_{ij} \equiv x_{ij}/Xj$. Gross outputs from the macromodel are multiplied up the columns of the A Matrix to establish a provisional flow table. Total outputs are then added up across each row and the excess demands (or excess supplies) are then redistributed proportionately back across the rows to determine an adjusted flow table.

• A Matrix requirements with distribution of excess demands according to a weighted minimization algorithm: The provisional flow table is computed as shown above for A matrix requirements with B Matrix distribution of excess demands. Excess demands, however, are redistributed across the rows in a fashion which minimizes the change in flows subject to a prescribed weighting scheme which can be interpreted as representing a priority ranking of sectors.

After a flow table has been determined according to one of the above procedures, material inputs to each sector are determined by the column sum. In the next iteration of the model, these material input series influence sector outputs through the sectoral production functions and the I-0 procedure is repeated.

2. Current Developments for a More Complete Integration in SOVMOD III

The development task which was most important during Phase Three was the extension of the I-0 integration used with SOVMOD II. These extensions included further experimentation with balancing algorithms and modeling of coefficient movement for long-term projections.

a. Algorithms to Move Soviet Input-Output Data

The algorithm developed during Phase Two, for interpolating between actual input-output tables, was designed so that specialized information on technological change could influence the coefficient adjustment process. With suggestions by input-output specialists reviewing this sequence of balanced tables, we have constructed an improved sequence of tables for 1959-72 using the same algorithm. Experiments were also made with an alternative balancing method where a linear programming algorithm performs a full-matrix minimization of weighted coefficient adjustment instead of the iterative approach to separable minimizations across each row and column.[1]

b. The Modeling of Coefficient Movement

After the determination of a sequence of I-0 tables, the next step is the endogenization of matrix coefficients, i.e., the modeling of coefficient movement over time. For models of Western market economies, Preston and others have used relative prices to help explain the long-term movement of the matrix of I-0 coefficients. To explain coefficient movements in the Soviet planned economy, an analogous system of equations was estimated utilizing relative wages and trends.

c. Net Delivery Constraints on End-Use Categories

In the development of SOVMOD I, Higgins used the 1966 Input-Output Table to compute synthetic real "delivery" measures for categories of consumption.[2] Presently in SOVMOD III, the balanced I-0 tables 1959-1972 include a final demand vector normalized on GNP. Eventually, we propose to use this information on net production by sector in the determination of various categories of end-use. For example, net production of industrial materials may be related to net exports of such materials to the CMEA and the Developed West. This also becomes an important link for connecting material imports to domestic production in the macromodel.

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1 Gene D. Guill and Ross S. Preston, "The Use of Linear Programming in Estimating the Changes in Soviet Input-Output Data," Working Paper #41 (December 1975).

2 Green and Higgins, op. cit., Chapter 6.

When the end-use quadrant of the reconstructed 1972 Input-Output Table becomes available, we will be able to balance a sequence of end-use quandrants (H matrices) over the period 1959-72. "Delivery" measures derived from the solution of the model would then operate directly on categories of end-use.

C. The Consolidation of the First Three Years' Research

With the close of Phase Three, it is appropriate to stop and consider the tasks of consolidating three years' research. Essentially, these tasks involve the standardization of the product and its general distribution to a broad constituency of policymakers and professional economists. Considerable progress in these areas has been made but there will remain major tasks of consolidation in subsequent years.

1. Documentation of a Family of Models

It is now clear that what has heretofore been the SRI-WEFA Econometric Model of the Soviet Union should now be regarded as a family of econometric models. With various models specialized for dealing with different sets of questions, the issues of standardization and compatibility become paramount. With SOVMOD I virtually retired except for learning purposes and SOVMOD II based on older Western data, the core of the model family will be an updated version of SOVMOD III. All models will use the same WEFA support software programs, use the same Databank (with some exceptions), and share common variable names. Our primary objective is to allow all models to evolve but to facilitate the transfer of innovations where appropriate. The principal models which will constitute this family are the following:

- The Medium-Term Macromodel (SOVMOD III). This constitutes the core system used for scenario analysis and annual forecasting for a 2-5 year horizon. It continues to provide the partial integration of the I-O component available now in SOVMOD II plus the component used to move the I-O table dynamically.

- The Medium-Term Macromodel with an Extended Foreign Trade Component. This model, specialized for PROJECT LINK and other foreign trade studies, will include extended components for USSR-CMEA trade and East-West trade generally.

- The Long-Term Growth Model. This model will be specialized to deal with technical change, structural change and goals for 10-25 year projections. For efficiency in model development, certain components of the macromodel may be compressed, e.g., the State budget or foreign trade. Those components may be restored in full detail for final applications.

- Defense-Related Models. These models will incorporate different estimates and specifications of Soviet defense expenditures for comparative purposes and scenario analysis.

2. Standardization of the Databank

The Databank, which has been developed during the three years of the project, is essential to effective research and model applications, by the SRI-WEFA team and others. Data used for SOVMOD I have been fully documented in the preparation of the Green-Higgins book,[1] but for many

[1] Green and Higgins, op. cit.

other variables it is a costly process to fully document series for outside users. One task of consolidation is to complete full documentation of existing data in a convenient form for access by other scholars.

A related issue is the policy of public distribution of the Databank with documentation. The project has freely made available the data existing in the Databank. Continued funding support is essential to maintain this service to the scholarly community.

Of particular importance is the standardization of the annual update process for the project Databanks. Should all series be updated each year or only those used in the family of models? The current procedure is somewhere in between these extremes, with an updating of many variables of interest which are not presently in the model. Essentially, the procedure for annual updating will be codified and centralized at Wharton EFA with continued supervision by SRI members of the project team.

3. Publication of SOVMOD III

Given the variety of current model developments, the project has begun preparation of a second book concerning the SRI-WEFA Model. As it is currently conceived, the new book would not be concerned with the same material as Green and Higgins but rather with a more technical presentation of SOVMOD III. This volume could stand as a reference for econometric modeling of nonmarket economic systems and document all equations of SOVMOD III.

D. The Emergence of a Research Team

One major consequence of the SRI-WEFA project has been the establishment of a unique research team centered at the University of Pennsylvania in Philadelphia. Although outside scholars have provided valuable guidance at certain stages, the true dynamics of this research project have been the sequence of staff meetings which began in the fall of 1973 and have continued, more or less regularly, since then. It is in these meetings and the extensive contacts between meetings that innovations in specification and system design have emerged and been refined.

Senior supervision of the SRI-WEFA Project has been provided by Lawrence R. Klein, Herbert S. Levine and Ross S. Preston. Principal investigators during this first year were Donald W. Green and Christopher I. Higgins. With Dr. Higgins' return to the Australian Treasury in the second year, Gene D. Guill and Peter Miovic began as researchers on particular aspects of the project and have now in the third year broadened their participation as principal investigators. Also in the third year, Edward A. Hewett of the University of Texas has joined the project as a specialist on Soviet foreign trade and Holland Hunter has assumed a growing role in introducing the model and its potential to the Washington community. Furthermore, a significant number of research assistants, primarily graduate students at Penn, have gained experience in econometrics, programming, and the quantitative study of planned economies. The project team has demonstrated a capacity for integration with senior personnel actively participating in specification and application studies and research assistants authoring or co-authoring project working papers.

The institutional associations have also contributed to the quality of research. In Philadelphia, the project has gained extensive contact with other econometric modelers through Wharton EFA, the Economic Research Unit of the Department of Economics, and Project LINK. Particularly valuable have been the contacts with econometricians from Eastern Europe. Stanford Research Institute has also provided an important channel for interaction with other Western specialists on the Soviet economy as well as with Soviet economists and officials through its multiple relations with the USSR.

II A YEAR'S EXPERIENCE WITH SOVMOD II

In this chapter, we report on certain model refinements of SOVMOD II, on our experience in transferring the model from Philadelphia to Washington, D.C. and to SRI headquarters in Menlo Park, California, and on a number of application studies performed with SOVMOD II. As indicated in last year's Phase Two Documentation, our plan for Phase Three was to undertake application studies of: the 1975 harvest, technology transfer to the Soviet Union, an evaluation of the new Soviet 15-year plan, and longperiod simulations. We have carried out all of these studies, with the exception of the evaluation of the 15-year plan, since the Soviets did not complete that plan on schedule and, as of this writing, have still not published any data on it. In place of our intended 15-year plan study, we undertook a study of the new Soviet 10th Five Year Plan (FYP). A description of this study is included below.

A. Model Refinements and Transfer from Philadelphia to Washington, D. C. and Menlo Park, California

During the past year we have subjected SOVMOD II to an increasingly stringent set of tests. These have led to certain refinements in the model and prepared the ground for the design and implementation of SOVMOD III. The main way of carrying out this validation of the model has been through the use of simulations.

The initial sample period dynamic simulations carried out with SOVMOD II more than a year ago suggested that certain equations were not tracking well and could cause problems in forward projections. This was particularly true of the foreign trade sector where several equations had to be reestimated. However, even in the current version of the model we have had to exogenize Soviet grain imports and gold sales.

Simulations beyond the sample period, first to the end of the 1970s covering the Soviet 10th FYP and then into the 1980s, alerted us to other possible problem areas. While the economic implications and results of those applications of the model are reported below, it is useful to point out some of the modifications that were made in the process of carrying out that research.

In the shorter term (3-5 years out), the simulations were generally stable. A few trends had to be suppressed or attenuated and a number of adjustments made to the endogenous variables. The main adjustments were in the equations for the allocation of labor between city and country, and for labor force participation, in Soviet trade for CMEA where a discontinuous break in prices occurred subsequent to the sample period, and in the timing of impacts stemming from the 1975 harvest failure. Some minor adjustments were made in the equations for industrial branch investment and employment, and in the State Budget revenues. This degree of model adjustment is quite comparable to experience with models of Western market economies.

When extending our projections into the 1980s, an additional set of problems arose. It became increasingly difficult to preserve certain balances and internal consistencies. For example, the model did not ensure that projections of industrial branch outputs, employment or investment would sum to their respective all-industry totals. Also, as the projection horizon was extended, the relative shares of certain categories in GNP, whether examined from sector-of-origin, end-use or income sides, took on values that became less and less plausible. Some of these tendencies could be compensated for by the experienced user. But, in addition, we have designed ways which enforce consistencies and have added them to SOVMOD II, and in SOVMOD III have provided for them in a more extensive way. Future development in this direction will rely heavily on development of the input-output sector of the SRI-WEFA models.

Finally, in order to draw on the knowledge and experience of a wider circle of specialists on the Soviet economy, we have pursued the development of model software which enables an easy transfer of the SRI-WEFA model to other computer installations. SOVMOD II has been transferred and successfully run by groups in Washington, D. C. and Menlo Park, California. In the latter case, this transfer was to a CDC computer system from the IBM system in use at WEFA. This required some extensive reprogramming which is now completed; it will allow for an easier transfer of the model to other CDC installations in the future. For SOVMOD III we have gone one step further. We have installed the model on a system that permits it to be used on a time-sharing basis through an interactive terminal. In the future, a user will be able to access the model through the telephone lines.

B. Consequences of the 1975 Grain Harvest (December 1975)[1]

In this application study, we constructed a control solution for 1973-76 and then evaluated the macroeconomic response to harvest failure which was estimated in SOVMOD II. Alternative scenarios for 1975 grain harvests of 160, 150 and 140 million metric tons (MMT) were evaluated. Finally, the implications of a harvest failure of such magnitude were assessed in examining Soviet attitudes toward the US/USSR grain agreement.

1. A Control Solution, 1973-76

The objective of a "control solution" is to indicate the probable course of the Soviet economy if conditions had been "normal." In SOVMOD II, normality in Soviet agriculture is defined by mean values of the weather variables (spring-summer precipitation and winter temperature). There

[1] Donald W. Green, "The 1975 Soviet Grain Harvest, the Tenth Five-Year Plan and the U.S./USSR Grain Agreement," published in United States-Soviet Grain Agreement, S. 2492 and Other Matters, U.S. Senate Hearings, Subcommittee on International Finance of the Committee on Banking, Housing and Urban Affairs, 9-10 December 1975 (U.S. GPO, Washington, D.C., 1976).

are two stages in the determination of such a control solution. First, projections are made for the exogenous variables in the model on the basis of specific information and the extrapolation of recent trends. Second, the path of the economy generated by the model from those projections of exogenous variables is then examined and adjusted to conform with more recent data and the judgments of specialists on the Soviet economy.

The major features of that control solution for 1973-76 are presented in Table 2-2 column (2). Under normal weather assumptions, we projected a 1975 harvest of approximately 206 MMT followed by a 1976 harvest of 218 MMT. Moderate growth in GNP of 4.3 percent in 1975 was to be followed by 5.6 percent growth in 1976. Industry was projected to grow at 6.5 percent in both years with light industry growing at a much lower rate. The rate of growth of consumption was projected to rise from 1975 to 1976 with the declining growth rate of capital investment. Exports and imports were projected to grow in 1975 by approximately 15 percent in nominal terms with increasing Soviet trade deficits with the CMEA and the Developed West appearing in 1976. Soviet liquidity in hard currency was projected to fall from its relatively high level in 1974 because of trade deficits and the decline in world gold prices.

2. Administrative Harvest Response in the Soviet Economy

In estimating a macroeconometric model of the Soviet Union, we found that distinctive administrative response patterns could be interpreted as reactions to the state of the harvest. In quantifying such response patterns there was considerable evidence available given the major harvest failure in 1963 and lesser setbacks in 1960, 1965, 1969, and 1972. It is clear that 1975 represents a harvest disaster comparable to the 1963 experience.

To understand the necessity for Soviet administrative response to harvest fluctuations, we shall first consider the major consequences of a harvest failure. To begin, the agricultural sector accounts for a higher proportion of national product in the Soviet Union than in Western industrialized economies. This observation is reinforced by noting that over 50 percent of real household expenditure is for food in the USSR. A shortage in grain, if sufficiently severe, may necessitate reductions in livestock feed or processed flour. Furthermore, if the poor harvest extends to industrial crops there will be derived shortages of other consumer goods produced. If the Annual Plan is maintained, such shortages in food and consumer goods will generate a disequilibrium between money incomes and wage-good supply at fixed prices. Whether prices are raised or not, such a disequilibrium on the wage goods market will lower the effective real wage for employees.

To lessen the disincentive effects and worker unrest, we have found that the Soviet administration departs from the Annual Plan when a harvest crisis appears. The principal responses to a deficient harvest which were identified and specified in SOVMOD II are the following:

- A reduction in the rate of growth of investment, particularly in agriculture, light industry, the construction sector, and the services category;
- An increased slaughter rate for productive livestock with shortrun increases in meat supplies;
- An increase in the production of consumer durables in the machine-building branch; and
- A compensatory effort in agriculture during the following year, through increases in labor participation, investment and material supplies.

A given harvest deviation, measured as a proportion of peak production, will have a specific quantitative impact on these other variables of the macromodel. The reduction in capital investment restrains the growth of money incomes without restricting the supply of wage goods in the short run; this helps to reduce excess demand observed on the wage goods market. Increased supplies of meat also help to ease the shortrun monetary disequilibrium. Both of these two responses, however, lower the longrun supply of wage goods and serve primarily to distribute the shortages more smoothly over time. The reduction in capital investment enables the machine-building branch to augment its production of consumer durables which absorbs additional money income of households in the shortrun.

3. Consequences of the 1975 Grain Harvest: Alternative Scenarios

Given the uncertainty (at the time of this study) concerning the actual level of the 1975 Soviet grain harvest, we decided to compute alternative scenarios for 160, 150 and 140 MMT. These three scenarios share common assumptions for the State Budget in 1976 (the actual Budget figures published in Pravda which represent a partial response to the harvest crises), grain imports from the Developed West, and Soviet financing of those imports with credit drawings and gold sales. These assumptions are indicated in Table 2-1 along with the 1975 adjustments to grain output and gross agricultural output to define the three scenarios. Our projection for grain imports is based upon an estimate of 25 MMT imported in 1975-76 at an average price of $160 per metric ton.

Several comments should be made concerning the measures of grain output and agricultural production. In SOVMOD II, we used a Western adjusted output series for Soviet grain production rather than the Official index. For the period 1973-76, we have used an adjustment parameter of 0.65 to convert the Official measure into the Diamond measure.[1] Furthermore, the impact of the grain harvest on total agricultural output (also a Western measure) is based upon the observed percentage decline in 1972. The ratio of the percentage declines in grain output to gross agricultural output for that year (0.59) was applied to 1975. This assumes that the composition of crops sown and the pattern of weather impacts on crop yields were approximately equal in those two years.

