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REVISED VERSION OF THE SOVAM

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FOREWORD

Understanding the nature and dimensions of the world food problem and the policies available to alleviate it has been the focal point of IIASA's Food and Agriculture Program (FAP) since it began in 1977.

National food systems are highly interdependent, and yet the major policy options exist at the national level. Therefore, to explore these options, it is necessary both to develop policy models for national economies and to link them together by trade and capital transfers. Over the years FAP has, with the help of a network of collaborating institutions, developed and linked national policy models of twenty countries, which together account for nearly 80 percent of important agricultural attributes such as area, production, population, exports, imports and so on. The remaining countries are represented by 14 somewhat simpler models of groups of countries.

The countries constituting the Council of Mutual Economic Assistance (CMEA) together are a major influence on the world market. An aggregate food and agriculture model of the CMEA, in which the CMEA is treated as one nation has been developed by the FAP, as part of the IIASA/FAP basic linked system.

In addition, development of detailed models for some of the major nations constituting the CMEA was undertaken. The development of the Soviet Agricultural Model (SOVAM) was started in late 1983 in collaboration with a number of institutions in the Soviet Union. These include the All-Union Research Institute of Cybernetics in Agriculture, the Computer Center of the USSR Academy of Sciences, the All-Union Research Institute for Systems Studies, and the Central Economic Mathematical Institute.

In this paper Vladimir Iakimets and Vladimir Lebedev describe a revised version of the SOVAM.

Kirit S. Parikh
Program Leader
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ABSTRACT

This paper contains the revised description of the Production and Exchange module of the programmed version of the SOVAM. The structure of this version and information flows in the model are also explained. The specifics of the algorithmic and programming implementation of the SOVAM are given.

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CONTENTS

REVISED VERSION OF THE SOVAM

Vladimir Iakimets
Vladimir Lebedev

1. Introduction

This paper is aimed to give the detailed description of the revised version of the SOVAM, including the structure and information flows of the programmed model, formalized description of the agricultural production module and exchange module. The background and requirements to the SOVAM were given in Iakimets (1984). The general structure of this model and ideas for the implementation of main modules were outlined in Fedorov and Iakimets (1985). The first formalized description of the SOVAM can be found in Iakimets and Kiselev (1985). In that paper attention was paid to the economic background for the model.

However, during the implementation of the programmed version of the SOVAM, the improvement and revision of some elements of the model became necessary. During the process of simulation experiments with the SOVAM in a stand-alone mode, the revised versions of its main modules were prepared. Apart from the formalized description of the revised versions of the Production and Exchange modules that will be given in this paper, the next paper will contain the description of the Policy module.

2. The main distinctive features of the SOVAM

The structure of the Soviet macroeconomic national agricultural policy model (SOVAM) was conceived from the beginning (Iakimets 1984) in such a way to reflect the specifics of the USSR agricultural policy and direction for the intensification of agricultural production taking into account changes in world market induced by interactions of other national models within the BLS.

Realizing the complexity of a construction of an adequate USSR model of such a level of aggregation as the BLS models are, we have had in mind the implementation of an "open" model. It means that the model under development should be allowed a step-by-step improvement and detailization of its structure, information flows, objectives and constraints on the basis of simulation experiments with it with the BLS.

Due to the specifics of the centrally planned economy and peculiarities of the Soviet agricultural system and Soviet foreign trade, the macroeconomic agricultural policy model (SOVAM) developed possesses a number of distinctive features in comparison with the other BLS models with the standard structure. In this section the main such features implemented in the formalized and programmed version of the SOVAM are briefly described.

(1) The policy to provide the country's population with food commodities under stabile moderate prices always was, is, and will be, one of the most important strategic elements of the Soviet national economy. Recent implementation of this policy is reflected by the USSR food program for the period 1982-1990. The principal objective of this program is to achieve targeted consumption of the main staple foods for people, reflecting the improvement of the balance of their diet mainly due to an intensification of the internal production. Therefore the current tendencies in implementation of these targets are used in the model explicitly.

(2) Direct influences of fluctuations of world market prices on domestic consumer and producer prices are absent even for climatically unfavourable years. Therefore policy instruments describing the domestic price formation system are determined by internal conditions of agricultural production and distribution of agricultural commodities.

However, in spite of permanently increasing trends of production, volumes of produced outputs, especially crop outputs, are fluctuated mainly due to weather impact. It affects the structure of balances of the crops commodities utilization and especially those crops which are used for livestock feed.

As an implication to alleviate the effects of weather fluctuations the world market is used for import of feed commodities to support livestock production. In this sense the SOVAM should reflect explicitly relationships between livestock production, fluctuations of domestic feed production induced by weather influences, and agricultural trade. In that sense the production of livestock commodities is strongly dependent upon the intensification of internal crop production through agro-technological improvement and for the transition period when the stabile crops production is achieved, the world market will be considered as a source for import in cases of shortages of domestic feed outputs. Therefore the SOVAM envisages three levels of agro-technological improvement of internal production with the help of corresponding yield functions. The special module for planning of agricultural output, import, feed and acreage allocation taking into account world market prices for the previous year was created in the SOVAM for these purposes.

