Modelling of Centrally Planned Food and Agriculture Systems: A Framework for a National Policy Model for the Hungarian Food and Agriculture Sector

Csaki, C., Jonas, A. and Meszaros, S.

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A FRAMEWORK FOR A NATIONAL POLICY MODEL FOR THE HUNGARIAN FOOD AND AGRICULTURE SECTOR

C. Csaki

A. Jonas

S. Meszaros

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PREFACE

Food production is one of the most decentralized activities of mankind with many country and regional-specific features. The food problem of the world is to a large extent a local one, and conclusions on the future development of the world's food and agriculture can be drawn only based on investigation at the national and regional level. Accordingly the focal point in the Food and Agriculture Research Program at IIASA is the modelling of various national food and agriculture systems.

In this paper the first results of IIASA's modelling work on the agriculture of CMEA (Council for Mutual Economic Assistance) member countries, the structure and the mathematical description of a national policy model for the Hungarian food and agriculture sector are presented. The elaboration of the Hungarian Agricultural Model is a joint undertaking between IIASA and three institutions in Hungary. The mathematical structure of the model has been developed based on Ferenc Rabar's and Michel Keyzer's methodological research on general structure and linkage of national food and agriculture models, and in an interaction with the work proceeding on other national policy models at IIASA.

Michel Keyzer: Linking of National Models of Agriculture: An Introduction (IIASA, 1977, RM-77-2).

Analysis of a National Model with Domestic Price Policies and Quota on International Trade. (IIASA, 1977, RM-77-19).

International Trade Policies in Models of Barter Exchange (IIASA, 1977, RM-77-51).

Kirit S. Parikh: A Framework for an Agricultural Policy Model for India, (IIASA, 1977, RM-77-59).

Food and Energy Choices for India (IIASA, 1977, RR-77-24).

SUMMARY

In this paper the general structure and mathematical description of the Hungarian Agricultural Model is presented. As an introduction the basic characteristics of food and agriculture systems in the centrally planned economies and IIASA's approach in their modelling and some features of Hungarian agriculture are discussed.

The Hungarian Agricultural Model has a descriptive and dynamic (recursive with a one year time increment) character. Besides the disaggregated food and agriculture (25 agricultural and 25 processed food commodities) the rest of the economy is also considered. The model is in fact a system of interconnected models. The economic management and planning submodel describes the decision making and control of socialist state following the idea of central planning of the economy. The desired structure of food production, export, import and investment targets are calculated by a linear programming model. The submodel of real sphere covers the whole national economy. The major blocks of the latter submodel are related to production (linear programming models for socialist agriculture and food processing sector, nonlinear optimization model for household and private agriculture), consumption and trade including nonlinear demand system as well as updating available resource and other model parameters.

CONTENTS

BACKGROUND TO THE DEVELOPMENT OF THE HUNGARIAN AGRICULTURAL MODEL

INTRODUCTION

Because the food production is one of the most decentralized activities of mankind, the focal point in the Food and Agriculture research at IIASA is the modelling of various national food and agricultural systems. The international and East-West characteristics of IIASA offer a good opportunity for the appropriate modelling of market as well as centrally planned economies. Of course, the realistic and detailed modelling of countries with entirely different economic and political systems can only be done by detailed economic analysis.

In this paper we briefly review the basic characteristics of food and agriculture systems in the centrally planned economies. IIASA's approach in the modelling of this area is also outlined. Afterwards, a report is given on our ongoing work on the Hungarian Agricultural Model (HAM) as a prototype for other CMEA (Council for Mutual Economic Assistance) member countries. First results of the structure and the mathematical description of HAM are presented.