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[1] The grain series used in the model is total grain net of seed. The adjusted series for grain output and agricultural production are presented in D.B. Diamond and C.B. Krueger, "Recent Developments in Output and Productivity in Soviet Agriculture," in Joint Economic Committee (U.S. Congress), Soviet Economic Prospects for the Seventies (U.S. GPO, Washington, D.C., 1973).

TABLE II-1

DEFINITIONS FOR HARVEST SCENARIOS

New Assumptions for All Scenarios (Control Assumptions in Parentheses.)

Descriptions (Units)	1975	1976
Financing of Centralized Investment (billion current rubles)	85.4* (85.4)	88.3 (91.4)
Financing of Transport/Communications (billion current rubles)	18.8* (18.8)	19.6* (19.8)
Financing of Agriculture (billion current rubles)	37.1* (37.1)	37.2 (40.8)
Official Defense Expenditure (billion current rubles)	17.4 (17.4)	17.4 (18.0)
Nonpersonnel Defense Expenditure (billion current rubles)	12.8 (12.8)	12.8 (13.1)
Grain Exports from Developed West (million current dollars)	1500. (200.)	2500. (200.)
Hard Currency Credit Drawings (million current dollars)	1500. (1000.)	2000. (1000.)
Gold Sales (million current dollars)	500. (300.)	700. (300.)

*Actual Data

Adjusted Harvest Levels for 1975

Variables	Control	Scenarios 160	150	140
Grain harvest, official (M. metric tons)	206.	160.	150.	140.
Grain harvest, Western estimate (M. metric tons)	135.3	105.2	98.1	91.1
Gross agricultural production (B. 1965 rubles)	71.0	66.3	63.9	61.3

In Table II-2 we have presented a summary of results for the control solution, the 140 scenario, and the other two scenarios with a slightly better harvest for 1975. The major impacts of the 140 MMT harvest in 1975 may be summarized as follows:

- A reduction in the growth rate of real GNP in 1975 from 4.3 to 2.0%, and a loss of over 15% of the projected increment in GNP from 1974 to 1976
- A reduction in the growth rate for Soviet industry in 1976 from 6.5 to 4.0%
- A reduction in the growth rate of capital investment by 2 percentage points in 1975 (6.1% to 4.1%) and by over 1 percentage point in 1976 (5.4 to 4.5%)
- A reduction in the growth rate of total consumption by 1.8 percentage points in 1975, and by about 1 percentage point over the two years 1975-76
- A reduction in the projected annual growth rate of nominal machinery imports from the Developed West from over 20% to 12% during 1975-76
- An increase in the Soviet trade deficit with the Developed West by $1.5 billion for the period 1975-76.

These projections are not much different from what the Soviet leadership itself is anticipating for 1975-76. The speech by Baybakov on the Annual Plan for 1976 indicates GOSPLAN's projections as follows:[1]

- Growth rate of national income to be 4% in 1975 and 5.4% in 1976
- Growth rate of industry to be 7.5% in 1975 and 4.3% in 1976 (4.9% in heavy industry and 2.7% in light industry).

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[1] Speech by the Chairman of N.K. Baybakov, "O gosudarstvennom plane razvitiya narodnogo khozyastva SSSR na 1976 god," Pravda, pp. 1-3 (3 December 1975).

TABLE II-2

SUMMARY RESULTS

Variables (Units)	(1) Year	(2) Control Solution	(3) 140 Scenario	(4) 150 Scenario	(5) 160 Scenario
Level of GNP (B. 1970 rubles)	1974	432.4	432.4	432.4	432.4
	1975	450.9	441.0	443.5	445.9
	1976	476.2	469.5	470.6	471.7
Growth rate of GNP (%)	1974	4.42	4.42	4.42	4.42
	1975	4.28	1.98	2.56	3.12
	1976	5.60	6.46	6.11	5.79
Level of industrial output (B. 1970 rubles)	1974	222.7	222.7	222.7	222.7
	1975	237.2	236.7	236.7	236.8
	1976	252.5	246.2	247.1	248.1
Growth of industrial output (%)	1974	6.50	6.50	6.50	6.50
	1975	6.52	6.32	6.33	6.33
	1976	6.46	3.99	4.38	4.77
Growth of consumption (%)	1974	5.09	5.09	5.09	5.09
	1975	4.86	3.07	3.41	3.74
	1976	5.51	6.38	6.04	5.71
Growth of new capital investment (%)	1974	6.85	6.85	6.85	6.85
	1975	6.09	4.14	4.65	5.14
	1976	5.35	4.50	4.51	4.52
Imports of machinery from Developed West (M. cur. $)	1974	2548.	2548.	2548.	2548.
	1975	3138.	2841.	2848.	2856.
	1976	3750.	3148.	3157.	3166.
Net exports to Developed West (N. cur. $)	1974	502.	502.	502.	502.
	1975	-231.	-1176.	-1177.	-1177.
	1976	-975.	-1610.	-1643.	-1675.

The major difference between our projection and GOSPLAN's is in the 1976 growth rate for light industry where SOVMOD II actually projects a decline of 1-1½% compared with GOSPLAN's indication of a 2.7% increase. If GOSPLAN's target is fulfilled, that would indicate a substantial state intervention on behalf of the Soviet consumer using SOVMOD II as a standard of average past responses.

The two consequences of the 1975 harvest which are most significant for Soviet longrun growth are the reduction in new capital investment and the reduction in machinery imports from the Developed West. The differences in capital investment between the control solution and the 140 MMT Harvest Scenario are indicated in Table II-3; they are a consequence of the harvest crisis, the reduction in the financing of centralized investment, and the lower Official Budget for defense.

4. Conclusion: The U.S./USSR Grain Agreement of 1975

The 1975 grain harvest clearly called into question the 10-year program associated personally with Chairman Brezhnev, a program which we have previously labeled "Project Independence a la Russe." The objective of this program was to establish Soviet independence of Western agriculture as well as to increase the annual *per capita* consumption of meat in the Russian diet. In contrast to the earlier "Virgin Lands Campaign" of the 1950s, the essential strategy of the Brezhnev program was to increase agricultural output through mechanization, the application of additional capital to existing acreage and manpower. Given the severe problem of weather faced by the USSR, mechanization was intended to raise the expected level of agricultural output and to reduce its variation. Weather plays a crucial role in determining Soviet agricultural output, not only because of its impact on biological yields but also because of Soviet organizational difficulties in providing labor and equipment to various regions when the harvest must be gathered in a short period. Problems with capital maintenance and spare parts, inadequate rural transportation, and the inefficiency of urban workers and students in seasonal agricultural work all contribute to Soviet vulnerability to the weather.

Alternatives to the past Brezhnev approach which have been suggested are not very attractive to Soviet leaders. First, there is the expansion of northern acreage for hard grains; yields there are not high but are less uncertain. The problem with the reclamation of northern acreage is the high cost and therefore the necessity for sacrifices elsewhere. Second, there is the alternative of organizational reform in Soviet agriculture, a policy which would meet substantial resistance from the State and Party bureaucracies. This would involve perhaps changes in the scale of farms, the reduction of administrative regulations over crop compositions and scheduling, or the establishment of wholesale markets for agricultural products and inputs. Third, there is the prospect of a reduction in economic aspirations, an acceptance of the constraint which deficient growth in agriculture poses for a system committed to rising living standards. Finally, there is the possibility of allowing greater shortrun dependency on Western grain supplies, a policy with undesirable economic and political consequences for Soviet leaders. The eventual policy adopted may actually be a combination of all four alternatives.

If the 10th FYP is evidence for the reduction of aspirations, then the U.S./USSR grain agreement signed in September 1975 indicates the possible Soviet acceptance of a long-term interrelationship with the U.S. economy. This agreement commits the two nations to an expected annual transaction of 6-8 million metric tons of grain for the period 1976-80. The minimum is rather rigid except during a severe harvest in the U.S. while the maximum is less rigid since it calls only for consultation for Soviet purchases in excess of 8 million metric tons. The U.S. stands to benefit from this agreement, but the advantages to the USSR are also clear. The requirement of 6 million metric tons to be purchased each year by the Soviet Union will contribute to high, stable demand in the U.S. grain market. But according to the model, this does not represent a burden to the Soviets. Even assuming "normal" weather through 1980, the model has projected desired Soviet imports of Western grain of 5-10 million metric tons for each year.

Overall, the agreement adds to Soviet economic options in dealing with its agricultural problem. Politically, however, it does represent a compromise with the longstanding Soviet principle of economic independence and, in this regard, it is in consonance with the Kissinger policy of building a web of interrelatedness between the Soviet and U.S. economies.

C. Technology Transfer to the USSR (March 1976) [1]

The Soviet Union is currently in a period of rather intense importation of advanced technology from the developed industrial countries. This is not the first time in Russian history that such importing of technology has occurred. For it occurred in tsarist times, during the reign of Peter the Great and later in the period of rapid industrialization of the 1980s. And it again occurred in the Stalinist forced draft industrialization era of the 1930s.

In these past periods of importation of advanced technology, the Russians were able, within a compressed span of time, to approach contemporary economic development levels in the West and, to some extent, even the levels of contemporary technology in the West. Yet in the longer run, as the advanced nations of the West continued to develop new technology, the Russians were not able to maintain their relative position, and they fell back.

Among the Soviet economic institutions which affect the ability of the economy to absorb, master, and create new technology are the following:

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[1] Donald W. Green and Herbert S. Levine, "Implications of Technology Transfers for the USSR," SRI-WEFA Working paper #42, March 1976 (prepared for the NATO Colloquium, Spring 1976)

- The managerial incentive mechanism that has more or less dominated the Soviet scene since the 1930s. Innovation always involves risk. The compensation for risk is reduced by the fact that success today will mean a higher target tomorrow, and success in the system requires the regular meeting of targets. Furthermore, experimentation interferes with current production. Thus, managers resist innovation and try to keep targets low. There is much discussion in the Soviet Union on how to get around this problem, but nothing very effective has been introduced so far.

- The organization of research and development (R and D). Considerable expenditure is devoted to R and D in the Soviet Union, but to a great extent it is separated from the production process, and less attention is paid to development than to research. As a result, while new technology is generated and foreign research studied, the implementation and diffusion of such technologies are limited. One of the reforms currently underway, the creation of large "scientific production associations," offers the promise of bringing the Soviet organizational relationship between research, development, and production more into line with the pattern dominant in the West.

- The technology transfer process is primarily a people-process. Technology is best transferred from firm to firm and from country to country by people (managers, engineers, sales engineers, etc.) rather than by publications (including blueprints) or products themselves. In the postwar period, the Soviets have concentrated on the latter approaches while making minimal use of the former. Currently, however, they appear to be paying more attention to the people part of the process.

The elements discussed so far have related to Soviet institutions and practices, but the Russians under the tsars also had trouble mastering modern technology and maintaining its dynamic change. What common elements in the pre and post-revolutionary Russian scene may explain these common difficulties?

- The creative destruction aspect of technical change--that is, when something new is done and it is successful, the old is destroyed. In a politicized, bureaucratic economy, as was the case under both tsars and bolsheviks, those who operate existing activities and technologies are much better able to protect themselves against the threat of new activities and technologies.

- The absence of a threat of bankruptcy in the noncompetitive Soviet economy has an impact because, while the innovational process responds in a positive way to high rewards for successful innovational, it also responds to the fear of being driven out of business by dynamic competitors. The latter may be more significant than the former, especially in regard to the diffusion of new technology.

- The Soviets have primarily imported foreign technology for domestic purposes rather than for exports which would have to be internationally competitive. Thus, once the new technology was in place, there was no pressure on those using it to keep it up to changing foreign levels, and the technology languished.

Even though the Russians may have been deficient in the way they have borrowed and maintained foreign technology, both Western observers and current Soviet policymakers appear convinced that foreign technology has contributed to Soviet industrial growth. However, the quantitative significance of the technology transfer remains a major unanswered question.

During the construction of the SRI-WEFA Econometric Model of the Soviet Union, a new methodology was developed for evaluating the quantitative impact of imported machinery on Soviet industrial production which to a certain extent provides a measure of the gains from technology transfer.[1] The incorporation of this feature within the complete macroeconometric model provides a framework for evaluating the direct and indirect benefits of Soviet machinery imports through counterfactual scenarios in the past and conditional projections into the future.

In an attempt to quantify the gains from technology transfer, there are clear advantages to focussing on imported machinery and equipment. Machines imported from nations more technologically advanced can shift a domestic production function upward in three different ways:

(1) directly through higher productivity in domestic production;
(2) indirectly through use in the production of more efficient domestic machinery; or
(3) even more indirectly through the transmission of information which results in a higher domestic level of technology.

In order to estimate the contribution of imported machinery to Soviet industrial production, we first construct a measure of foreign capital from Soviet import data, and use that measure to disaggregate the capital stock into foreign and domestic categories. Production functions are then estimated with three factors of production: labor, foreign capital and domestic capital. We assume that each imported machine carries potential information which may raise the level of Soviet technology. Given a constant expenditure of internalization effort (analysis and diffusion) per unit of imported machinery, the level of domestic technique will depend upon current and past levels of machinery imports. When one estimates the "contribution" to output of the marginal foreign machine, there are two components to the marginal productivity: one, a direct measure of productivity, and two, its contribution to the productivity of domestically produced machinery. If this "learning" component is significant then we ought to find the marginal productivity of foreign capital estimated in a production function to be higher than what one might judge reasonable for

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[1] This methodology was introduced in Donald W. Green and Marc Jarsulic, "Imported Machinery and Soviet Industrial Production: An Econometric Approach," SRI-WEFA Working Paper #39 (December 1974).

direct productivity relative to domestic capital. and that is exactly what our preliminary econometric results suggest (see Table II-4). Howeve., these data do not take into account additional costs to the use of foreign machinery (see discussion below).

As in other components of the Soviet macromodel, we have sought to specify the pattern of bureaucratic regularity (rule of thumb), identify contingencies to which such bureaucratic rules must respond, and clarify where possible the role of administrative intervention in shifting the rule from epoch to epoch. The "rule of thumb" in this hypothesis is that real foreign machinery is allocated proportionately to the allocation of domestic investment over time within any given category of investment. Over the sample period 1961-73, the observed import/investment ratio shifted upward in the late 1960s with shortrun variations "explained" in part by the liquidity measure. The retardation in real machinery imports during the mid-1960s was due first to the restriction in industrial investment and second to the decline in Soviet hard currency liquidity after the 1963 harvest failure.

How might Soviet development have been different had those shifts in Soviet machinery demand not taken place? By retrospectively repealing "detente" consequences for East-West trade, we obtained measurement of Soviet gains from machinery imports holding the historical environment constant: financing of investment, defense expenditure, weather, the world economy, etc.

In scenario analysis, we first construct a control solution as a standard of reference for counterfactual experiments. For our control solution, we solved the model dynamically from 1968 to 1973 using actual historical values for all variables in the period of solution. Once the control solution was determined, a No-Detente scenario was computed. We adjusted only the machinery import component of the model. Industrial investment and capital formation were unchanged; the foreign/domestic composition of industrial capital stock does change with consequences for industrial pr uction. The decline in Soviet imports results in an increase in Soviet hard currency liquidity which acts to boost machinery imports in the following year. The hard currency liquidity gain also lessens next year's exports to the Developed West which in turn lowers the liquidity position in the year after that. The shift in capital composition also generates another systemic process through the employment loop. A reduction in the growth of average labor productivity in industry lowers the growth of the real industrial wage. This reduces subsequent growth in industrial employment through participation effects and, with a longer lag, through a rural/urban migration effect.

In comparing our Scenario with Control, we may observe the full system impacts of the detente effect on Soviet machinery imports. Table II-5 presents several measures which indicate the magnitude of this detente effect. The model suggests that the growth of industrial production from 1968 to 1973 would have been only 28.4% without those additional imports of Western machinery, i.e., approximately 15% of the growth in the control solution (33.7%) would have been foregone.

The situation of the Soviet economy in the mid-1970s is somewhat different from that of the mid-1960s, in part because of the substantial imports of Western machinery during the period 1968-74. To increase our understanding of the quantitative contribution of technology transfer, projective scenarios with 10 percent upward and downward shifts in Soviet demand for foregin machinery were constructed. For projective analysis, the derivation of a control solution is considerably more difficult than for retrospective analysis because of uncertainty concerning the paths of exogenous variables. For these scenario exercises, a control solution was prepared for an extended analysis of the Tenth Five Year Plan.