(3) To reflect the impact of weather fluctuations on crops output a separate module for adjustment of planned indicators was introduced within the SOVAM. In this module apart from recalculation of the crops output, the adjustment of stocks, import volumes and balances for crops utilization are considered explicitly. This is once more a distinctive feature of the model.

(4) The dependence of livestock output on feed supply forced to introduce three types of feed balances (in feed units, protein and concentrates utilization). It effected the extension of lists of commodities for example, by introducing as one of the main commodities green feeds. It is especially important if the available potential for increasing its production in the Soviet Union is taken into account.

(5) Apart from this commodity, a number of other (important for Soviet agriculture and agricultural trade) commodities were included in the SOVAM list. These changes were concerned mainly with disaggregation of such commodities in the BLS list as "other food", "other animal" and "non-food" (see Table 1). In compiling the SOVAM list of commodities such criteria as their current importance for Soviet agriculture, coincidence with targeted consumption in the food program, possible restructuring of future output as well as significance for Soviet agricultural trade were taken into consideration.

(6) According to a number of current governmental resolutions decisions concerning the improvement and intensification of crops and feed production were made. Some of these decisions are related to possible structural changes of the agricultural production in the USSR. Therefore, instead of the BLS-like model we constructed a simulation optimization model, variables of which can be used for searching for preferable acceptable combinations of some structural changes (acreage structure, interbalanced volumes of feed and livestock commodities production, etc.).

Table 1. Commodity Lists

	SOVAM	Units of measurement	FAP	Units of measurement
1.	wheat	10^3 mt	1. wheat	10^3 mt
2.	rice, milled	10^3 mt	2. rice, milled	10^3 mt
3.	coarse grain	10^3 mt	3. coarse grain	10^3 mt
4.	green feed	10^3 mt		
5.	protein feed	10^3 mt protein equivalent	7. protein feed	10^3 mt protein equivalent
6. 7. 8. 9. 10.	vegetable oil sugar vegetables potato fruits	10^3 mt 10^3 mt 10^3 mt 10^3 mt 10^3 mt	8. other food	mill US $ 1970
11.	cotton	10^3 mt	9. non-food	mill US $ 1970
12.	bovine & ovine	10^3 mt carcass weight	4. bovine & ovine	10^3 mt carcass weight
13. 14.	pork poultry	10^3 mt carcass weight 10^3 mt	6. other animal	10^3 mt protein equivalent
15.	dairy	10^3 mt fresh milk equivalent	5. dairy	10^3 mt fresh milk equivalent
16.	eggs	10^3 mt protein equivalent	6. other animal	10^3 mt protein equivalent
17.	wool, greasy	10^3 mt	9. non-food	mill US $ 1970
18.	non-agriculture	mill US $1970	10. non-agriculture	mill US $ 1970

(7) Taking into account the existence of the specific time relationship between volumes of production of feeds and livestock commodities expressing in that the feed produced in current year harvest is used with time lag delay for livestock production in the next year, in the model the double balancing the livestock commodities is stipulated. Namely, the balance of the livestock commodities utilization in a year under simulation is based on data about volumes of the production of these commodities, calculated in the previous period and planned values of human consumption and import of it in current year. The

balance of these commodities utilization for the next year is calculated taking into account values of desired targeted consumption and sought for planned production in year (t+1) and planned import in year t.

3. Structure and information flows of the model

This section contains the description of the structure and information flows of the SOVAM current version (Figure 1) and its list of commodities compared with the BLS list (Table 1). Main distinctive features of the SOVAM described in Section 2 are reflected in its structure and are induced corresponding information flows. Because this paper does not contain the formalized description of the agricultural policy module (it will be done in the next paper) therefore corresponding information flows connecting this module with other modules of the SOVAM are given without mathematical notations.

As it is shown in Figure 1 the SOVAM has three main modules: Policy, Production and Exchange modules. The Policy module includes two submodules: decisions on budgeting, production, consumption and foreign trade and the submodule of national accounting. The Production module contains three submodules: module for planning of agricultural output, module for adjustment of planned output and module of non-agricultural production. The Exchange module includes the exchange procedure by itself and three intermediate blocks for aggregating and splitting imports and prices of commodities from the SOVAM commodity list to the BLS one and vice versa. The description of mathematical notations given in Figure 1 can be found in the next section of this paper.

Let us now give a short description of the main information flows of the SOVAM following the specific features of the model given in the previous section.

(1) Based on the results of simulation in year (t-1) within the Policy module decisions on budgeting, production, consumption and foreign trade in accordance with determined functions and relations are elaborated for the year under simulation. These include first of all allocation of total investments between agricultural and nonagricultural sectors and decisions concerning the public and private consumption and foreign trade. Production decisions are related to rates and shares of agricultural production and to generation of inputs for agriculture. Consumption decisions include targets for agricultural and non-agricultural goods consumption. For example, these targets for agricultural goods are generated following the USSR Food Program. Trade decisions are related mainly to the calculation of planned value of export (import) of goods for the year under simulation.