Around this control path, two scenarios were constructed by shifting Soviet demand functions for foreign machinery. In Scenario A, all features of the control solution are maintained except that the constant term in each machinery demand function is increased by 10 percent. In Scenario B, those terms are reduced by 10 percent. Consequently, dynamic multipliers in both directions for imported machinery could be calculated. The broad features of these scenarios are presented in Table II-6. Two important

TABLE II-3

INVESTMENT CONSEQUENCES OF THE 1975 HARVEST

Units = Billion Rubles

Sector	140 Scenario less Control 1975	1976	Percentage of Total Impact 1975-76
Agriculture	-0.99	-1.65	50.6
Industry	-0.31	-0.51	15.7
Construction	-0.25	-0.28	10.1
Transport/communications	0.	0.06	-1.1
Housing	0.	0.02	-0.4
Services and trade	-0.49	-0.82	25.1
Total	-2.04	-3.18	100.0

Note:

The major impact projected is on the agricultural sector (50% of the 5.2 billion ruble reduction) and the second largest impact is on the category of services and trade (25%).

TABLE II-4

ESTIMATION RESULTS: RATIO OF MARGINAL PRODUCTS

Category	Western or Total Imports	Ratio of MPs[1]
Aggregate industry	Western	15.2
Chemicals and petrochemicals	Western	17.9
Machine-building and metalworking	Total	7.4
Petroleum products	Total	5.7

[1]Ratio of marginal product of foreign machinery to marginal product of domestic machinery.

TABLE II-5

THE IMPACT OF DETENTE: MAIN INDICATORS

Indicator	Detente Control	No Detente Scenario
	Percentage Growth, 1968-73	
Gross national product	30.3 %	27.7 %
Industrial production	33.7	28.4
Chemicals & petrochemicals	33.9	26.6
Machine-building	42.6	40.8
Foreign trade turnover	57.9	52.9
Aggregate consumption	26.0	21.9
	Valued in 1973	
Imported Western machinery (billion 1955 rubles)	10.14	8.27
Hard currency reserves (million current $)	-318.	878.

observations derive from these experiments. First, the multipliers for Western machinery are lower for the USSR in the 1970s than they were at the end of the 1960s, though they are still large. With the more rapid accumulation of Western machinery relative to domestic capital in the period of detente, the ratio of marginal products has declined from the sample-period level. Second, and for similar reasons, the multiplier downwards is greater than the multiplier upwards.

There appears to be an apparent contradiction between the qualitative impression of Soviet difficulties with the absorption of advanced technology at the microeconomic level and the quantitative estimates of the impact of imported Western machinery at the macroeconomic level, derived from the SRI-WEFA Soviet econometric model. The results appear to show a greater payoff to the importation of foreign technology than might have been assumed from the qualitative-analytical and anecdotal literature (both Western and Soviet) on the Soviet economy.

A number of methodological problems in calculating Soviet gains from technology transfers come into focus when the process of technology transfer is considered more carefully. One of the major ones is omitted costs. In this study the reported Soviet expenditure on imports of Western machinery is related to the derived increments of industrial output. However, the process of technology transfer involves additional expenditures of domestic resources (particularly skilled manpower) as well as supplementary payments for technical assistance from abroad. Unfortunately, these expenditures at the aggregate level, at least those involving domestic resources cannot be observed. If one were to adopt the common "rule of thumb" of three rubles internal expenditure for each ruble of external expenditure, the impact multipliers would be reduced by a factor of four--from 12-15 to 3-4. This issue bears particularly on the "reasonableness" of the No-Detente scenario. One would expect that a reduction in the scale of imports would release domestic technology "transfer" resources to the factory floor, with a consequent increase in production from the scenario path. However, in principle at least, this potential reallocation of factors within aggregate industry should already be taken into account by the econometric estimation over the sample period.

TABLE II-6

CONTROL SOLUTION AND DEMAND-SHIFT SCENARIOS, 1973-80

Indicator	Scenario B 10% Decrease	Control Solution	Scenario A 10% Increase
		1975-80 Growth	
Gross national product*	23.5%	24.0%	24.6%
Industrial production†	39.5 (30.8)%	40.6 (31.8)%	41.7 (32.8)%
Petroleum products	42.5 (36.6)%	43.4 (37.5)%	44.4 (38.5)%
Chemicals & petrochemicals	52.5 (31.3)%	55.0 (33.5)%	57.4 (35.5)%
Machine building	53.6 (32.7)%	54.5 (33.5)%	55.0 (33.9)%
		1980 Value (Billion 1955 Rubles)	
Stock of imported machinery			
Aggregate industry	18.41	19.57	20.72
Petroleum products	3.18	3.37	3.57
Chemicals & petrochemicals	3.45	3.67	3.88
Machine building	3.46	3.66	3.85

* Five-year moving average for 1975.

† Western sample indexes for Soviet industrial output are in parentheses. These growth projections are converted to Official Soviet statistics using adjustment factors determined for 1966-70.

D. The Tenth Five Year Plan (June 1976)[1]

This assessment of the feasibility of the Soviet 10th FYP was the result of analysis employing SOVMOD II, then the current version of the SRI-WEFA Econometric Model of the Soviet Union. This assessment was based on the Basic Guidelines for the Soviet economy for 1976-80, which were published in the Soviet Press following their approval at the 25th Communist Party Congress,[2] and on projections of the world economy.

There are many advantages in using an econometric model for evaluating official Soviet Plans. First, since the model is an interdependent system of technical and behavioral relations, the analyst is able to consider indirect effects as well as direct effects, i.e., the total system impact, in quantitative terms. Second, since this macromodel is concerned with income flows and expenditures throughout the Soviet economy, one may explore the consequences of a Plan in areas not treated extensively in the published document. For example, we will consider the consequences of the Plan for household income and consumption, the State budget, controlled and market prices, the composition of foreign trade, and the Soviet balance of payments. Third, the establishment of the model with supporting software allows the analyst to construct a variety of alternative projections, encompassing total system effects, based upon variations in Soviet policy, the world economy, and the weather.

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[1] See Donald W. Green, Gene D. Guill, Herbert S. Levine, Peter Movic, "An Evaluation of the 10th Five Year Plan Using the SRI-WEFA Econometric Model of the Soviet Union," SRI-WEFA Working Paper #47, July 1976 (to be published in: Joint Economic Committee, Soviet Economy in a New Perspective, GPO, 1976).

[2] See Pravda (9 March 1976)

1. Overview

A reduction of aspirations was signaled first by the Plan and State Budget for 1976, published two weeks before the initial draft of the Basic Guidelines for the Tenth Five Year Plan in December 1976. The Ninth Five Year Plan had been significantly underfulfilled and the growth rates foreseen for the Tenth Five Year Plan were less ambitious and in line with actual experience under the Ninth Plan. Two bad harvests, in 1972 and 1975, were major factors in the underfulfillment, but it is clear that the gains in productivity that had been anticipated in the Ninth Plan were unrealistic. Only the target for the growth of foreign trade had been overfulfilled--linked, in part, to Soviet concern with lagging productivity.

The stress in the Tenth Five Year Plan is on improvement of the efficiency of production. The diminishing rate of growth of the labor supply and the diminishing effectiveness of capital investment in increasing output were implicitly recognized. The Plan calls for industrial labor productivity to grow more rapidly than capital investment. Since no major organizational changes in the economy are anticipated by the Plan, its fulfillment may well depend on imports of machinery and equipment from the Developed West.

2. Control Solution for the Soviet Economy, 1973-80

The term "control solution" indicates that a judgment of conditional plausibility and internal consistency has been made by the analyst. A forecast, on the other hand, discriminates among control solutions through the study of additional criteria for plausibility. This control solution begins in 1973, since values for some of the variables in SOVMOD II were not available beyond 1972.

A comparison of the control solution with the Basic Guidelines for the Tenth Five Year Plan indicates that aggregate output targets for industry and agriculture are feasible. Plan projections for growth in real income per capita and real volume of foreign trade, however, were not borne out in the control solution.

TABLE II-7

COMPARISON OF THE TENTH FIVE YEAR PLAN WITH THE SOVMOD II CONTROL SOLUTION

(Percentage Growth from 1975 to 1980)

	Basic Guidelines Targets[1]	SOVMOD II Control[2]
GNP	--	24.9
National income	24.-28.	--
Industrial output	35.-39.	39.4 (30.7)[3]
Industrial labor productivity	30.-34.	33.8 (25.4)[3]
Industrial employment	3.8	4.2
Agricultural output (5-year average)	14.-17.	14.5 (12.5)[3]
Real income per capita	20.-22	18.3
New Capital investment (5-year total)	24.-26.	25.0
Total consumption	--	24.4
Foreign trade turnover	30.-35	23.3

[1] Source: Pravda (March 1976)

[2] Source: SOVMOD II Control (5 May 1976)

[3] Model projections converted to Soviet GVO projections using adjustment factors computed for 1966-70. The unadjusted SOVMOD II projections are given in parentheses. The adjustment factor is a standard approximation: (1. + g (Official) / 1. + g (Western), where g = rate of growth

TABLE II-8

THE GROWTH OF INDUSTRY, 1976-80

(Percentage Growth from 1975 to 1980)

Industrial Category	Output	Labor Productivity	Employment	SOVMOD II Control Projection: Output[1]	Labor Productivity[1]	Employment
Total industry	35-39	30-34	3.8	39.4	33.8	4.2
Dept. A (Producer goods)	38-42					
Dept. B (Consumer goods)	30-32					
Electroenergy	34-38	27-29	6.3	33.0	29.1	3.0
Petroleum						
Crude	26-30	28-30	-0.8			
Refined products	25-30	39-41	-8.9	43.4	44.4	-0.7
Natural gas	38-50	43-45	0.			
Coal	13-16	22-24	-6.9	11.9	30.4	-14.2
Ferrous metallurgy						
Steel	13-21	23-25	-5.6	19.7	24.4	-3.8
Nonferrous metallurgy						
Rare metals	30	23-25	4.8	36.0	30.8	4.0
Chemicals & petrochemicals	60-65	59-61	1.6	53.9	52.7	0.8
Machine-Building & metalworking	50-60	50	3.3	51.8	40.3	8.2
Construction materials	30	24-26	4.0	34.9	30.6	3.3
Forest products	} 22-25	25-27	} -1.2	23.5	28.5	-3.9
Paper and pulp		23-25		37.8	35.9	1.4
Light industry	26-28	23-25	2.4	18.8	15.3	3.0
Processed food	23-25	24-26	-0.8	23.6	25.2	-1.3

[1] Model projections are converted to Soviet GVO projections using adjustment factors computed for 1966-70.

TABLE II-9

FOREIGN TRADE CONSEQUENCES OF THE 10TH FYP

Composition by Area, Imports and Exports

Area	Share of Total Imports 1973	Share of Total Imports 1980	Share of Total Exports 1973	Share of Total Exports 1980
CMEA	0.518	0.528	0.464	0.455
Other Socialist	0.072	0.042	0.109	0.077
Developed West	0.294	0.351	0.237	0.345
LDC	0.115	0.078	0.090	0.060
Unspecified	0.001	0.001	0.100	0.063

Measures of Hard Currency Liquidity[1]

Gold-Import Ratio = Value of Gold Reserves at Market Price/Total Imports from the Developed West.

Debt-Export Ratio = Total Debt Less Hard Currency Stock/Total Exports to the Developed West.

Year	Gold-Import Ratio	Debt-Export Ratio
1973	1.116	0.669
1974	1.663	0.489
1975	0.778	0.896
1976	0.679	1.223
1977	0.822	1.013
1978	0.741	0.803
1979	0.667	0.612
1980	0.599	0.442

[1] The estimates of Soviet gold reserves, hard currency reserves and indebtedness used in the model were published in J.T. Farrel, "Soviet Payments Problems in Trade with the West," in Joint Economic Committee, Soviet Economic Prospects for the Seventies (Washington, 1973).

Scenario I, an alternative considering Soviet restriction of imports, was motivated by the following reasoning:

- unrestricted imports may be infeasible either because the required expansion of exports cannot be accomplished or because hard currency deficits incurred are unacceptable to the leadership, Western bankers, or both;
- after the very poor 1963 harvest, the USSR faced a similar dilemma and the scenario was based on that type of response.

Thus, in Scenario I, imports of machinery and raw materials from the CMEA and the Developed West were reduced as well as drawings on Western credit. As a result, Soviet GNP growth over 1976-80 was reduced by 2.1%, industrial growth by 2.5%, growth of real per capita income by 2.7%, and growth of total consumption by 3.7%.

Variations in weather conditions were examined in Scenarios II-A and II-B. In scenario II-A, above-normal weather conditions, the conditions of 1966-70, were imposed and for Scenario II-B, the below-normal weather conditions of 1961-65 were imposed. Normal weather, as assumed in the control solution, was defined as the sample mean for the weather variables over the 1959-72 period.

Scenario II-A shows the growth of GNP to be 10.7 billion rubles greater over the five-year period due to the above-normal weather. Scenario II-B, on the other hand, show GNP growth for the Tenth Five Year Plan reduced by almost 9 billion rubles from the control solution projection. About 60% of the weather impact falls on new capital investment; the remainder, on inventories and residual end-use categories. The impact on food consumption is nearly compensated by changes in the consumption of durables. Surprisingly, industrial output growth is greater than the control in both Scenario II-A and II-B. While the above-normal weather impact is to be expected, the below-normal weather increase in the growth of industrial output can be traced to model projections of population movement and nonagricultural labor participation.

While targets for industrial growth at the branch level also appear feasible, the control solution again raises some questions. Because the allocation of capital investment among the branches of industry had not been published, investment was allocated by the model on the basis of historical patterns. A comparison of the plan and control solution projections for light industry, then, indicates that fulfillment of the plan target for that branch would require a greater allocation of capital investment to light industry than that projected by the model. On the other hand, the modest target for the petroleum industry in the plan may indicate the restriction of growth of investment from historical rates by planners or anticipation of diminishing effectiveness of capital investment.

The control solution projects that the current degree of income-expenditure imbalance with a mild rate of domestic inflation will persist over the 10th FYP period. An increasing gap between administered prices and "free" farm prices might well trigger a price reform, judging from past experience. A growing deficit in the State Budget is also projected and an adjustment in expenditures or revenues will be required.

Agriculture is expected to remain a lagging sector through the 1976-80 period. This has been recognized by the leadership as to made evident by the moderation of the growth target in the Tenth Plan. While the plan document gives little detail in the foreign trade sector, the model projects a relative increase in Soviet trade with the CMEA and Developed West and relative decline in trade with the Third World. The measure of Soviet hard currency liquidity is projected to fall sharply in the control solution, and the ratio of debt less stock of hard currency to total Soviet exports to the Developed West rises substantially through 1976.

3. Scenario Experiments

Several alternative projections to the control solution were considered to examine the total system impact of variations in Soviet import policy, weather conditions, and the state of the world economy.

TABLE II-10

SCENARIO RESULTS: MAIN INDICATORS FOR 1976-80

Indicator: Rates of Growth	Control Solution	Scenario I: Import Restriction	Scenario IIa: 1966-70 Weather	Scenario IIb: 1961-65 Weather
GNP	23.5%*	23.0%*	24.5%*	23.3%*
Industrial output	39.4%†	38.4%†	39.5%†	39.5%†
Agricultural output (5 year average)	14.5%†	14.5%†	17.5%†	12.1%†
Real income per capita	18.3%	16.8%	19.4%	17.6%
New capital investment (5 year total)	25.0%	25.0%	26.2%	23.8%
Total consumption	24.4%	23.5%	23.9%	25.3%
Foreign trade turnover (real)	23.3%	16.1%	23.5%	23.2%

Notes:

*Since GNP in 1975 is depressed because of the poor harvest, we have related a GNP five-year average (1973-77) of the Control Solution to the level of GNP in 1980.

†Model projections were converted to Soviet GVO projections using adjustment factors computed for 1966-70.