(2) On the basis of some of the above mentioned decisions (consumption targets, inputs and shares of production of various agricultural goods, etc.) and based on the data of the equilibrium world market prices for the previous year and given planned targets for livestock outputs within the module for planning of agricultural output the optimization problem is solved. The allocation of acreage and determination of planned volumes of crop outputs and their utilization for feed for year t and livestock output for year (t+1), as well as determination of planned volumes of import for all agricultural commodities is sought in this module. Balances of crops utilization for feed and balances for each commodity utilization for the year under simulation and balances of possible utilization of livestock commodities in the next period (t+1) are taken into account during this problem solving.

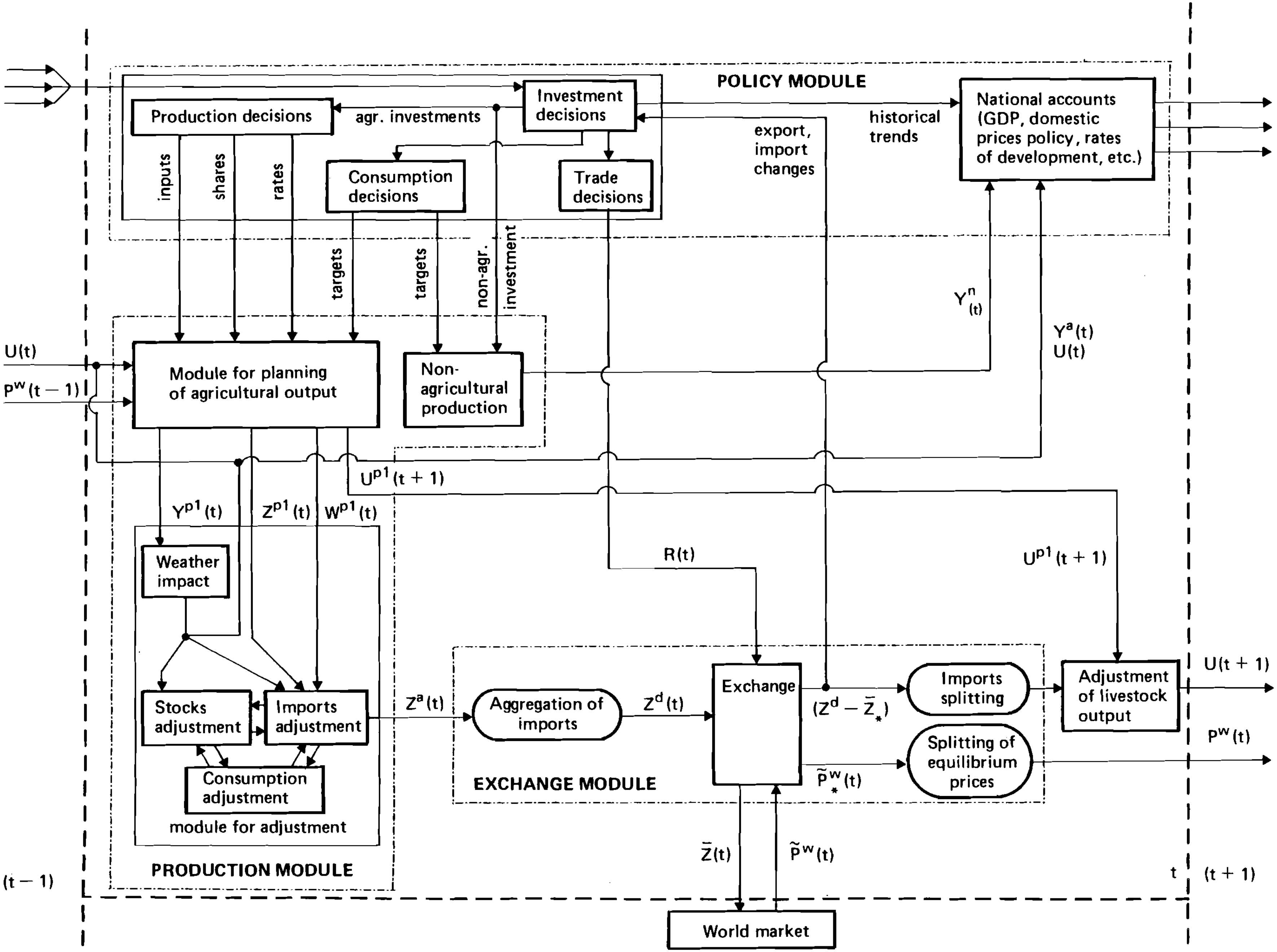

Figure 1: The SOVAM Structure and Information Flows

(3) Planned outputs and imports for crops found in the module for planning of agricultural output are corrected within the module of the adjustment of planned output, taking into consideration exogenously generated information on the impact of weather fluctuation on various crop production. As a result new values of crop outputs and their utilization are found. As an implication the change of balances for utilization of commodities occur through corresponding manipulations of stocks and imports taking into account parameters and constrains given in the Policy module.

(4) Updated desired imports are aggregated to be consistent with the BLS list of commodities for the linkage procedure. These aggregated values of imports (desired) are used then for the exchange with the world market within the framework of the BLS iterative procedure for searching equilibrium prices. To reflect the impact of the world market on these prices during this iterative procedure the value of trade balance endogenously (for the SOVAM as a whole) calculated within the Policy module is used in the exchange module. If the first estimate of this value turns out to be more than the expected value of agricultural imports then received savings are transmitted into the Policy module and these are distributed there in a predetermined proportion between consumption and investments. Final adjustment of the commodity balances is realized after the splitting aggregated imports corresponding to equilibrium prices.

(5) Results of the simulation for the year t are used as input data for the next period (t+1). Thus the adjustment of livestock output is made and national accounts including GDP calculating based on data on agricultural and non-agricultural outputs and domestic prices, utilization of GDP for consumption, investment and foreign trade etc.

It should be noted that modules for preparation of input, intermediated and output files are not shown in Figure 1.

4. Production module

4.1. Planning of agricultural production and trade

Let us denote:

$i = \overline{1,n_c}$ is index of crop commodities, $n_c = 11$,

$i = \overline{1,n_l}$ is index of livestock commodities, $n_l = 6$,

$k = \overline{1,K}$ is index of the agrotechnology used for crop production, $K = 3$.

The total number of the agricultural commodities in the SOVAM is

$n = n_c + n_l = 17$

Let us specify variables of the module under consideration:

$x_{ik}(t)$ is the acreage of i-th crop cultivated under k-th agrotechnology in year t, $i = \overline{1,n_c}$, $k = \overline{1,K}$;

$u_i^{pl}(t+1)$ is planned output of i-th livestock commodity in year (t+1), $i = \overline{1,n_l}$;

$z_i^{pl}(t)$ is planned import (export) of i-th commodity in year t, $i = \overline{1,n}$;

$w_i^{pl}(t)$ is planned utilization of i-th crop commodity for feed in year t, $i = \overline{1,n_c}$.

Let us specify also the following intermediate variables:

$Y_i^{pl}(t)$ is planned output of i-th crop commodity in year t, $i = \overline{1,n_c}$,

$d_i^{pl}(t)$ is planned human consumption of i-th crop commodity in year t, $i = \overline{1,n}$,

$\omega_i^{pl}(t)$ are normative losses of i-th crop in year t, $i = \overline{1,n_c}$;

$\mu_i^{pl}(t)$ is normative utilizaton of i-th crop for seeds in year t, $i = \overline{1,n_c}$;

$\chi_i(t)$ are losses of i-th livestock commodity in year t, $i = \overline{1,n_l}$;

$\nu_i(t)$ is an intermediate utilization of i-th livestock commodity in year t, $i = \overline{1,n_l}$

$\chi_i^{pl}(t+1)$ are expected losses of i-th livestock commodity in year (t+1), $i = \overline{1,n_l}$;

$\nu_i^{pl}(t+1)$ is an expected intermediate utilizaton of i-th livestock commodity in year (t+1), $i = \overline{1,n_l}$;

Parameters given for the planning module include:

a_i is normative expenditures of feed units for the production of one unit of i-th livestock commodity, $i = \overline{1,n_l}$;

b_i is normative expenditures of proteins for the production of one unit of i-th livestock commodity, $i = \overline{1,n_l}$;

c_i is normative expenditures of concentrates for the production of one unit of i-th livestock commodity, $i = \overline{1,n_l}$;

q_i is content of feed units in one unit of i-th feed, $i = \overline{1,n_c}$;

β_i is content of protein in one unit of i-th feed, $i = \overline{1,n_c}$;

g_i is coefficient of normative expenditures of i-th concentrate, $i = \overline{1,n_c}$;

σ_i is allowed change of the acreage for i-th crop, $i = \overline{1,n_c}$;

Δf_{ik} is normative increment of fertilizer application for i-th crop cultivated under k-th agrotechnology, $i = \overline{1,n_c}$, $k = \overline{1,K}$;

ω_i is coefficient of normative losses of i-th crop, $i = \overline{1,n_c}$,

μ_i is coefficient of normative utilization of i-th crop for seeds, $i = \overline{1,n_c}$,

χ_i is coefficient of normative losses of i-th livestock commodity, $i = \overline{1,n_c}$;

ν_i is coefficient of normative intermediate consumption of i-th livestock commodity, $i = \overline{1,n_l}$;

τ_{i+1} is parameter for determination of shares of meat production, i = 12, 13;

U_i^o are right-hand constraints for meat production, i = 12, 13;

η_{i+1} is parameter determining the structure of meat import, i = 12, 13;

φ_f is amount of feed units given for agriculture outside,

φ_p is amount of protein given for agriculture outside,

A is maximum available total acreage,

γ_1, γ_2 are correspondingly shares of wheat and rice outputs used for feed.