TABLE II-11

SCENARIO IMPACT OF WEATHER ON SOVIET GROWTH, 1976-80

Scenario IIa: 1966-70 Weather Pattern

Scenario IIb: 1961-65 Weather Pattern

Variable (Units)	Scenario	Control Value 1976	Scenario Less Control Value 1976	1977	1978	1979	1980	Sum 1976-80
Gross national product	IIa	469.30	3.50	-0.82	1.52	1.10	5.42	10.72
(B. 1970 rubles)	IIb	469.30	-0.49	0.61	-6.85	-1.52	-0.70	-8.95
New capital investment (total)	IIa	114.54	0.73	0.58	0.96	1.32	2.69	6.28
(B. 1969 rubles)	IIb	114.54	-0.12	-0.02	-1.61	-2.05	-2.34	-6.14
Food Consumption	IIa	133.24	0.52	0.10	0.26	1.00	1.64	3.52
(B. 1970 rubles)	IIb	133.24	-0.05	0.08	-0.81	-1.24	-1.14	-3.16
Durables consumption	IIa	21.15	-0.05	-0.27	-0.41	-0.80	-1.24	-2.77
(B. 1970 rubles)	IIb	21.15	0.01	0.05	0.23	0.89	1.57	2.75
Agricultural production	IIa	74.77	3.53	-0.98	1.47	1.07	5.31	10.40
(B. 1965 rubles)	IIb	74.77	-0.50	0.64	-6.95	-1.23	-0.52	-8.56

TABLE II-12

THE IMPACT OF THE WESTERN RECESSION

ON THE SOVIET ECONOMY, 1976-80

Scenario III: Recession in World Trade, 1975-76, Replaced with Steady 7% Growth

	Units	Control	Scenario III
Growth in GNP, 1975-80	Percent	23.5*	23.9*
Growth in industrial output, 1975-80	Percent	39.4†	40.3†
Nominal growth of Soviet imports of machinery & equipment from the Developed West, 1974-80	Percent	137.	143.
Nominal growth of Soviet exports to the Developed West, 1974-80	Percent	158.	170.
Hard currency reserves, 1980 (end year)	$ Million current	-798.	1451.
Debt-export ratio,** 1980	-	0.442	0.194

Notes:

* Five-year average (1973-77) used for 1975 level of GNP.

† Model projection converted to Soviet GVO basis.

** Debt less Hard Currency Reserves divided by Total Exports to the Developed West.

Scenario III was designed to examine the impact of the Western recession on the Soviet economy. The scenario replaced the 1975 recession observed in world trade by steady growth at 7% for 1975-80. Credit drawings on the West were also reduced by $4 billion. In comparison with the control solution, industrial production in Scenario III was 3.85 billion rubles greater over the 10th FYP and the Soviet Union's international position in 1980 was much improved, $2 billion additional in hard currency reserves and a lower debt ratio. The longrun impact on industrial output from increased machinery imports would primarily occur after 1980 because of the lags involved in import and installation.

4. The Input-Output Component Applied to the Tenth Five Year Plan

Two alternative projections were attempted for the 10th FYP using the integrated I/O component of SOVMOD II. In Alternative I, the growth rates of material inputs were imposed from the control solution projections. Generally, projected branch growth rates were lower in Alternative I because of reduced output elasticities for capital in the three-factor production functions. This indicates the general sensitivity of production functions. This indicates the general sensitivity of production function projections to variations in specification.

In Alternative II, branch material inputs were determined endogenously through the interaction of the I/O system and the three-factor production functions. The greatest changes from Alternative I to Alternative II occurred in industrial branches with the largest output elasticities for material inputs. Sectoral interdependencies introduced in Alternative II have a leveling effect on branch growth rates--i.e., branches that were projected to have growth rates less than the economy average grow more quickly under Alternative II than in the Control.

5. Conclusions

This evaluation of the Soviet Tenth Five Year Plan using the SRI-WEFA Model leads to a conclusion of Plan feasibility, at least for the main indicators released in the Basic Guidelines. This conclusion, it should be noted, depended upon the Plan itself for only indications of the employment constraints and Soviet investment intentions. From there, the Model's projections rest basically on the past performance of the Soviet economy as captured in the system of estimated equations. In a sense, then, Soviet planners appear to have adjusted their expectations to past experience, rather than rely on the adjustment of experience to excessive expectations.

The Model suggests certain areas of likely Plan underfulfillment as, for example, in the somewhat strained Plan targets for growth in incomes and foreign trade. There is also some divergence between the Plan and the control solution in the targets for individual industrial branches. It is possible, however, that these divergencies have appeared because the (unpublished) Plan allocation of investment differs from the Model's projections.

The Model also generates, in a system-wide consistent way, a wealth of detail which appears in the control solution. While only reporting on a small portion of this detail, we have indicated continuing difficulties in the agricultural sector and a potential realignment of internal prices. Pressure for such a realignment stems from three sources of strain in the system: a model-predicted divergence between administered and free prices, a widening deficit in the State Budget, and continued pressures of world inflation through the foreign trade sector. All three strains could be "eased" by implementing another "price reform".

E. Alternative Long Range Soviet Growth Strategies[1]

In another application, SRI analysts used SOVMOD II to examine Soviet economic growth prospects over the next 15 years, allowing for variation in both domestic and external conditions. This study was directed toward an assessment of the impact of economic factors on the Soviet Union's long run position in the world arena. Although the Soviet system is directed by political criteria in setting its goals, Soviet authorities are constrained in their choices among economic policy alternatives. Land, labor, capital and system-wide productivity are all under great pressure, even though input productivities are generally far below Western levels. In addition, Soviet policy is increasingly influenced by their participation in the world market. The study sketched four alternative economic paths for the USSR over the next 15 years. These scenarios are only first approximations of the more detailed scenarios around specific issues which could be formulated using the SRI-WEFA Soviet econometric model.

1. The Baseline Projection

A baseline projection to 1990 was constructed by extending the SOVMOD II Control Solution. It projects output growth slowing down through the 1980s, a trend reflecting a number of powerful underlying forces, especially the growing shortage of labor. Tightness in the labor market results not only from a slow growth rate for total population, but also from a lower participation rate in both agriculture and industry over the next 15 years. The projection for agriculture assumes "normality" in weather conditions and a stabilization of the ratio between actual and potential grain harvests at the favorable ratio of 0.9. Nonetheless, the

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[1] See Holland Hunter, M. Mark Earle, Jr., and Richard B. Foster, "Assessment of Alternative Long-Range Soviet Growth Strategies," June 1976 (to be published in: Joint Economic Committee, Soviet Economy in a New Perspective (U.S. GPO, Washington, 1976)

agricultural sector continues to lag behind the rest of the economy. Finally, the baseline projection assumes that Soviet economic relations with the outside world continue in their present form over the next 15 years. Under these assumptions, Soviet imports and exports continue to expand along the lines that have developed in the last decade.

2. Four Alternative Frameworks for Growth

Soviet economic expansion can easily deviate from the baseline projection if domestic and external conditions over the next 15 years change markedly. Four alternative hypothetical paths were constructed using sets of adjustments and assumptions.

The first projection tested the impact of easy conditions, both domestic and external. A parameter was inserted for technological progress in all sectors to improve productive effectiveness beyond what is already in the baseline production functions. Import and export prices were adjusted to improve Soviet terms of trade. The result of these adjustments enables the USSR to substantially increase its output over the baseline projection. Consumption growth rates do not fall as under the baseline projection, while investment grows much more rapidly. The overall annual growth rate for GNP jumps in the early 1980s and then declines to a level above that of the late 1970s. Both consumption and investment increase their share of GNP by comparison with the baseline projection.

In the second projection, hard conditions, both domestic and external, were assumed. Technological progress in the 1980s is 2% per year less favorable than in the baseline projection and external terms of trade move against the USSR. Such unfavorable conditions noticeably reduce the growth rate of Soviet output. The impact is especially severe on consumption. Services sector output is larger under these conditions than in the baseline projection since services are less affected by foreign trade. The combined impact of these developments reduces the share of consumption in GNP compared to the baseline projection.

The third projection combined easy conditions at home with difficult external conditions. In this case, the downward impact from abroad is concentrated in consumption while investment and other GNP end-uses react more favorably to easy domestic conditions than in the baseline projection. Food consumption rises as a result of favorable domestic conditions, but consumption of durables and services falls markedly in response to the unfavorable developments assumed for foreign trade. Average growth rates for GNP are only slightly lower than with favorable trade conditions.

Finally, the fourth projection assumes difficult conditions internally and favorable conditions in foreign trade. The results show perceptible shifts in internal consumption of output, favoring households. Aggregate consumption is lower than in the baseline projection while investment is off and other uses fall. This time, the change in consumption reflects a sharp downward shift in the availability of food, while other consumption categories are higher than in the baseline test.

3. Six Policy Variations, Responding to Altered Conditions

Using SOVMOD II, the impact of hypothetical changes in policy that might occur in response to specified surrounding conditions can be tested. In the event that easy domestic and external conditions prevail in the early 1980s, Soviet authorities might decide to direct more resources into investment. The effect of such a policy, as shown by this variation, would be to raise the level of GNP slightly. Stronger application of this policy would tighten consumer belts. Another policy intervention under favorable conditions might be increased attention to national defense. The results are unattractive. The levels of household consumption and investment are lower than without policy changes, while the measure of defense purchases is up, and the net impact is to reduce GNP. An opposite policy change might arise if, for example, defense outlays were held constant after 1982 under an international agreement. In this case GNP will rise, as will consumption, whereas the added investment option reduces consumption. The general implication is clear: reductions in Soviet defense outlays release resources that can provide both greater consumption and greater investment in heavy industry.

Should domestic conditions prove less favorable than anticipated, a strong regime might put more resources into investment. In this variation, the results are similar to those of adding more investment when conditions were easy. There is a net stimulus to the economy, but further policy shifts in this direction would be at the expense of household consumption. Favorable conditions in foreign trade do not permit the USSR to make up for difficulties in the domestic economy. Another policy, if external conditions are favorable and domestic conditions difficult, might be an increase in defense expenditures. Here, GNP goes down compared to the projection without the defense increase and consumption and investment will fall; consumers' belts are tightened and industrial growth is slowed.

Finally, under a scenario where domestic conditions are easy, but external economic trade conditions are unfavorable, the policy might be to reduce defense outlays. In this case, consumption and investment will rise compared to their levels without policy adjustments, and GNP as a whole also rises. The modest responses resulting with the present model formulation suggest that actual responses in the USSR would be larger, and more substantive defense reductions would have an even more beneficial effect on the civilian economy.

4. Economic Implications

Although these alternative projections are far from specific forecasts, a few general conclusions can be drawn. The major finding is that Soviet output expansion will continue to slow down, except under assumptions of extremely favorable surrounding conditions. The slacking off of labor-force increments, declining effectiveness of capital investment, and other forces that have caused the tapering growth of the last 15 years will influence the coming 15 years as well. A second observation is that the Soviet economy, especially outside agriculture, has been expanding in a stable, unswerving fashion--though at gradually declining rates-- for a quarter of a century, and that this steady growth has not ended. Third, these computations suggest how hard it will be, in the absence of major institutional changes, for the Soviet economy to respond in any fundamental way to the benefits of large-scale participation in the world economy. In particular processes, however, where advanced foreign technology has been installed successfully, striking gains have resulted. Major constraints on Soviet gains from foreign trade in the 1980s are the limited dimensions of Soviet export capacity and limited world demand for Soviet exports, and the limited internal flexibility of the Soviet system. Finally, the examination of upward and downward shifts in defense spending indicates how responsive the Soviet economy would be if such policy changes were made. Increased defense outlays cut heavily into both consumption and investment increase. The broad impact of defense changes is prompt and unambiguous, while the consequences of changes in external trade conditions are less certain.

III MACROMODEL DEVELOPMENTS IN THE SRI-WEFA MODEL: SOVMOD III

While the SRI-WEFA group was utilizing SOVMOD II in the applications discussed in Chapter II, the development of a third-generation model was already in progress. This new model, SOVMOD III, represents a major advance beyond SOVMOD II for three major reasons. First, it is estimated using more recent Western estimates for Soviet GNP, production, income and consumption; these new data include the OER's final versions of the 1970 GNP accounts and also the data appearing in the 1976 J.E.C. volume.[1] Second, it incorporates a revised specification for industrial production functions and a disaggregated agricultural sector which emphasizes the importance of grain production and the livestock sector. Third, it provides for the first time a component of equations which moves the Input-Output matrix over time, thus providing the capacity for long-term projections using an endogenous input-output system. This Chapter discusses the first and second features, the macromodel developments in SOVMOD III. In Chapter IV, the new I-O component in SOVMOD III will be presented and explained.

A. The Data Base for SOVMOD III

The SRI-WEFA Model has been constructed using a combination of official Soviet data and Western estimates.[2] In regard to the Western reconstructed data used in the Model, SOVMOD I and II were estimated

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1 Office of Economic Research, USSR: Gross National Product Accounts, 1970, A (ER) 75-76, November 1975; Joint Economic Committee, U.S. Congress, The Soviet Economy in a New Perspective, U.S. GPO, Washington, 1976 (hereafter referred to as JEC 76).

2 A discussion of these data issues is provided in Donald W. Green and Christopher I. Higgins, SOVMOD I: An Econometric Model of the Soviet Union, Chapter 1 and Appendix B (New York: Crane-Russak, 1977).

with estimates available in the fall of 1973 when the project began. This included the estimates for Soviet agricultural output, industrial output, household income, consumption, wages, employment, and foreign trade which appeared in the JEC 1973 volume.[1] The GNP accounts in the Model, both established price weights in 1970 and time-series for many GNP components, were based on a preliminary working paper with Appendices which was made available to us in October 1973.[2] These estimates were not extended to 1973 and 1974; instead, there were shifts in methodology and price weights which eventually culminated in the database which was used in SOVMOD III.

Some of these revised Western estimates were available during the estimation of SOVMOD II in Phase Two of the project. New employment data, provided by the Foreign Demographic Analysis Division, U.S. Department of Commerce, were used in the population and employment block.[3] New industrial output indexes based on 1970 prices were used in the estimation of production functions for branches of industry. However, the major macromodel development in SOVMOD II was the disaggregation of supply to seventeen sectors and most of the SOVMOD I database was maintained.[4] Since most of the revised data was still provisional, it seemed preferable to postpone reestimation with the new

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1 Joint Economic Committee (U.S. Congress), Soviet Economic Prospects for the Seventies (U.S. GPO, Washington, 1973). (Hereafter referred to as JEC 73).

2 Office of Economic Research, Estimates of Soviet GNP, Working Paper (October 1973).

3 Stephen Rapawy, Preliminary Working Papers, FDAD, Bureau of Economic Analysis, U.S. Department of Commerce, Mimeo (1974).

4 Donald W. Green, Lawrence R. Klein and Herbert S. Levine, "The SRI-WEFA Soviet Econometric Model: Phase Two Documentation," SSC-TN-2970-3, SRI/Strategic Studies Center, Chapter III (October 1975).

database until Phase Three. It should be emphasized, therefore, that although the applications reported in Chapter II were based on SOVMOD II, it is the new SOVMOD III which incorporates as its database the latest estimates by Western experts.

In a later section of this Chapter, the GNP accounts in SOVMOD III will be discussed and compared with the OER estimates. In the remainder of this section, we will briefly describe the other new data utilized in the estimation of SOVMOD III and how these data differ from those used for SOVMOD I.

1. Agricultural Data

The agricultural sector in SOVMOD I was estimated using OER estimates based on 1965 and 1966 prices. In particular, the 1966 Soviet input-output table was used for expenditure weights in the series for material inputs. Furthermore, 1968 prices were used in the aggregation of commodity output series and the value of livestock. The new OER agricultural data used in SOVMOD III are conceptually the same, but 1970 prices are now used.[1]

2. Industrial Output Data

The new industrial output indexes used in SOVMOD III differ from the old SOVMOD I indexes because of a shift in price weights from 1968 to 1970, some changes in the commodity samples, and the introduction of some new methodology for the construction materials and machine-building branches.[2]

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[1] David W. Carey, "Soviet Agriculture: Recent Performance and Future Plans," in JEC 76.

[2] Rush V. Greenslade, "The Real Gross National Product of the U.S.S.R., 1950-1975", in JEC 76.

3. Household Income and Consumption

SOVMOD I data on household income and consumption were largely derived from the estimates by Bronson and Severin.[1] To their estimates of household money income was added an estimate of agricultural income-in-kind extended from the RAND studies of Soviet GNP over the period 1956-66. In the past several years there have been several methodological and empirical changes in the OER estimates of income and consumption and these innovations have been incorporated in data which are used in SOVMOD III. The price weights have also been changed from 1968 to 1970 to be consistent with the GNP accounts.[2]

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[1] David W. Bronson and Barbara S. Severin, "Soviet Consumer Welfare: The Brezhnev Era," in JEC 73.

[2] Gertrude E. Schroeder and Barbara S. Severin, "Soviet Consumption and Income Policies in Perspective," in JEC 76.