Let us define exogenously calculated (in relation to the module under consideration) parameters in year t:

$d_i^*(t)$ is target of human consumption of i-th commodity $i = \overline{1,n}$;

$\Delta F(t)$ is increment of total amount of fertilizers delivered to agriculture (relative to basic year);

$\Pi_f(t)$ is the output of feed units from pastures;

$\Pi_p(t)$ is the output of protein from pastures;

$Y_{ik}(t)$ is trend yield of i-th crop cultivated under k-th agrotechnology ($i = \overline{1,n_c}$, $k = \overline{1,K}$) calculated for example as follows:

$$Y_{ik}(t) = yo_i + \alpha_{1i} \cdot t + \alpha_{2i} \cdot \Delta K_a(t) + \alpha_{3i} \cdot \Delta f_{ik},$$

where yo_i is initial value of yield, α_{1i} , α_{2i} , α_{3i} are statistically estimated parameters, and $\Delta K_a(t)$ is exogenously (for the module under consideration) calculated increment of capital stocks in agriculture,

$p_i^w(t)$ is world market price* for i-th commodity, $i = \overline{1,n}$,

Θ is policy parameter to reflect targets in trade of livestock commodities.

Aggregating and splitting the world market prices from the SOVAM list to the BLS list of commodities and inversely is implemented as follows:

$p_i^w(t) = \bar{p}_i^w(t)$, $i=\overline{1,3}$

$p_5^w(t) = \bar{p}_7^w(t)$,

$p_6^w(t) = 0.27\ \bar{p}_8^w(t)$,

$p_7^w(t) = 0.118\ \bar{p}_8^w(t)$,

$p_8^w(t) = 0.175\ \bar{p}_8^w(t)$,

$p_9^w(t) = 0.069\ \bar{p}_8^w(t)$,

$p_{10}^w(t) = 0.18\ \bar{p}_8^w(t)$,

$p_{11}^w(t) = 0.18\ \bar{p}_9^w(t)$,

$p_{12}^w(t) = \bar{p}_4^w(t)$,

$p_{13}^w(t) = 0.098\ \bar{p}_6^w(t)$,

$p_{14}^w(t) = 0.123\ \bar{p}_6^w(t)$,

$p_{15}^w(t) = \bar{p}_5^w(t)$,

$p_{16}^w(t) = 0.11\ \bar{p}_6^w(t)$,

$p_{17}^w(t) = 0.934\ \bar{p}_9^w(t)$.

Here $\bar{p}_i(t)$ is world market price of i-th commodity for the BLS list. And finally we specify the following parameters of the module which are endogenously calculated:

$x_i(t-1)$ is acreage of i-th crop, $i = \overline{1,n_c}$

$u_i(t)$ is output of livestock commodity, $i = \overline{1,n_l}$

The problem is to find values of

$x_{ik}(t)$, $i = \overline{1,n_c}$, $k = \overline{1,K}$, $w_i^{pl}(t)$, $i = \overline{1,n_c}$, $u_i^{pl}(t+1)$, $i = \overline{1,n_l}$, $z_i^{pl}(t)$, $i = \overline{1,n}$

to minimize

$$\sum_{i=\overline{1,n}} p_i^w(t-1) \cdot z_i^{pl}(t)$$

subject to:

A. Crop Production

$$Y_i^{pl}(t) = \sum_{k=\overline{1,K}} y_{ik}(t) \cdot x_{ik}(t)\ , \qquad i = \overline{1,n_c} \qquad \text{crop output;}$$

$$(1-\sigma_i) \sum_{k=\overline{1,K}} x_{ik}(t-1) \le \sum_{k=\overline{1,K}} x_{ik}(t) \le (1+\sigma_i) \cdot \sum_{k=\overline{1,K}} x_{ik}(t-1)\ , \qquad i = \overline{1,n_c}$$

constraints for changes of i-th crop acreage ;

$$\sum_{i=\overline{1,n_c}} \sum_{k=\overline{1,K}} x_{ik}(t) \le A \qquad \text{total acreage;}$$

* Endogenous using these prices will be described in the paper about linked version of the SOVAM.

$x_{ik}(t) \geq x_{ik}(t-1)$, $\quad i = \overline{1,n_c}$

condition for non decreasing acreage of i-th crop under k-th agrotechnology in next year;

$\sum_{i=\overline{1,n_c}} \sum_{k=\overline{1,K}} \Delta f_{ik} \cdot x_{ik}(t) \leq \Delta F(t)$ fertilizer application:

B. Balances of feed utilization

$\sum_{i=\overline{1,n_l}} a_i \cdot u_i^{pl}(t+1) - \Pi_f(t+1) - \varphi_f \leq \sum_{i=\overline{1,n_c}} q_i \cdot w_i^{pl}(t)$, feed units balance;

$\sum_{i=\overline{1,n_l}} b_i \cdot u_i^{pl}(t+1) - \Pi_p(t+1) - \varphi_p \leq \sum_{i=\overline{1,n_c}} \beta_i \cdot w_i^{pl}(t)$, protein feeds balance;

$\sum_{i=1,n_l} c_i \cdot u_i^{pl}(t+1) \leq \sum_{i \in G} g_i \cdot w_i^{pl}(t)$,$G = \{1,2,3\} \in \overline{1,n_c}$ balance of concentrates;

$w_i^{pl}(t) = \gamma_i \cdot Y_i^{pl}(t)$, $i = \{1,2\} \in \overline{1,n_c}$ utilization of wheat and rice for feed.