B. Disaggregation of the Agricultural Sector

Early in the initial Phase of the SRI-WEFA Project it became clear that the agricultural harvest played a central macroeconomic role in the Soviet economy. The agricultural sector also poses a major challenge to the econometric modeler because of the simultaneity of output and variable inputs. Two systems of simultaneity appear to be relevant for Soviet agriculture. The first system connects weather conditions, employment, wages, material inputs from other sectors and agricultural production. The second system of simultaneity concerns the livestock sector and connects crop output to the increment in the herd, feed for livestock and animal product output. The first system of simultaneity caused estimation problems for earlier econometric studies of Soviet agriculture, problems which resulted in a very high output elasticity for labor.[1] In SOVMOD I, this estimation problem was solved with a two-stage procedure: (1) a linked-peak series was explained by the primary factors of labor and capital, and (2) deviations from peak output were explained by weather variations.[2]

In SOVMOD II, this approach to agricultural production was extended to the determination of grain output, a variable important in the foreign trade component of the model. Because the grain series (both the official series and Western-adjusted series) are dominated by a small number of bumper harvests, a linked-second peak series was interpolated and defined as capacity output. This series was regressed on labor (state and collective farm employment only) and capital with actual deviations from

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1 Hans-Jürgen Wagener, "Sectoral Growth - The Case of Soviet Agriculture," Forschungsbericht 1973 (Osteuropa-Institut München, Munich, 1974); Michael Marrese, "An Econometric Model of the Soviet Agricultural Sector," SRI-WEFA Working Paper #21 (July 1974).

2 Donald W. Green, "The Agricultural Sector of the SRI-WEFA Model," SRI-WEFA Working Paper #26 (September 1974).

capacity determined by weather variables. The two weather variables constructed for SOVMOD I, spring-summer precipitation and winter temperature, have been updated and are still used in SOVMOD II and III.[1]

A reestimation of the agricultural sector was necessary for SOVMOD III given the availability of new OER data in 1970 prices. At the same time, it seemed promising to disaggregate the agricultural sector and to investigate the grain balance estimates recently released by OER. A production function for grain was estimated using the official Soviet output statistics as part of a general econometric analysis of the grain balance data. The general conclusion of that analysis was that the estimates of grain stocks derived from the balances were not as statistically significant as proxy measures derived from production alone.[2] Consequently, the grain balance system was not introduced in SOVMOD III although the production function for the official grain series was included in the final model.

The disaggregation of the agricultural sector began with the separation of collective farm employment from state farm employment. This involved the estimation of separate participation equations (N.11 and N.12) and wage equations (W.2 and W.3). Collective farm employment varies with current harvest conditions while employment on state farms does not. After a harvest failure, the equations indicate a shift toward state farm employment and away from collective farms. Private agricultural employment was found to rise during better harvest conditions. The average wage on State farms was found to adjust to the smoothed capacity-output series (XAGTN) while the collective farm wage adjusted to the actual output series (XAGT70). Collective farm incomes, as was known before, adjust much more to the conditions of the past harvest.

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1 Green and Higgins, op.cit., Appendix B.

2 Donald W. Green, "The Soviet Grain Balance: An Econometric Evaluation of the OER Estimates, 1960-1973," SRI-WEFA Working Paper #48 (June 1976).

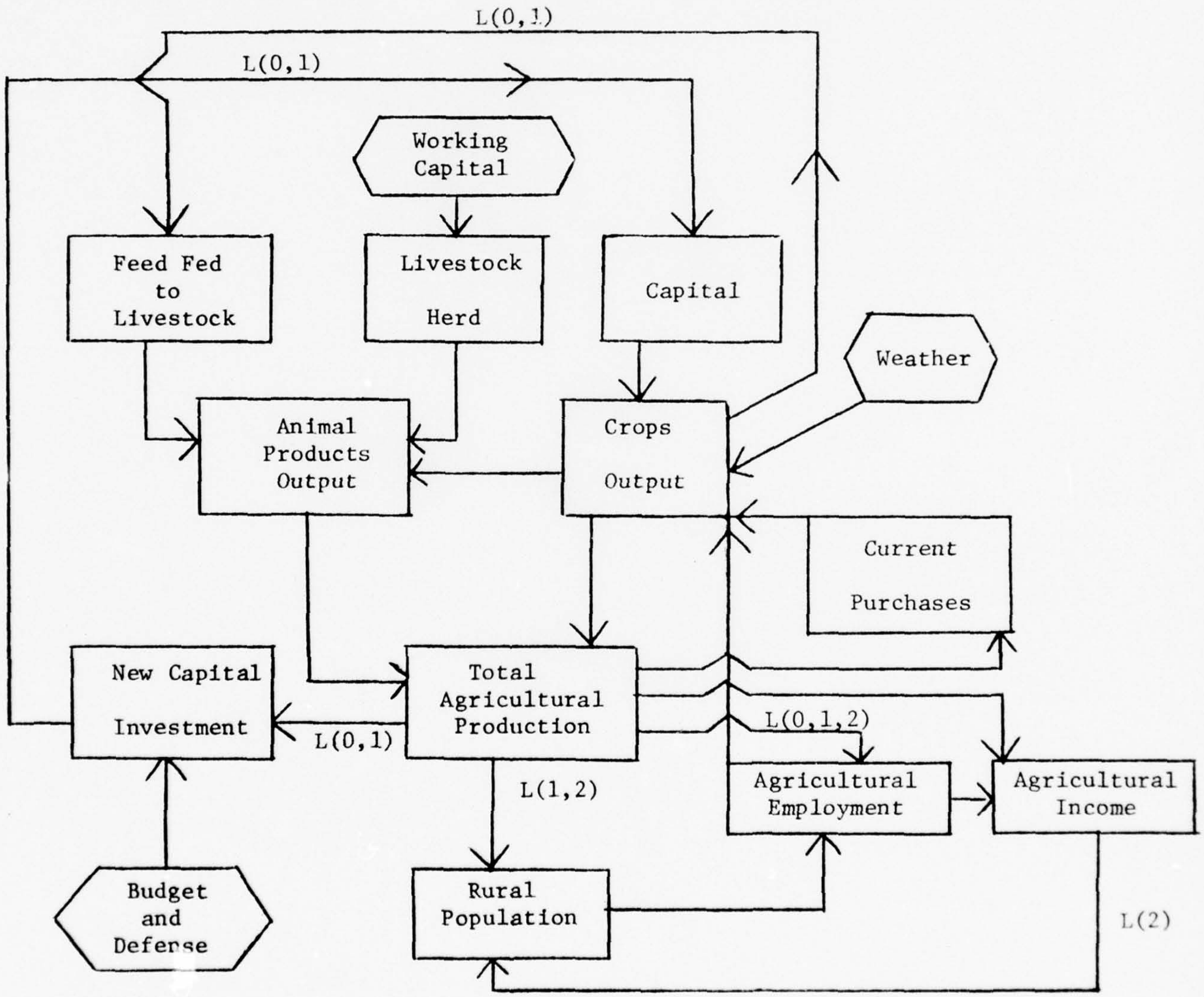
Besides the production functions for total agricultural output and grain, functions have been estimated for total crop output, animal products, and meat production. In Figure III-1, a simplified diagram of the agricultural sector in SOVMOD III is provided; not shown is the meat subsector within animal products and grain which is a component of crop output. The major exogenous variables in the sector are the weather indexes which influence crop output, annual budget financing and defense expenditures which affect capital investment in agriculture, and the structure of working capital which influences the growth of the livestock herd. The two systems of simultaneity are clearly indicated in Figure III-1: (1) the interdependence of the livestock herd and feed for livestock in the determination of animal product output, and (2) the simultaneity of total agricultural output, current purchases from other sectors, capital stock (through current investment), and employment (through collective farm participation rates). The simultaneity present in this agricultural sector of the SRI-WEFA Model should eventually lead to the application of simultaneous equation techniques in estimation.

Several features are noteworthy about the estimated equations in SOVMOD III. First, total agricultural output is predicted more accurately by the aggregate production function (X.1) than by using separate production functions for animal products (X.3) and crops (X.2) with the value of feed (A.3) subtracted. This suggests an offsetting movement which raises animal product output when crop output falls. This response is further indicated in the equation for meat (X.4) with a negative coefficient on the state of the harvest. Other components in the animal product category probably decline with poor harvest conditions, e.g., dairy products, resulting in the positive coefficient in equation (X.3).

Figure III-1

THE AGRICULTURAL SECTOR IN SOVMOD III

Links are simultaneous unless denoted by the lag operator: L(1,2) indicates a one and two-year lag. Hexagons indicate exogenous variables.



C. A Respecification of Industrial Production Functions

A very important aspect of Phase Three of the SRI-WEFA Project was a reconsideration of the production function literature on the Soviet Union. A central concern of this investigation was to establish a micro-economic view of Soviet production, consistent with Western understanding of Soviet planning and incentives, which would support a macroeconomic estimation of production functions. The approach, which is described elsewhere,[1] represents a technocratic or engineering view of Soviet organization. This provides a specification of the expansion path rather than a static conception of enterprise isoquants or cost functions. This approach does not require any assumptions of cost-minimizing or output-maximizing behavior.

The functional form eventually used in our SOVMOD III estimation is a rate-of-growth specification equivalent to a Cobb-Douglas production function:

$$\Delta X_t/X_t = C + a \Delta N_t/N_t + b \Delta K_t/K_t$$

Our reconsideration of the production functions in the SRI-WEFA Model was also stimulated by the experimental projections to 1980 using the I-O component in SOVMOD II.[2] It was observed that the introduction of material inputs into the specification of production tended to reduce the output elasticity for capital; in projections, this often reduced the growth rates for industrial branches. This sensitivity in projections to variations in specification indicated the value of judgmental consideration and experimentation. Consequently, in the determination of production functions for SOVMOD III we have not been guided solely

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[1] Donald W. Green, "The Microfoundations of Soviet Production Functions: An Engineering Approach," SRI-WEFA Working Paper #45 (April 1976).

[2] Green, Guill, Levine and Miovic, op.cit., Section 5 in JEC 76.

by econometric results. Technical progress rates have been imposed for several branches given the typical multicollinearity in these estimations. We have also tried to make the two factor and three factor production functions more consistent in terms of factor elasticities. The parameters for industrial branches included in SOVMOD III are presented in Table III-1 below.

TABLE III-1

PRODUCTION FUNCTION PARAMETERS FOR SOVMOD III[1]

Branch	Two-Factor Labor	Two-Factor Capital		Two-Factor Trend	Three-Factor Labor	Three-Factor Capital		Three-Factor Materials	Three-Factor Trend
Electronenergy	.696 (7.53)	.284 (7.18)		.03	.899 (5.82)	.293 (4.19)		.051 (1.28)	(1968 on) .031 (3.69)
Coal products	.183 (1.68)	.340 (6.93)		.01	.175 (1.17)	.467 (4.96)		.048 (0.69)	
Petroleum products[2]	.373	.385 (3.80)	.253 (3.98)		.225	.429 (3.63)	.078 (1.16)	.143 (1.79)	
Ferrous metals	1.058 (3.18)	0.164 (1.91)		.02	.816 (3.58)	.036 (0.42)		.267 (2.64)	.02
Nonferrous metallurgy[6]	.609 (1.72)	.325 (3.83)		.02	.380 (1.16)	.292 (2.65)		.110 (0.71)	.02
Chemicals and petrochemicals[2]	.359	.192 (4.45)	.089 (3.51)	(1965 on) .047 (5.78)	.143	.212 (2.22)	.099 (2.52)	.128 (0.67)	(1965 on) .042 (3.66)
Machine-building and metalworking[2]	.907 (5.36)	.260 (3.03)	.196 (2.75)		.718 (3.23)	.113 (0.95)	.166 (1.85)	.200	
Forest products[3]	.486 (0.99)	.237 (5.64)		.02	.128 (2.30)	.342 (4.48)		.248 (2.30)	
Paper and pulp[6]	.324 (1.21)	.281 (2.55)		.02	.166 (0.77)	.393 (4.32)		.310 (4.88)	
Construction materials	.59	.176 (3.03)		.051 (5.13)	.284	.206 (1.53)		.171 (1.15)	.030 (1.39)

TABLE III-1

PRODUCTION FUNCTION PARAMETERS FOR III[1] (continued)

	Two-Factor			Three-Factor			
Branch	Labor	Capital	Trend	Labor	Capital	Materials	Trend
Soft goods[4] (cont)	.921 (4.60)	.219 (4.11)		1.435 (3.36)	0.033 (0.19)	0.161 (1.14)	
Processed foods[5]	.639 (1.91)	.102 (0.91)	.01	.863 (2.74)	.121 (1.23)	.177 (2.76)	

1 t-Statistics of estimated parameters are indicated in parentheses below the parameter. Parameters imposed are those without such statistics. Labor share in 1970 established price value-added used for imposed labor parameters in two-factor equations; that share is multiplied by the ratio of value-added to gross value of output in 1970 for three-factor equations.

2 In these branches, capital is disaggregated into domestically produced fixed capital and imported machinery, respectively.

3 In the three-factor equation for forest products the estimated coefficients for labor and material inputs are constrained to the proportions of labor share and material inputs in the gross value of output.

4 The two-factor equation for soft goods also has a coefficient for lagged agricultural output (0.228; t-statistic 3.12) as a proxy for material inputs.

5 The two-factor equation for processed food also has a coefficient for the lagged harvest measure (0.020; t-statistic 1.67), the ratio of actual to capacity output.

6 The capital series used for nonferrous metallurgy is the series for ferrous metallurgy; for paper and pulp, the forest product capital series is used.

D. Income and Consumption

With the availability of revised estimates for income and consumption as discussed previously, those components of the SRI-WEFA Model were respecified in some respects and then reestimated for SOVMOD III. Disposable money income of households in current rubles is calculated using OER procedure and estimated as follows:

ZGW*	Gross earnings, State employees	Equation	(Z.1)
+ZWK*	Collective farm wage payments	"	(Z.2)
+ZSAG*	Income from the sale of farm products	"	(Z.3)
+ZMPA*	Military pay and allowances	"	(Z.4)
+BTRAN*	Transfer payments	"	(B.7)
+ZPCP*9	Distribution of cooperative profits		
=ZTG*	Gross household money income	"	(Z.5)
-TAXES*	Personal taxes	"	(T.6)
-TDUES*9	Dues, trade union and party		
-TINSP*9	Insurance premiums		
=ZTD*	Disposable household money income	"	(Z.6)

Wage earnings (ZGW* + ZWK*) are a function of employment and average wages for the six productive sectors with agriculture disaggregated for State and Collective farmers. The income from agricultural sales is a function of the current harvest and the negotiated agricultural price. Transfer payments to households are also dependent on the current harvest, as well as upon the government wage rate. Taxes on the population are related to gross wage earning through estimated statutory tax rates (T.5) with adjustments for local taxes and lotteries.

Real disposable income is computed by deflating nominal money income by the consumption price deflator and adding a 1970 ruble estimate of agricultural income-in-kind. The latter estimate from the RAND GNP estimates for 1956-66 is extended to 1974 on the basis of actual and normal agricultural harvests. The estimate in 1960-65 prices is shifted to 1970 rubles using the negotiated agricultural price. Previously, this RAND estimate was treated as a current ruble figure added to disposable money income before deflation. Essentially, the new procedure in SOVMOD III augments disposable money income (the OER measure deflated) by a real measure which is moved by the agricultural harvest.

In the final revision of SOVMOD II, a new alternative of consumption was introduced where the services category is a direct function of the output measure for services. The other consumption categories would then be either income-determined or GNP-determined through the residual end-use variant of the SRI-WEFA Model.[1] In SOVMOD III, there are now five alternative determinations of household consumption defined below:

	Alternatives				
	I	II	III	IV	V
Aggregate consumption	IN	ID	RE	RE	ID
Food	ST	IN	ST	SN	SN
Nondurables	ST	IN	ST	SN	SN
Durables	ST	IN	ST	SN	SN
Services	ST	IN	ST	XS	XS
Non-Services	ID	ID	ID	ID	IN

Where
ID = Identity Determination
IN = Income-Determined
RE = Residual Determination
SN = Share of Non-Services
ST = Share of Total
XS = Output Determination of Services

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1 Green and Higgins, op.cit., Chapter 6

E. Defense and State Reserves

In the initial specification of the SRI-WEFA Model, Soviet defense expenditures were treated primarily as a prior claim on the production of durable goods. The Model was specified so that the impact of defense expenditures was measured by a real rate of growth or a ratio of nominal expenditures. Thus the level of Soviet defense expenditures did not affect the estimated behavioral relations in the Model; the level of Soviet defense only appeared in the GNP accounting of end-use. We provisionally adapted the Cohn "budgetary approach" in separating the official defense budget into personnel and nonpersonnel components.[1] The nonpersonnel component plays an important role in SOVMOD II in constraining the growth of new capital investment and consumer durables.