C. Structure of the meat output

$u_i^{pl}(t+1) \geq U_i^o - \tau_{i+1} \cdot u_{i+1}^{pl}(t+1)$ $\quad i = 12,13.$

D. Balances of the utilization of commodities:

for crops

$d_i^{pl}(t) = Y_i^{pl}(t) + z_i^{pl}(t) - w_i^{pl}(t) - \omega_i^{pl}(t) - \mu_i^{pl}(t)$, $\overline{1,n_c}$

$\omega_i^{pl}(t) = \omega_i \cdot Y_i^{pl}(t)$, $\overline{1,n_c}$

$\mu_i^{pl}(t) = \mu_i \cdot \sum_{k=\overline{1,K}} x_{ik}(t)$, $\quad i = \overline{1,n_c}$;

for livestock commodities (current year)

$d_i^{pl}(t) = u_i(t) + z_i^{pl}(t) - \chi_i(t) - \nu_i(t)$, $\overline{1,n_l}$

$\chi_i(t) = \chi_i \cdot u_i(t)$ $\quad i = \overline{1,n_l}$

$\nu_i(t) = \nu_i \cdot u_i(t)$ $\quad i = \overline{1,n_l}$

for livestock commodities (next year)

$u_i^{pl}(t+1) + \Theta \cdot z_i^{pl}(t) - \chi_i^{pl}(t+1) - \nu_i^{pl}(t+1) \geq d_i^*(t+1)$, $i = \overline{1,n_l}$

$\chi_i^{pl}(t+1) = \chi_i \cdot u_i^{pl}(t+1)$ $\; i = \overline{1,n_l}$

$\nu_i^{pl}(t+1) = \nu_i \cdot u_i^{pl}(t+1)$ $\; i = \overline{1,n_l}$

E. Structure of the meat trade

$z_i^{pl}(t) \geq \eta_{i+1} \cdot z_{i+1}^{pl}(t)$ $\quad i = 12,13$

F. Human consumption of commodities

$d_i^{pl}(t) \geq d_i^*(t)$ $i = \overline{1,n}$

4.2. Module of the adjustment of planned output

This module is used for the adjustment of planned values of output and import for some of the commodities under the impact of weather fluctuations, generated with the help of scenarios, constructed on the basis of analysis of historical data. For these purposes changes of stocks of commodities are implemented taking into account the value of a grain equivalent (Q (t)) of the difference between planned and "actual" output.

Actual output of crops under weather fluctuations ($Y_i^a(t)$) is determined as follows:

$$Y_i^a(t) = \xi_i(t) \cdot Y_i^{pl}(t)\,, \qquad i = \overline{1,n_c}.$$

Grain equivalent of deviations in feed supply from planned value is defined as follows:

$$Q(t) = \gamma_1(Y_1^a(t) - Y_1^{pl}(t)) + (Y_3^a(t) - Y_3^{pl}(t)) + (Y_4^a(t) - Y_4^{pl}(t)) / q_3 -$$
$$- \sum_{i=1,3} \omega_i(Y_i^{pl}(t) - Y_i^a(t)) +$$
$$+(q_9/q_3) \cdot (w_9^a(t) - w_9^{pl}(t))$$

where

$w_9^a(t) = \max\,\{w_9^{pl}(t) - Y_9^{pl}(t) + Y_9^a(t),\,0\}$ is actual utilization potato for feed,

Stocks of corresponding commodities are used for elimination of consequences of weather shocks:

$\Delta S_1(t) = \max\{(1-\gamma_1) \cdot (Y_1^a(t) - Y_1^{pl}(t)),\,-S_1(t)\}$ changes of wheat stocks.

$\Delta S_3(t) = \max\{Q(t),\,-S_3(t)\}$ changes of coarse grain stocks

where

$S_i(t+1) = S_i(t) + \Delta S_i(t), \qquad i = 1,3$ are stocks of wheat and coarse grain

Corresponding adjustment of the import of commodities is made:

$z_1^a(t) = z_1^{pl}(t) + (1-\gamma_1) \cdot (Y_1^{pl}(t) - Y_1^a(t)) + \Delta S_1(t)$ for wheat

$z_3^a(t) = z_3^{pl}(t) - Q(t) + \Delta S_3(t)$ for coarse grain

$z_9^a(t) = z_9^{pl}(t) + \max\{Y_9^{pl}(t) - Y_9^a(t) - w_9^{pl}(t),0\}$ for potato

$z_i^a(t) = \max\,\{z_i^{pl}(t) + (1-\omega_i)(Y_i^{pl}(t) - Y_i^a(t)),0\}, \qquad i = 6,7,8,10$

for vegetable oil, sugar, vegetables and fruits.

$$z_5^a(t) = \max\{z_5^{pl}(t) + (Y_4^{pl}(t) - Y_4^a(t)) \cdot (\beta_4 - \beta_3/\,q_3) +$$
$$+ \sum_{i=6,11} (Y_i^{pl}(t) - Y_i^a(t)) \cdot \beta_i +$$
$$+(w_9^{pl}(t) - w_9^a(t)) \cdot (\beta_9 - \beta_3 \cdot q_9/q_3)\,,\,0\}$$ for protein feed

$z_i^a(t) = z_i^{pl}(t),\; i = 2,\overline{11,17}$ for rice, cotton and all livestock commodities.

5. Exchange module

First of all the aggregation of imports for agricultural commodities calculated in the adjustment module to the imports of the BLS list of commodities is implemented as follows:

$\bar{z}_i^d(t) = z_i^a(t) \qquad i = \overline{1,3}$

$\bar{z}_4^d(t) = z_{12}^a(t)$

$\bar{z}_5^d(t) = z_{15}^a(t)$

$\bar{z}_6^d(t) = 0.098 \cdot z_{13}^a(t) + 0.123 \cdot z_{14}^a(t) + 0.11 \cdot z_{16}^a(t)$

$\bar{z}_7^d(t) = z_5^a(t)$

$\bar{z}_8^d(t) = 0.27 \cdot z_6^a(t) + 0.118 \cdot z_7^a(t) + 0.175 \cdot z_8^a(t) + 0.069 \cdot z_9^a(t) + 0.18 \cdot z_{10}^a(t)$

$\bar{z}_9^d(t) = 0.18 \cdot z_{11}^a(t) + 0.934 \cdot z_{17}^a(t)$

Here $\bar{z}_i^d(t)$ is desirable import of i-th commodity of the BLS list. What is concerned to the non-agricultural commodity, it is determined here as follows (linked version of the SOVAM will contain endogenous calculation of it):

$$\bar{z}_{10}^d(t) = -\min\{R(t), \sum_{i=\overline{1,9}} \bar{p}_i^w(t-1) \cdot \bar{z}_i^d(t)\},$$

where R(t) now is exogenously given.* R(t) is hard currency available for import of agricultural commodities in year t. "Actual" imports in response to world market equilibrium prices ($\tilde{p}_i^w(t)$) are calculated as follows:

$$\bar{z}_i(t) = \bar{z}_i^d(t) - |\bar{z}_i^d(t)| \cdot \frac{\sum_{i=\overline{1,10}} \tilde{p}_i^w(t) \cdot \bar{z}_i^d(t)}{\sum_{i=\overline{1,10}} \tilde{p}_i^w(t) \cdot |\bar{z}_i^d(t)|}, \; i = \overline{1,10} \;;$$

As a matter of fact this formula is the solution of the following optimization problem:

$$\sum_{i=\overline{1,10}} h_i \cdot (\bar{z}_i(t) - \bar{z}_i^d(t))^2 \rightarrow \min_{\bar{z}_i}$$

subject to:

$$\sum_{i=\overline{1,10}} \tilde{p}_i^w(t) \cdot \bar{z}_i(t) = 0 ,$$

where h_i are specifically defined weights.

Within this module the calculation of the actual output for livestock commodities for the next period (t+1) is also made.

$$u_i(t+1) = \left\{ 1 - \frac{\sum_{i=3,7} \beta_i \cdot (\bar{z}_i^d(t) - \bar{z}_i(t))}{\sum_{i=\overline{1,n_l}} b_i \cdot u_i^{pl}(t+1)} \right\} \cdot u_i^{pl}(t+1)$$

* Endogenous calculation of R(t) will be described in the next paper devoted to policy module.

6. Algorithmic and programming specifics of the SOVAM implementation.

The work on computer implementation of the SOVAM for the BLS was performed as a two-phase activity. In a few words the first phase might be defined as "validating the model". The term "validating" should be treated here in a very broad sense. Extremely high level of aggregation of the model (imposed by its assignment) provides a wide spectrum of opportunities for varying the structure of its relations and for defining numerical values of its parameters. Our purpose was to choose the version of the model's structure and the values of model's parameters which would provide sufficient fitness of the results of simulation of past to historical data and also would provide credible forecasts for the future. At the same time, when varying the model's structure we had not to go out of the set of naturally interpretable relations, and choosing the values of those parameters which have clear physical meaning we had not to get apart from their statistical estimates. The restrictions stated were considered as necessary conditions for the model's adequacy.

When we planned the work on computer implementation of the model, we definitely understood that its starting version (reasonably different from the version described above) would be modified many times and that necessary improvements might only be defined through multiple numerical experiments with the model. The effectiveness of experiments of that kind strongly depends on the quality of the software involved into the experiments. Of particular importance are robustness of the programs which realize the principal computations and conveniences supplied by the programs used for processing of input data and displaying the results of runs. With this respect we organized the first phase of our work on the basis of three general purpose software units: The MINOS optimizing package, the cross-compiler GEMINI, and the table generator FORTAB (the second and third were designed by V. Lebedev). The MINOS package was used as robust tool for solving linear program in the planning module, the GEMINI made it possible to reduce to a minimum the reprograming efforts related to variations in the model's structure, and FORTAB provided features for simplifying the work on displaying the results of experiments in a visually convenient form.

The chart of information flows during test experiments with the model is shown in Figure 2. The programs which are executed one time for each step t of simulation run and the data files created during the run are surrounded by a dashed line. The program for generating MPS - input for MINOS in accordance with formula of the planning module and the program that implements the module of adjustment of planned output with preliminary decoding of MPS - output are created by GEMINI.