It became clear by Phase Three of the SRI-WEFA project that a more extensive analysis of the Soviet defense sector was required. However adequate the budgetary approach was as an indicator of the trend in Soviet defense through the mid-1960s, it is clearly inadequate for the period since 1965. The virtually constant level of the official defense budget over the period 1970-75 cannot be reconciled with other indications of increasing Soviet military strength and the growing sophistication of Soviet military hardware. Consequently, an extended specification of the defense sector was designed and partially implemented in Phase Three.[2]

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1 Stanley H. Cohn, "Economic Burden of Defense Expenditures," in JEC 73.

2 Donald W. Green, "The Defense Sector in a Soviet Macromodel: A New Specification for the SRI-WEFA Model, "Working Paper #43 (January 1976; revised July 1976).

In the present version of SOVMOD III, Cohn's estimate of the non-personnel component of the official defense budget continues to play a role as a constraint on other categories of the use of durable goods. However, the personnel category has been explicitly decomposed into a manpower level (exogenous) and an average wage for military manpower which is related to the average wage for Soviet industry. Furthermore, a new category of State Reserves has been added to the end-use side of the national accounts using Cohn's recent estimate derived from the working capital accounts.[1] His estimation begins with a control total for annual growth in working capital and reserves. The estimate of the growth in state reserves is a residual after the subtraction of changes in working capital of State enterprises, unfinished construction and working capital of collective farms. This estimate of the change in State Reserves is now used in SOVMOD III as an indicator of defense expenditures beyond the budgets for defense and science. The composition of this category remains unclear but it probably includes mostly procurement of military durables. Since Cohn's preferred deflator for this series, an equal-weighted index of the official price index for MBMW and Becker's adjusted index, is virtually equivalent to a constant deflator, the series has not been deflated in the construction of a constant 1970 ruble series for Defense and State Reserves. The levels of defense expenditures in SOVMOD III are higher than in previous versions of the model, though they are below the OSR revised estimate.[2]

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1 Stanley H. Cohn, "A Re-Evaluation of Soviet Defense Expenditure Estimates," SRI, Draft Copy (June 1976).

2 Office of Strategic Research, Estimated Soviet Defense Spending in Rubles, 1970-1975, SR 76-10121U (May 1976).

Several tasks remain for follow-on research in this area. This new estimate for State Reserves, as well as the extended OSR series and Lee's residual estimate for military procurement,[1] should be introduced in the behavioral equations for new capital investment and consumer durables. This will provide some indication of the statistical robustness of these different estimates. Furthermore, such alternative versions of the interaction between the military and civilian sectors could be compared in full-system simulations within the framework of SOVMOD III.

In Table III-2 below are presented the current and constant ruble estimates of Soviet defense and State reserves presently used in SOVMOD III, as well as their proportion in Soviet GNP.

TABLE III-2

DEFENSE LEVELS IN SOVMOD III

Year	Defense plus State Reserves (Billion Current Rubles)	Defense plus State Reserves (Billion 1970 Rubles)	Percentage of Real GNP: Defense plus State Reserves
1960	17.3	17.75	8.13
1965	29.6	30.61	10.70
1970	35.4	35.40	9.30
1974	39.4	40.18	8.79

[1] William T. Lee, Soviet Defense Expenditures for 1955-1975, GE75TMP-42 (Draft of 31 July 1975).

F. Other Developments in the Macromodel

Most other changes in the macromodel components of SOVMOD III represent minor adjustments in specification to control inconsistency or diverging trends for longrun projections. These adjustments frequently represent adaptations given the applications experience gained with SOVMOD II during Phase Three. This interplay of application and model refinement is an essential characteristic of good econometric modeling and forecasting. In this section, these minor refinements in the Model will be briefly described and explained.

1. Investment

The principal change in specification here was to normalize dummy variables to a mean value of zero rather than a positive number. Most of the administrative interventions in the capital investment sector have been in the downward direction. Projections based on equations estimated with typical dummy variables (equal to 0 or 1) are thus biased upwards. The current specifications for investment growth allow the model user to run projections which are most consistent with the sample-period growth rates by setting coefficients for administrative dummy variables to zero. Other trends previously embedded in these growth equations have been terminated within the sample period, e.g., housing investment. Campaigns to complete investment projects, which occurred in certain branches in 1969 and 1973-74, now play a prominent role. Such campaigns tend to reduce capital investment such project completion expenditures tend to be less than project initiation expenditures.

Inventories in domestic trade (1.21) are now related in equilibrium to light industrial output rather than the consumption of nondurables and durables. Shortrun movements in such inventories are now related to the current difference between light industrial output and consumption, the state of the harvest in the previous year, and the change in nonpersonnel defense expenditures.

Inventories in the nontrade, nonagricultural category are now related to the growth of heavy industrial output rather than total nongaricultural GNP. Annual variations in inventories are primarily explained by the gap between projected heavy industrial output (based on lagged growth rated over four years) and actual output.

Capital repair has been moved from the GNP block in SOVMOD I to the Investment block in the new model. A new variable for total investment (ISUM, I.26) has been introduced which includes new capital investment, capital repair, inventories, and changes in the livestock here. All variables are in 1970 rubles.

2. Capital

As in the capital investment equations, dummy variables have been set to a zero mean in order to provide more consistent projections. The exceptions to that occur when we feel a change in capital stock represents a spurious revaluation or sectoral transfer which does not change the longrun price conversion between investment expenditures and capital stock. Examples of the latter are the 3.5 billion ruble increment in basic funds in domestic trade in 1965 and the 7.75 billion ruble increment to the housing stock in 1962. The identities which determine the stock of imported machinery now utilize a conversion coefficient of .712 and the German export price deflator for nonelectrical machinery and equipment.

3. Wages

In this block, trends in the estimated equations have been delimited and dummy variables have been set to zero means; again, this is to enhance projective consistency for SOVMOD III. A system of additional wage equations has been estimated to determine relative wages by branch for the endogenous movement of the I-O Matrix.

4. State Budget

In the expenditures component of the budget block (B), trends and dummy variables have again been adjusted in respecification for gains in projection consistency. Two new categories have been added which appear in the GNP end-use accounts: an index of research and development expenditures and an index of State administrative expenditures. These categories differ from the State budget variables for science and administration.

5. Foreign Trade

The foreign trade block was not respecified and developed in Phase Three. The SOVMOD II specification for exports and imports, which was partially revised in the fall of 1975, was retained in SOVMOD III. Equations were reestimated only when the data for independent variables had changed; for example, the equation for exports of consumer goods to the CMEA was reestimated using the new series for agricultural output. The measure for hard currency liquidity was adjusted with a revision of world gold prices and therefore machinery import equations were estimated as well. SOVMOD III still includes equations for the endogenous determination of grain imports from the Developed West and gold sales, but those variables are usually exogenized for application studies using the Model.

G. The GNP Identities: End-Use and Income Residuals

SOVMOD I and II were constructed using a preliminary estimate of Soviet GNP in 1970 prepared by the Office of Economic Research. In Phase III, the new generation SRI-WEFA Model was designed to be compatible with the published version of the GNP accounts for 1970.[1] The control total of 380.7 billion 1970 rubles and the end-use composition will be matched by SOVMOD III. There are several differences in weights and time series selected to move GNP categories which do result in some variation between OER and SOVMOD III estimates of GNP for other years. In this section of the report, these differences will be briefly explained. Finally, the derivation of the GNP end-use residual and a GNP income residual used in the structure of SOVMOD III will be described.

On the sector-of-origin side of the GNP accounts, the major difference between SOVMOD III and the OER data is the set of established price weights. OER has removed state subsidies from sector GNP in established prices and these subsidies reappear in the category of unallocated. The unallocated category also includes the residual category of other money income for households. Rather than move this large component of GNP (33 billion rubles) with an arbitrary series set exogenously for the Model, subsidies have been returned to the sector-of-origin weights in established prices. The remainder (14 billion rubles) of other branches and unallocated is moved by the GNP total of observed sectors. Thus the sum of agricultural and nonagricultural GNP in the Model is increased by 3.7% to match the 1970 control figure.

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[1] Office of Economic Research, USSR: Gross National Product Accounts, 1970, A (ER) 75-76 (November 1975).

Besides the difference in weights, the SOVMOD III series for Soviet GNP will differ slightly from the OER series because different indexes are used for construction and transport/communications. In SOVMOD III, the output index for construction is the activity series for State construction organizations while the transport/communications index used is a weighted index of physical transport measures and the ruble series for communications.[1]

On the end-use side of the accounts there are no major differences in the 1970 established price weights. Differences do arise in the inventory measure and in the explicit treatment of net exports and defense in SOVMOD III. There are two categories of inventories in the SRI-WEFA Model: (1) domestic trade, and (2) nontrade, nonagricultural inventories. These series are constructed using the methodology of Moorsteen and Powell.[2] There is no explicit series included for agricultural inventories, including grain reserves, so those conceptually will appear in the end-use residual. Exports and Imports are aggregated in current dollars, converted to foreign trade rubles at the official exchange rate, deflated using official price indexes, and converted to domestic rubles using the conversion coefficients developed in SOVMOD I.[3] Defense expenditures appear explicitly in the end-use accounts of SOVMOD III as discussed in Section III-E above; these include the category of State Reserves separate from the inventory accounts of State organizations.

With the enumeration of the GNP accounts as summarized in Table III-3 below, there appears a residual category of end-use GRESEM3. Over the period 1960-73, this variable has a mean value of 2.7 billion 1970 rubles with a maximum value of 10 billion rubles. One half of the variance of GRESEM3 around a constant term is explained by the current and previous harvests[4], indicating the probable presence of agricultural inventories.

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[1] This series for transport/communications is documented in Green and Higgins, op. cit., Appendix B.

[2] Ibid.

[3] Ibid.

[4] See equation (G.6) in Appendix B to this Report.

TABLE III - 3

The GNP Accounts in SOVMOD III

Sector of Origin	End-Use	Income
Agriculture	Consumption	Household disposable income
Nonagriculture	Accumulation	Income
-Industry	-New capital investment	Amortization
Construction	-Capital repair	Taxes on the social sector
-Transport/ communications	-Inventories	
-Domestic trade	-Livestock additions	Taxes on the population
-Services	Administration	Gross profits
-Military manpower	Science	
Other branches and Unallocated	Defense	Unobserved income
	-Manpower	
	-Nonpersonnel	
	State reserves	
	End-use residual	
Total	Total	Total

Conceptually this category should also include valuation errors (foreign trade and 1970 weights for domestic categories), statistical discrepancy, and other unobserved categories of GNP end-use.

In the structure of SOVMOD III, the GNP accounting identities may be used to determine consumption as the residual end-use category and/or gross profits as the residual income category. The residual consumption features have been explained in Section III-D above. The residual income feature was added to the final version of SOVMOD II to provide a current ruble estimate of GNP and a residual estimate of gross profits. Observed income flows in current rubles are used as an estimate of nominal GNP, inflated to correspond with the 1970 estimate to GNP:

$$GNP3^* = (ZDT^* + ZIK60 \cdot PAFC70/100. + ZPG^* + ZDT^* + TOSS^* + TPOP^*)\ /.9231$$

Observed incomes are household disposable money income, agricultural income-in-kind, gross profits, amortization, State taxes on the social sector and taxes on the population. This income measure of GNP defines a deflator for GNP (PGNP3) which is modeled in Equation (P. 14): A 1% per year inflation rate and a 13% increase with the 1967 price reforms. The income identity may then be imposed in the simulation of SOVMOD III to determine gross profits with Equation (Z.9b).

IV THE INPUT-OUTPUT COMPONENT OF SOVMOD III

Macroeconometric models of market economies have traditionally emphasized the underlying determinants of demand and income while allowing aggregate production to be determined as the sum of expenditures of effective demand. Within this framework, aggregate demand performs the crucial role of stimulating industrial activity which in turn determines labor requirements and influences the level of investment. When these models are disaggregated, it becomes necessary to provide a link between the final expenditure categories and sectoral production. The first attempts at incorporating this link, which implies an input-output relationship, were made with regression equations relating sectoral output directly to the final expenditure categories of gross national product.[1] More recent attempts have sought to take advantage of the nonstochastic estimates of the elements of the conversion matrix provided by input-output data.[2]

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[1] F.M. Fisher, L.R. Klein, and V. Shinkai, "Price and Output Aggregation in the Brookings Econometric Model," in J.S. Duesenberry, G. Fromm, L.R. Klein, and E. Kuh, eds., The Brookings Quarterly Econometric Model of the United States (Chicago: Rand McNally and Co., 1965) and D.T. Kresge, "Price and Output Conversion: A Modified Approach", in J.S. Duesenberry, G. Fromm, L.R. Klein, and E. Kuh, eds., The Brookings Model: Some Further Results (Chicago: Rand McNally and Co., 1969).

[2] R.S. Preston, "The Wharton Annual and Industry Forecasting Model", Economics Research Unit, Department of Economics, University of Pennsylvania (1972); and R.S. Preston, "The Wharton Long Term Model: Input-Output Within the Context of a Macro Forecasting Model," International Economic Review, Vol. 16, No. 1, pp. 3-19 (February 1976).

Although our work in developing the input-output component of the SRI-WEFA Soviet Econometric Model has benefited greatly from earlier work in the area, the role of the input-output component in the SRI-WEFA Soviet Econometric Model is quite different from that of the input-output component in econometric models of market economies. This difference is due principally to the emphasis which the SRI-WEFA Soviet Econometric Model places upon the determinants of production and supply rather than demand and income. Within SOVMOD the primary causal flow runs from input supplies, to output, and finally to end use. Production functions perform the crucial role of transforming inputs into outputs which are then distributed among final spending categories. Consequently, it was desirable to develop an input-output component which would interact with the production functions in the determination of sectoral outputs. This chapter discusses the development of the income-output component of SOVMOD III and describes in detail the interaction between the input-output component and the macromodel.

A. Development of the Input-Output Component

1. The Input-Output Component of SOVMOD II

In addition to its role as a second-generation macroeconometric model, SOVMOD II was also designed as a framework for extensive experimentation with the integration of an input-output system. The principal objective of this research was the determination of a sequence of balanced input-output tables for the period 1959-72. The basis for the derivation of this sequence of tables is provided by the Soviet input-output tables constructed for the years 1959, 1966 and 1972.

As is generally known, these Soviet input-output tables have never been released in their complete three-quadrant formats, and it has been necessary for Western analysts to reconstruct the missing entries in these tables before they can be used in Western studies of the Soviet economy.[1] At the present time the 1959 and 1966 reconstructions have been completed and these tables are available for use.[2] The 1972 table, however, was only released in 1975, but we are grateful to Professor Treml and analysts at the Foreign Demographic Analysis Division of the U.S. Department of Commerce for providing a preliminary version of this reconstructed table in time for these data to be included in the present study.[3]

The technique which was used to derive the sequence of balanced input-output tables for the years 1959-72 was a combination of linear interpolation and weighted RAS balancing.[4] The weighted RAS algorithm was designed to distribute the adjustments across the coefficient matrix in accordance with the stability of individual coefficients. Since it was

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1 Vladimir G. Treml, Dimitri M. Gallik, Barry L. Kostinsky and Kurt W. Kruger, The Structure of the Soviet Economy (New York: Praeger Publishers, 1972).

2 Vladimir G. Treml, Dimitri M. Gallik, and Barry L. Kostinsky, "Conversion of Soviet Input-Output Tables to Producers' Prices: the 1966 Reconstructed Table," Foreign Economic Reports, No. 1, U.S. Department of Commerce (Washington, 1973); Vladimir G. Treml, Dimitri M. Gallik, and Barry L. Kostinsky, "The Conversion of Soviet Input-Output Tables to Producers' Prices: The 1959 Reconstructed Table," Foreign Economic Reports, No. 7, U.S. Department of Commerce (Washington, 1975).

3 This preliminary version of the 1972 Soviet input-output table is in purchasers' prices. Since we have chosen to work with the input-output tables in producers' prices, it was necessary to convert the 1972 table into producers' prices. This conversion was carried out by the author according to the methodology described in Treml, et al., "The Conversion of Soviet Input-Output Tables to Producers' Prices: The 1966 Reconstructed Table," op. cit.

4 Gene D. Guill, "The RAS Method of Coefficient Adjustment and Soviet Input-Output Data, "Working Paper #34 (September 1975).

not possible to deflate the reconstructed Soviet input-output tables to a constant price base and there exists theoretical as well as empirical support for the argument that input coefficients are likely to remain more stable in current prices than in constant prices,[1] it was decided to apply this estimation procedure to the current price input-output data. The annual data required by this procedure-observations on sectoral GVOs and material inputs in current prices-were largely constructed from sebestoimost' data available in Soviet statistical handbooks.[2] The particular problem posed by the 1967 price reform was handled by revaluing the 1966 table into postreform prices and treating the revalued table as benchwork data for the estimation between 1966 and 1972.

This estimation procedure generates a set of input-output tables in current prices for the period 1959-72. In order to integrate these tables into the constant 1970 price macromodel, it is necessary to incorporate price deflators for each point where there is feedback

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1 L.R. Klein, "In the Interpretation of Professor Leontief's System," The Review of Economic Studies, 20, pp. 131-136 (1952-1953); Klein, A Textbook of Econometrics, pp. 200-210, (Evanston, Ill.: Row, Peterson and Co., 1953); J. Haldi, "A Test of Two Hypotheses Concerning Interpretation of Input-Output Coefficients," Weltwirtschaftliches Archiv, 83, pp. 1-14 (1959); K. S. Sarma, "Comparative Performance of Input-Output Models with Alternative Production Functions," unpublished Ph.D. thesis, University of Pennsylvania, Philadelphia, Pa. (1972); C.B. Tilanus and G. Rey, "Input-Output Volume and Value Predictions for the Netherlands, 1948-1958," International Economic Review, 5, pp. 34-35 (1964); P. Sevaldson, "Changes in Input-Output Coefficients" in T. Barna (ed.) Structural Interdependence and Economic Development, pp. 303-328 (New York: St. Martin's Press, 1963).

2 This procedure involved the reconstruction of the Soviet financial accounts for each industrial sector beginning with the year 1959. In this exercise, data on employment, average wages, fixed capital stock, amortization, and profits were applied to the official Soviet distribution of costs in percentage terms to yield estimates of the gross value of output and value-added by industrial sectors.

between the two systems. In SOVMOD II this work was only partially completed, i.e., crude price deflators were used for the conversion of the constant price gross output predictions of the production functions into current prices and a single crude materials price was used to deflate material inputs.

The primary function of the input-output component in SOVMOD II is to account for the interdependency among the producing sectors of the model. This function is carried out by introducing information concerning material input flows among the sectors. First, total material input flows into each producing sector were included as a third factor in the estimated production functions along with labor and capital. The input-output tables were next transformed into allocation matrices by dividing each flow by its row total. These matrices were then introduced into the model as exogenous matrices which remained unchanged for a given year. The material input flows became endogenous variables which changed in response to changes in gross sectoral outputs. In the final solution, sets of material inputs and gross outputs were calculated which were mutually consistent with the input-output coefficient matrix for that year.[1]

Since the balanced input-output tables were derived only for the years 1959-72, it is necessary to record input-output data for years beyond 1972 in order that this exogenous input-output system can be used in forecasting exercises. For these exercises the 1972 input-output table was usually recorded for each year in the forecast period.

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1 The procedure described in this paragraph is only one of three alternative procedures in which exogenous input-output data can be introduced into SOVMOD II and used in determining an endogenous set of material inputs. In the other two procedures the input-output tables are first transformed into matrices of direct input coefficients by dividing each flow by its column total. In contrast to the procedure described above, these matrices of direct input coefficients are allowed to change in the solution process for a given year. Since our experience with these last two algorithms is limited to sample period simulations, they are not described in this chapter.

In other words, this system incorporated the assumption that the structural relationship reflected in the 1972 input-output table did not change in future years. Forecasts with this system and comparisons between these forecasts and the forecasts obtained using the two factor production functions of SOVMOD II revealed that the exogenous input-output component imposed a "leveling" effect on sectoral growth rates rendering unbalanced or disproportional development difficult to maintain.[1] Although the constraints imposed by this input-output system are partially valid, it is not possible to separate the effects of the introduction of sectoral interdependencies from the assumption of unchanging structural relationships among the sectors in the forecast period. Consequently, the primary objective in the further development of the input-output component became the endogenization of the input-output relationships themselves. This research, which is presented below, has enabled SOVMOD III to incorporate gradual changes in the intersectoral relationships among the producing sectors of the Soviet economy.

2. Experiments with Linear Programming

As mentioned in the previous section, the sequence of balanced input-output tables used in SOVMOD II was derived using techniques of linear interpolation and a modified RAS balancing procedure. This balancing procedure was constructed as a minimization algorithm in which

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1 Donald W. Green, Gene D. Guill, Herbert Levine, and Peter Miovic, "An Evaluation of the Tenth Five Year Plan Using the SRI-WEFA Econometric Model of the Soviet Union," in JEC 76.

objective functions were specified for each of the rows and each of the columns of the coefficient matrix. Indexes reflecting the stability of individual coefficients through time were introduced into these objective functions as the cost or penalty associated with the adjustment of each coefficient. These indexes enabled the balancing algorithm to pass the major impact of adjustment onto the less stable coefficients. This algorithm was then implemented as an iterative adjustment process in which adjustments were first carried out for the rows and then for the columns of the coefficient matrix - each time bringing the matrix more and more into balance with its marginal totals.

In spite of the desirable characteristics of this balancing algorithm, it remains the case that this adjustment procedure operates upon the rows and the columns of the coefficient matrix separately and thereby divides the adjustment process into discrete steps which are carried out in an iterative fashion. Because of this step-by-step implementation of the adjustment process, this method of coefficient adjustment fails to take into account the interdependencies of the rows and columns in the complete balancing process. For this reason, the indexes designed to affect the relative adjustment of coefficients in a prescribed manner in each step in the balancing procedure may fail to have the desired effect in the overall balancing process.

An alternative means of estimating the changes in input-output coefficient matrices which does take into account the interdependencies of the rows and columns in the overall adjustment process was developed by Matuszewski, Pitts, and Sawyer.[1] This algorithm differs from the weighted RAS method in that it relies upon linear programming rather

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[1] T.I. Matuszewski, P.R. Pitts, and John A. Sawyer, "Linear Programming Estimates of Changes in Input Coefficients," Canadian Journal of Economics and Political Science, Vol. XXX, No. 2, pp. 203-210 (May 1964).

than an iterative matrix balancing process to produce consistency between the estimated matrix and its marginal totals. As noted by Matuszewski, Pitts, and Sawyer, linear programming appears to provide a particularly well suited means of accomplishing this task since first, it can be used to minimize the adjustments over the entire coefficient matrix which are necessary to yield an "updated" matrix consistent with the marginal totals of the current year, and second, it is sufficiently flexible to allow the use of supplementary information concerning the changes in specific cells in the input-output matrix while maintaining the consistency of the overall results.

In our work in improving the input-output sector of SOVMOD II, we attempted to modify the estimation procedure of Matuszewski, Pitts, and Sawyer[1] and derive a sequence of input-output tables for the Soviet economy using this modified linear programming algorithm. These tables were then to be compared with the tables derived using the weighted RAS procedure in order to obtain additional insight into the properties of these matrix adjustment algorithms.[2]

The results of this research revealed that the accuracy of the estimates obtainable with this linear programming algorithm depends to a

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1 The modifications introduced into the linear programming algorithm were intended to render the data required by this estimation procedure consistent with the data available for the Soviet economy and improve the accuracy of the algorithm. In regard to the latter modification, indexes reflecting the stability of individual entries in the input-output matrix were introduced as coefficients of the activity variables in the objective function. These coefficients were intended to shift the major impact of adjustment onto the less stable flows of the input-output matrix.

2 For a detailed discussion of this research, see Gene D. Guill and R.S. Preston, "The Use of Linear Programming in Estimating the Changes in Soviet Input-Output Data," SRI-WEFA Soviet Econometric Model, Working Paper #41 (December 1975) and Gene D. Guill, Input-Output Within the Context of the SRI-WEFA Soviet Econometric Model," SRI-WEFA Soviet Econometric Model, Working Paper #44 (April 1976).

great extent upon the availability of supplementary information which can be introduced into the estimation procedure. This information might take the form of exact information describing the changes in a relatively large number of flows in the input-output table or a general set of constraints which describe the behavior of flows fairly accurately. In either case, this information was not available for the Soviet economy. Consequently, it was decided that the dependency of this modified linear programming algorithm on supplementary information rendered it less appropriate for the task of estimating a series of input-output tables for the Soviet economy than the weighted RAS procedure.

3. Endogenization of the Input-Output Component

A major advance in the development of SOVMOD is the complete endogenization of the input-output component. This feature allows the structural relationships among sectors to change in response to information generated within the macromodel. As a result, the input-output component of SOVMOD III can be used in scenario analysis and forecasting exercises without imposing an exogenous input-output structure on the producing sectors of the model.

The techniques which were used to endogenize the input-output relationships within the SRI-WEFA Soviet Econometric Model were derived from earlier results of Hickman and Lau[1] and Preston.[2] The first of these writers (Hickman and Lau) were concerned with the problem of changing coefficients in international trade share matrices and sought to explain these changes on the basis of relative prices, a time trend, and a partial adjustment variable. Recognizing the applicability of this work to the

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1 B.G. Hickman and L.J. Lau, "Elasticities of Substitution and Export Demands in a World Trade Model," European Economic Review 4, pp. 347-380 (1973).

2 Preston, "The Wharton Long Term Model," op. cit. and R.S. Preston and Yuen-Yun C. O'Brien, "Trade Impact Studies Using the Wharton Annual and Industry Forecasting Model," prepared for the United States Department of Labor, Bureau of International Labor Affairs (1975).

problem of price-induced material input substitution in an input-output framework, Preston used the techniques developed by Hickman and Lau to provide a means of directly endogenizing input-output relationships within the Wharton Long Term Model. The typical estimating equation used by Preston is of the form

$$x_{ij} - \ell^{o}_{ij} x_{\cdot j} = -\sigma_j x^{o}_{ij}\beta_{ij} - \sigma_j x^{0}_{ij}\alpha_{ij} t - \sigma_j (1-\delta_j) x^{o}_{ij} (P^{P}_{i} - P^{R}_{j}) \tag{1}$$

$$+ \delta_j (x_{ij} - \ell^{o}_{ij} x_{\cdot j})_{-1}$$

where

x_{ij} = constant dollar delivery of material inputs from sector i to sector j.

$x_{\cdot j}$ = constant dollar value of total material inputs into the j^{th} producing sector.

ℓ^{o}_{ij} = $x^{o}_{ij}/x^{o}_{\cdot j}$, i^{th} product's share in the j^{th} producing sector's total material inputs (superscript $_o$ refers to base year data).

σ_j = elasticity of substitution between any two material inputs in the j^{th} production process.

P^{P}_{i} = price index associated with the output of the i^{th} producing sector.

P^{R}_{j} = $\sum_{i=1}^{R} \ell^{o}_{ij} P^{P}_{i}$, price index associated with the material inputs into the j^{th} producing sector.

δ_j = partial adjustment coefficient entering the function from a partial adjustment hypothesis.

β_{ij} = constant term

t = time trend

α_{ij} = time trend coefficient.

In estimating this equation, all observations on the deliveries of material inputs to the j^{th} producing sector are pooled, and it is assumed that the σ_j are invariant with respect to the delivering sector. Linear restrictions are added to these pooled regressions to insure that the sum of the intercepts and trend coefficients for each producing sector, respectively, is equal to zero. When estimated in this way, the regression equations for the j^{th} producing sector possess the feature that adding across the delivering sectors results in a value of zero, i.e.,

$$\sum_{i=1}^{n} (x_{ij} - \ell^{o}_{ij} x_{.j}) = o$$

This property insures that the distribution of total material inputs among delivering sectors maintains the column identity of the input-output matrix.

The problem of endogenizing the input-output component of SOVMOD III is very similar in concept to the problem faced by Preston with the Wharton Long Term Model. However, since the Soviet economy is a planned economy in which prices are fixed by the state and do not reflect conditions of scarcity or demand, it is not reasonable to expect changes in relative input prices to be a primary factor in explaining shifts in material input use within a producing sector. Therefore, we decided to modify the Hickman-Lau specification, shown in equation (1), to include more appropriate measures of supply and demand conditions among material inputs in the Soviet economy. More research is still necessary in the attempt to derive meaningful shadow prices which could be substituted for observed prices in equation (1). In the meantime, it was decided to introduce average wage rates in producing sectors as the explanatory variables in this expression.[1] Equation (1) then becomes

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[1] Since the specification of equation (1) was derived under the assumption of cost minimizing behavior on the part of producers in purchasing material inputs to deliver a specific quantity of output, the modification suggested here weakens the theoretical basis of this specification. See P.S. Armington , "A Theory of Demand for Products Distinguished by Place of Production," International Monetary Fund Staff Papers, XVI, pp. 159-176 (March 1969).

$$x_{ij} - \ell^{o} x_{\cdot j} = -\sigma_j x^{o}_{ij} \beta_{ij} - \sigma_j x^{o}_{ij} \alpha_{ij} t - \sigma_j (1-\delta_j) x^{0}_{ij} (\omega^{P}_{i} - \omega^{R}_{j})$$

$$+ \delta_j (x_{ij} - \ell^{o} x_{\cdot j})_{-1} \qquad (2)$$

where

ω^{P}_{i} = average wage rate in the $i^{\underline{th}}$ producing sector

$\omega^{R}_{j} = \sum_{i=1}^{n} \ell^{o}_{ij} \omega^{P}_{i}$, an index of average wage rates weighted by the coefficients of the $j^{\underline{th}}$ producing sector.

Since wage rates in the Soviet economy are determined in part by the average productivity of labor, priority campaigns to attract labor inputs to a particular industrial branch, and locational circumstances which compensate for various disadvantages, a significant coefficient on the relative wage term in equation (2) is subject to several interpretations. First it may reflect a general priority of the producing sector. In this case, higher wage rates would probably be accompanied by higher allocations of investment funds and material inputs in order to increase the output of this sector. Commodities produced by this sector would then become more available in the overall economy, and it is likely that there would be a shift in favor of the use of these commodities as inputs among other producing sectors. If this interpretation is of primary relevance in explaining the relative wage rates among producing sectors in the Soviet economy, we would expect the σ_j's estimated with this specification to have a positive sign. There is also the possibility, however, that planners might attach a high priority to a given sector and successfully attract unskilled labor to that sector - thereby lowering the average wage rate within the industry. In this case it is no longer true that one should expect a positive sign on the estimated σ_j's.

An alternative explanation of a significant coefficient on the relative wage term in equation (2) suggests a recognition by planners of the relative scarcity of labor within the Soviet economy. According to this interpretation, planners might raise wages (and subsequently output prices in order to cover costs) in an effort to induce industries to substitute in favor of those material inputs with lower unit labor costs. Although this interpretation is less likely to explain the overall wage structure in the Soviet economy, it would be consistent with a negative sign on the estimated σ_j's.

The data required for the estimation of the coefficients in equation (2) are in part available from published sources, as either official Soviet releases or Western reconstructions of Soviet data, and in part must be constructed. Fortunately, estimates of ℓ^o_{ij} for the base year 1970[1] and time series data on x_{ij} were available from the sequence of balanced input-output tables in current prices used in SOVMOD II. Although the original Hickman-Lau equations were specified in terms of constant price data, it was necessary to use current price data in this exercise since only crude deflators are available for the Soviet economy with the exception of the 1967 price reform. Given ℓ^o_{ij} and the average wage rates in producing sectors, the ω_j^R are computed as

$$\sum_{i=1}^{n} \ell^o_{ij}\,\omega_i^P = \omega_j^R \ .$$

Selected results obtained using this pooled time series-cross section constrained regression technique are presented in Table 1. This table presents the estimated values of the short run elasticity of substitution $\sigma_j(1-\delta_j)$ and the speed of adjustment coefficient δ_j for 15 producing sectors and a single aggregate final demand category. In all cases but one, the speed of adjustment coefficients is highly significant and falls within the stable range of zero and one. The short run elasticity of substitution is positive in 11 of the 16 catagories presented. Among the remaining five catagories in which the elasticity of substitution is negative, its value is statistically significant in only two.

[1] Since the SRI-WEFA Soviet Econometric Model is constructed using 1970 base year weights, it was decided to use 1970 as the base year in this exercise.