The second phase of the work on implementation of the SOVAM for the BLS has required much more programming efforts than the first one. It is related to the specific of implementation of the BLS. Due to this specific it is undesirable to involve into computations with the system any larger general purpose packages like the MINOS. For this reason it was decided to apply for linear program in the planning module the iterative algorithm based on quadratic penalty functions. As CPU time needed for execution of simulating programs in the BLS is the critical factor, rather sophisticated implementation of the algorithm was necessary. In particular, such an implementation required that the input data of the LP problem would be transformed into the format somewhat similar to MPS format. Having at hand GEMINI system which is assigned just to simplify preparing of the programs for generating MPS files, it was natural to use that system somehow for organizing the abovementioned transformation in automatic manner. Apparently that implied multiple modifications in GEMINI and these modifications were performed. As a result the tool was created which permits to generate the different versions of the main module of Soviet agricultural model for the BLS automatically: one should

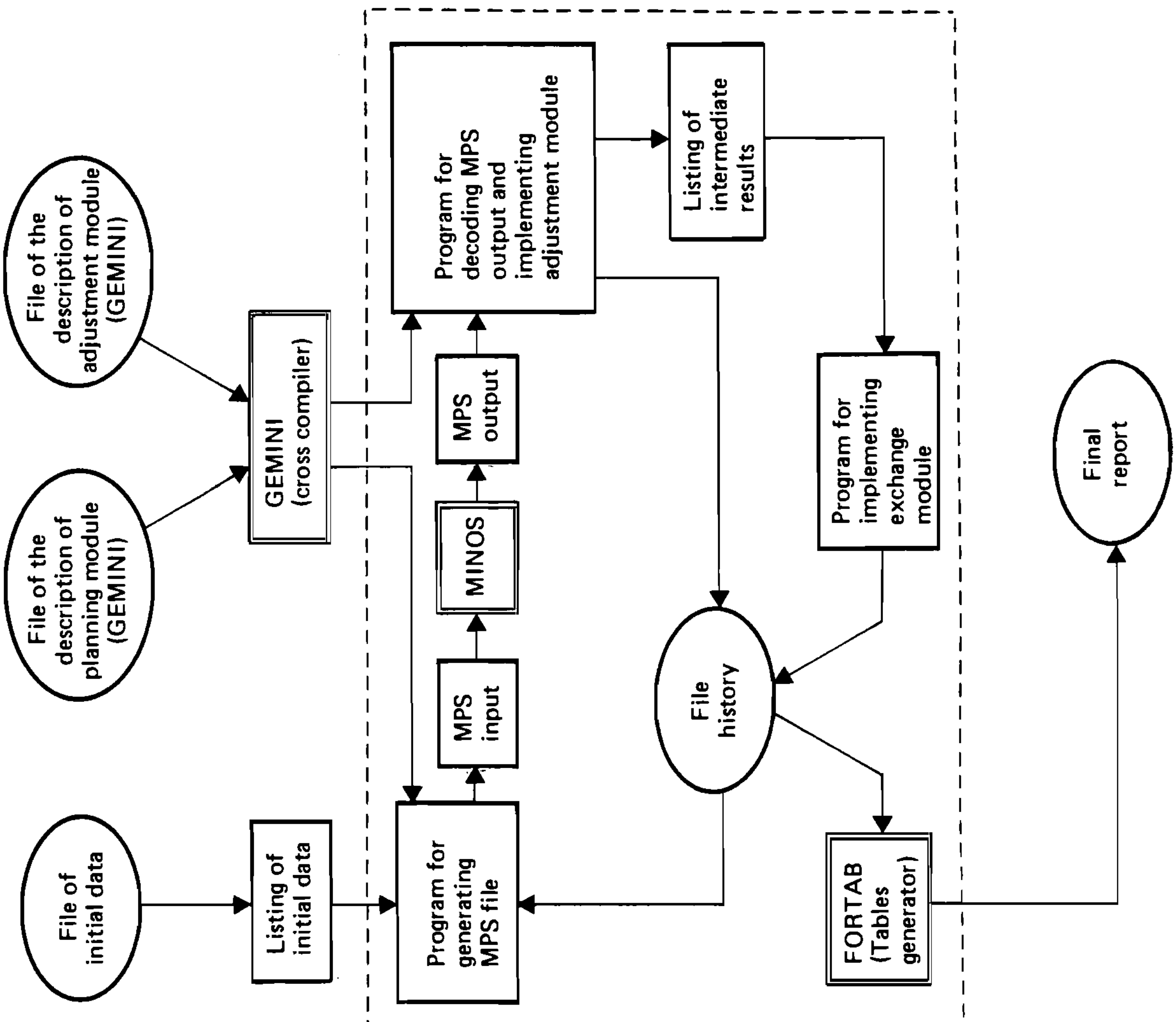

Figure 2: Software Structure for the SOVAM

only describe the planning module and the module of adjustment of planned output at GEMINI input language.

7. Conclusions

By virtue of specifics of the centrally planned economy the structure and the principal modules of the SOVAM for the BLS were created completely differently in comparison to other national agricultural policy models with standard structure. To implement such a so-called country-specific model it was necessary to envisage not only economic appropriate description of the SOVAM but also to organize specific software for validating and improving it. The formalized description of the two main modules: Production and Exchange modules are given in this paper as well as the software units used for computer implementation of the model and its interaction are explained in the paper.

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