TABLE IV-4

ESTIMATES OF $\sigma_j(1-\delta_j)$ AND δ_j FOR 15 PRODUCING SECTORS AND FINAL DEMAND

	$\sigma_j(1-\delta_j)$	δ_j
Metallurgy	-0.0766 (-0.4)	.6031 (9.1)
Coal	-0.1404 (-1.0)	.8547 (11.4)
Petroleum & gas	1.4957 (6.2)	-0.1272 (-1.5)
Electrical power	-0.0593 (-0.6)	0.9136 (23.4)
Machine-building and metalworking	0.3557 (1.8)	0.5070 (7.5)
Chemicals	0.1744 (1.1)	0.9466 (17.5)
Forest products	0.2030 (1.8)	0.7204 (13.3)
Paper	-0.1851 (-2.0)	0.8622 (16.0)
Construction materials	0.1525 (1.4)	0.7588 (15.3)
Soft goods	0.0204 (0.3)	0.6605 (10.6)
Processed foods	0.0304 (0.2)	0.3949 (5.7)
Construction	-0.6243 (-4.4)	0.4042 (7.8)
Agriculture	1.2589 (5.7)	0.7397 (16.0)
Transport and communications	.506 (22)	0.9193 (19.0)
Trade & distribution	0.1092 (0.5)	0.9722 (24.9)
Final demand	0.3162 (2.3)	0.3908 (6.1)

The results of this exercise suggest that most producing sectors in the Soviet economy substitute in favor of material inputs produced by sectors with relatively high average wage rates. This finding is in agreement with the hypothesis that average wage rates reflect the relative availability of different products within the Soviet economy. Although the sign on the estimated short run elasticity of substitution for the construction industry is not in agreement with this hypothesis, it can be explained if expansion in that sector is usually associated with increasing the numbers of unskilled workers, thereby lowering the average wage.

Finally, the positive sign on the estimated short run elasticity of substitution for the aggregate final demand sector is most likely an indication of the dominance of investment and public consumption within this aggregate rather than an indication of the behavior of Soviet consumers. The sign on this estimated coefficient therefore suggests that there is substitution through time among those goals delivered for end-use purposes in favor of goods produced by sectors with high average wage rates, i.e., priority sectors.

B. Input-Output Within the Context of SOVMOD III

As mentioned in the description of the input-output component of SOVMOD II, the primary purposes of the input-output component in the SRI-WEFA Soviet Econometric Model is to account for the structural interdependencies among the producing sectors of the model. This task is carried out by introducing material inputs as a third argument in the sectoral production functions, and using the input-output component to determine a set of material inputs which are mutually consistent with the underlying technological relationships existing within the economy at that time. In SOVMOD II these technological relationships were imposed upon the model exogenously. In SOVMOD III these technological relationships are determined endogenously and change in response to information generated within the macro model. A detailed description of the functioning of the input-output component of SOVMOD III is most easily presented by tracing the interaction between the macro model and the input-output component in the sequence of the solution algorithm.

For the purposes of our description, we shall enter the solution process at the point where the production functions, involving labor, capital, and material inputs as explanatory variables, are solved. The material input variables entering these functions are taken from the previous iteration's predictions. The predictions are deflated to 1970 prices using price deflators developed in preliminary work on rebasing the sequence of balanced input-output tables into 1970 prices.

Since the vector of gross output estimates obtained from the production functions is in constant prices and index number form, it is necessary for these estimates to be transformed into current price, nominal value statistics before they enter the input-output component. The exogenous deflators used in this exercise were constructed by taking the ratio between the Soviet current price GVO (gross value of output) statistics, which are consistent with the input-output component, and the Western estimates of Soviet production, which are consistent with the production functions. This vector of GVO indexes is then converted into current rubles using output levels from the 1966 input-output table.[1]

This vector of current price GVOs is next passed to the input-output component and used in determining two sets of variables: (1) a vector

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[1] Although metallurgy is treated as a single producing sector in the input-output component, it is disaggregated into ferrous and nonferrous metallurgy in the macromodel. Because material inputs are determined within the input-output component, there is only a single variable for material inputs into the metallurgy sector. This variable is consequently deflated and entered into the production functions for both ferrous and nonferrous metallurgy. Similarly, before the gross output predictions for ferrous and nonferrous metallurgy obtained from the production functions enter the input-output sector, it is necessary to aggregate these statistics into a single prediction for the metallurgy sector. Since these predictions are in index number form, it is necessary that they be weighted according to their relative importance in the aggregate sector. The weights used in this aggregation were 1970 value-added weights.

of sectoral material inputs which will be fed into the production functions in the next iteration, and (2) an allocation matrix whose elements are defined by

$$b_{ij} = \frac{x_{ij}}{X_i} \qquad \begin{matrix}(i=1, \ldots, n) \\ (j=1, \ldots, n+1)\end{matrix}$$

where

x_{ij} = the current value delivery of the output of sector i to producing sector j.

X_i = the current value GVO of producing sector i.

This allocation matrix will be used in the next iteration in determining sectoral material input flows.

The procedure in which these sets of variables are determined is described as follows. After the vector of current price GVOs is determined and passed to the input-output component, *it is multiplied by the previous* iteration's allocation matrix to yield a standard input-output flow matrix in current prices.

$$\underset{(nxn+1)}{[X]} = \underset{(nxn)}{\tilde{X}} \quad \underset{(nxn+1)}{B^{i-1}} \qquad (3)$$

where

$[X]$ = (nxn+1) input-output flow matrix

$\tilde{X}$ = (nxn) diagonal matrix with current price estimates of GVOs entered along the main diagonal and all off-diagonal elements equal to zero.

B^{i-1} = (nxn+1) allocation matrix determined in the previous iteration.

The elements along the columns of this flow-matrix are then summed to yield current price estimates of sectoral material inputs

$$\sum_{i=1}^{n} x_{ij} = x_{*\cdot j} \qquad (j=1, \ldots, n) \tag{4}$$

where

$x*_{\cdot j}$ = the current price value of material inputs into the j^{th} producing sector.

These estimates of sectoral material inputs will later be deflated and entered into the production functions in the next iteration.

Before returning to the macromodel, it is necessary to estimate an allocation matrix which can be used in the next iteration in determining sectoral material inputs. This matrix is constructed from a flow matrix estimated using the modified Hickman-Lau functions described in the preceding section. These functions require three sets of information: (1) current value estimates of total material input flows into each producing sector - obtained in equation (4); (2) information on average wage rates in producing sectors-generated by stochastic equations within the macromodel; (3) coefficients for the Hickman-Lau functions estimated over the sample period 1959-72. This information is entered into the modified Hickman-Lau functions, shown in equation (5) to yield a current value flow matrix.

$$x_{ij} = \ell^{o}_{ij} x_{\cdot j} - \sigma_j x^{o}_{ij} \beta_{ij} - \sigma_j x^{o}_{ij} \alpha_{ij} t - \sigma_j (1-\delta_j)\, x^{0}_{ij} (\omega^{P}_{i} - \omega^{R}_{j})$$

$$+ \delta_j (x_{ij} - \ell^{o} x_{\cdot j})_{-1} \tag{5}$$

The current iteration's allocation matrix is then constructed from this flow matrix by summing the flows along each row and then dividing each flow by its row total.

At this new point the vector of current value material input flows is deflated using exogenous material input price deflators and returned to the macromodel to enter the production functions in the next iteration. In the next iteration, this procedure is repeated and a new vector of material inputs and a new allocation matrix are calculated. In the final iteration, the values of material inputs and gross outputs will converge to their respective solution values. The values will be consistent with the structural relationships reflected in the allocation matrix used in the last iteration.

V FUTURE DIRECTIONS

A. Introduction

The extensive experience gained in building and using several generations of models of the Soviet economy has opened up new vistas in Western research on the centrally planned economies. The development of a family of econometric models has been an integral part of this vision of future research. Some applications would require only a small version of the SRI-WEFA Model, while others would require more detail with disaggregation in specific areas.

One might question this approach on the grounds that the different versions of the model would have different inner dynamics, tracing divergent paths under similar external impulses. So far, our experience with these models indicates that this is not a major problem. The main simultaneities and cyclical components can be found in all versions, representing what we called the core of the model.

What has changed has been the level of detail as different problems have been investigated. There still remains, however, a trade-off between the accuracy and ease of operation of the smaller versions, on the one hand, and the greater detail of the larger versions, on the other. This trade-off is shown by larger root-mean-squared errors for some variables in dynamic sample period simulations as we increase the size of the model, making more room for error cumulation. It should also be pointed out, however, that as the sample size was increased, better data obtained and preferred specifications settled on, the tracking of the different versions improved regardless of the size of the model. In the future, it is envisioned that more innovative and speculative research be carried out using the smaller core versions of the model, while the larger scale scenario-type applications, and particularly current forecasting, would be done with the more detailed versions.

B. Core Model Applications

1. Comparison with Other Centrally Planned Economies

Having succeeded in modeling the data generated by the Soviet economy, it would be interesting to see if the other centrally planned economies (CPEs) behaved in a similar way. Empirically, these comparisons could be carried out by applying the core model developed for the Soviet case to the other CPEs. If the approach were applied essentially uniformly to a series of countries, it would constitute a significant test of the hypothesis of technical, behavioral and administrative regularities embodied in the core model of the Soviet economy.

To be sure, one would expect to find significant differences in the relative importance of the different sectors (heavy industry of East Germany vs. agriculture of Bulgaria), openness of the economies (Hungary vs. the Soviet Union), or the impact of cyclicality in agriculture on the performance of the economy in question. We would also expect differences in speeds of adjustment in response to system contingencies discussed earlier in this report. Yet these divergencies would still be in the context and rhythm of coordinated Five Year Plans. By linking these models through their foreign trade sectors, we could also investigate the transmission of contingencies generated in one of the economies to their neighbors. This presents an unusual opportunity to conduct a series of comparative systems tests using a set of econometric models of different countries but all from essentially the same family.

2. Further Development of the Input-Output Component and of a Resource Allocation System

Our experience in long-run projections with SOVMODs I and II[1] has clearly indicated the importance of analyst intervention in factor

[1] Green and Higgins, op. cit., Chapter 4; Miovic, "Longterm Projections. . .", Earle, Foster, and Hunter, JEC 76.

allocation along the economy's growth trajectory. The factor allocation system simply was not built to respond to signals of existing or emerging shortages to the extent necessary to preserve intersectoral consistency over a horizon extending beyond 3-5 years. Yet Soviet priorities do shift, and material and labor shortages evoke responses by planners which should be quantifiable through careful econometric work.

In SOVMOD III this goal is considerably closer. The technology matrix now moves over time in response to a shifting composition of output generated by the production functions of the macromodel. In turn, as described in the previous chapter, the material inputs within the producing sectors are distributed in response to changing wages, a time trend and the previous year's material allocations. This creates the simultaneity essential to move the I-O table over time. On various paths traced by the full model, changing wages and changing labor productivity will have effects on sectoral growth rates. SOVMOD III thus exhibits an endogenous factor allocation mechanism for material inputs. This approach might be extended to influence the allocation of capital investment and labor in future work.

A major area of future work will be a disaggregation of final demand categories in the I-O matrix. This would permit the application of similar techniques to those used in moving the technology matrix over time. The comparison of deliveries generated by this input-output framework with the demands arising from the end-use side of the macromodel would generate a vector of excess demands. These could be used as synthetic measures of pressure within the economy when resource shortages force planners to change allocation patterns or objectives as expressed in the documents of the successive Five Year Plans. To keep consistency with the contingency approach used elsewhere in the model, these excess demands would be relevant in the various equations of the macromodel. Pressures that generate changes in the allocations of labor, capital and materials may be quite different from those affecting the inventory change or foreign trade.

3. A Guidance System for a Macromodel of the Planned Economy

One issue which has not been addressed directly by the SRI-WEFA Model concerns the ultimate goals of the Soviet system. The longterm paths of the capitalist market economies depend fundamentally on individual and collective preferences: the saving propensities of individuals and corporations, the distribution of income and the composition of consumer demand, and private vs. public sector consumption. Some guidance can be exerted in these economies through taxation and expenditure policies and there are certainly shifts in direction because of changes in technology, tastes and resources. There is no reason to presume, however, that these indirect guidance mechanisms are either consistent or in any sense optimal. In recent years, particularly with the advent of control theory, attempts have been made to introduce, sometimes only theoretically, a formal guidance mechanism into the determination of economic policies in market economies. A number of quantitative experiments have also been carried out usually by introducing an optimal control algorithm into a macromodel of the economy. Alternative policies are then simulated and evaluated according to a specified criterion. It will be some time, however, before this approach becomes part of the actual institutionalized process of economic decisionmaking.

In the case of the Soviet Union, successions of Five Year Plans have tried to set a course for the economy according to the vision of the future held by Soviet planners and the Party. If we could capture empirically these goals and the instruments being used to achieve them within the context of our econometric model, we could make a significant step in the direction of understanding the guidance system of the Soviet economy.

One of the main instruments that has been used in the past to push the Soviet economy in the desired direction has been the rate of capital accumulation. Targets for new capital investment, and their sectoral allocation, are available in the Plan documents. This information would be used to replace or supplement the shortrun budget financing data used presently in investment determination. Considering other instruments such as taxation, defense and nondefense state expenditures, and foreign trade objectives, we would have the basic tools to evaluate the feasibility and consistency of any selected expansion path.

At first, some of these instruments could remain as exogenous policy variables in the model. Eventually, a more formal procedure could be introduced by defining a loss function which would be minimized subject to the full SRI-WEFA Model as a constraint. The loss function would contain the targets and the instruments of particular importance. These would be aggregated with a set of weights reflecting the priorities of the planners. These weights could be determined by sample-period simulation or fixed exogenously.

C. Other Applications

The preparation of short and medium-term forecasts for the Soviet economy using the latest version of the model are expected to continue. Two years' experience at this task have now been accumulated. Forecasting records, however, are not built on the basis of a two-year experience. To be aware of the latest developments in the Soviet economy, as well as to keep the model current and improve it continuously, forecasting must be done on a regular basis.

Ideally, a major forecast would be done at least once a year. This forecast would embody the data revisions for the previous year or years, new model developments, new readings on the Soviet harvest (or weather conditions) and the data released in the Soviet annual plans. Between major updates, there could be special scenarios, analyzing the impacts of current developments in the Soviet and the world economy.

This may seem like a simple task once a model has been constructed. However, experience with models of Western economies confirms that a good modeler's work is never done. Models must be exercised continuously to preserve both the quality of the models and the teams of people associated with them.

APPENDIX A--VOLUME I

SRI-WEFA ECONOMETRIC MODEL: LIST OF WORKING PAPERS

0.[1] Green, Donald W. and Higgins, Christopher I., "A Preliminary Specification of an Econometric Model for the Soviet Union" (October 1973).

1.[1] Green, D. W., and Higgins, C. I., "The Use of Annual Plan Targets in an Econometric Model of the Soviet Economy: The Concept of an Implicit Plan," Appendices: List of Equations, List of Variables, Selected Bibliographies (December 1973).

2. Green, D. W., "Data and Accounting Issues Arising in the Construction of an Econometric Model of the Soviet Union" (December 1973: Revised, January 1974).

3.[1] Marrese, Michael, "A Preliminary Specification of a Soviet Agricultural Model" (December 1973).

4. Green, D. W. and Higgins, C. I., "Some Considerations in the Specification of a Plan-Behavioral Model of the Soviet Union" (February 1974).

5.[1] Higgins, C. I., "The Effects of Habit Persistence and Supply Constraints on Soviet Consumption: Some Preliminary Notes" (February 1974).

6. Saito, Mitsuo, "Econometric Studies on the USSR" (March 1974; Revised, September 1974).

7.[1] Higgins, C. I., "Notes on Trade Equations for the Soviet Model" (April 1974).

8. Green, D. W., "An Addendum to the Plan Behavioral Model of the Soviet Union" (April 1974).

9. Green, D. W., "The Soviet Construction Sector: Production Functions and Capital Formation" (April 1974).

10.[1] Green, D. W., "Capital Formation in Soviet Industry" (April 1974).

11.[1] Higgins, C. I., "Urban Labor Force, Non-Agricultural Wage Bill and Agricultural Employment" (April 1974).

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[1] Indicates paper has been superseded by a subsequent working paper.

12.[1] Marrese, M., "The Soviet Agricultural Sector: An Initial Glance" (May 1974).

13.[1] Green, D. W., "Capital Formation in Soviet Transport and Communications" (May 1974).

14. Green, D. W., "Soviet Transport and Communications, 1955-1972: Production Function Estimations" (May 1974).

15.[1] Green, D. W., "The Soviet Services Sector: Capital Formation and Production" (May 1974).

16.[1] Green, D. W., "Production Function Estimations for Soviet Industry" (May 1974).

17.[1] Green, D. W., "Nonagricultural Employment: Total and Sectoral Composition" (June 1974).

18. Green, D. W., "Capital Formation and Employment in the Non-agricultural Sectors of the USSR: The Implications for Production Function Estimates" (June 1974).

19. Higgins, C. I., "Average Wages: Can They be Endogenous?" (June 1974).

20. Higgins, C. I., "Choice of Market Determined Price for Agricultural Products" (June 1974).

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[1] Indicates paper has been superseded by a subsequent working paper.

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