The elaboration of HAM is a joint undertaking of IIASA and three institutions in Hungary (Center for Statistical and Economic Analysis at the Hungarian Ministry of Food and Agriculture, Research Institute for National Planning at the National Planning Bureau, and Department of Agricultural Economics at the Karl Marx University of Economic Sciences in Budapest). This cooperation and the work on HAM in general, is coordinated and supervised by a special committee under the Hungarian Committee for IIASA. Besides the authors, eight other scientists (Dr. Csaba Forgacs, Dr. Antonia Hüttl, Katalin Kelemen, Dr. Laszlo Kleininger, Dr. Gyula Modos, Dr. Maria Sebestyen, Joszef Strehn and Laszlo Zold), have participated in the project. The mathematical structure of the model has been developed on Ferenc Rabar's and Michel Keyzer's methodological research on general structure and linkage of national food and agriculture models and under the scientific leadership of Professor Rabar. The authors are grateful to them for their contribution to the development of HAM structure.
In the development of HAM among the authors C. Csaki was actually connected with the overall structure of the model and the Consumption and Trade Block. A Jonas was first of all responsible for the Government Economic Management Submodel and S. Meszaros for the Production and Parameter Updating Block. Based on several joint discussions the final model outline was formulated by C. Csaki.

THE BASIC CHARACTERISTICS OF FOOD AND AGRICULTURE SYSTEMS IN THE CENTRALLY PLANNED ECONOMIES AND IIASA'S APPROACH IN THEIR MODELLING.

In the CMEA member countries, the agricultural policy and policy goals are determined by the fact that they are integral parts of the central plans for the whole national economy. The basic figures of production and consumption are fixed by the national plan and realized by a coordinated systems of sectoral (industry, agriculture, etc.) regional, local (country, city, etc.) and enterprise plans.

In the planning of a country's economic development the ever-increasing fulfillment of constantly growing personal demands by the harmonious growth of production is considered a basic economic requirement. Therefore, the major policy goals in agriculture are to insure a level of consumption to satisfy industrial needs in agricultural products as determined by the national plan. Thus the government's agricultural aims are the following:

- the satisfactory growth of food production and increased efficiency and productivity in agriculture by:

  the concentration and specialization of agricultural production through the organization of large-scale state and cooperative farms and agro-industrial combines, and

  the modernization of the whole food production or certain of its branches by introducing industrialized production methods and techniques;

- a certain degree of self-sufficiency of the country in agricultural products;

- optimization of foreign exchange earnings from agriculture;

- the improvement of living and working conditions of the population, and

- the emphasized development of food processing industries to increase the share of processed foodstuffs being produced for consumption and export.

In the centrally planned countries, so-called direct and indirect policy instruments are used to realize the targets given by the national plan. Although in any given period of time, only a few of the above policy goals are emphasized, the system of policy instruments applied in agriculture generally is more complicated than in any other field of the economy.

The following list of policy instruments shows the complexity of the instruments used. The direct economic regulators of the government are, for example:

- the determination of the type, size, location, and schedule of the most important agricultural investments;
- the setting of targets for farm production;
- the central distribution of technical and financial resources of production;
- the determination of labor flow within agriculture and between agriculture and other branches of the economy;
- the establishment of new production organizations in agriculture.

The indirect economic regulators of government are, for example:

- state pricing and price policy;
- state budget and tax policy;
- the regulation of the depreciation system;
- the control of wages and the system of personal incentives in agriculture;
- centralized credit and interest policy;
- state subsidies;
- export tariffs, import restrictions;
- exchange rates.

In the CMEA member countries, the methods of handling agricultural production are not unified. The main policy goals are similar but methods for their realization often differ. Both direct and indirect means are applied in each country, but their role is different. In countries with centralized economic management systems, the governments operate basically by direct economic regulators. In those with decentralized economic management systems, the state control is essentially through indirect economic means.

With respect to modelling agriculture, based on this review of agricultural policy goals and instruments, we can draw two basic conclusions:

First, in the centrally planned economies, the whole agricultural system is controlled by the national plan and the market has only a partial role determined directly and indirectly by targets for production and consumption. Therefore, we need a different model structure from those developed for the conditions in the market economies.

Second, though the major agricultural policy goals are similar, there is no unified agricultural policy of CMEA countries as in the EC countries. Therefore, a country by country approach seems necessary in the modelling of this area.

STATE OF THE ART AND IIASA'S OBJECTIVES IN MODELLING CENTRALLY PLANNED AGRICULTURAL SYSTEMS.

In the centrally planned countries of Europe* several models have been developed to describe the agricultural economy. These modelling efforts were strongly influenced by the existing planning system of the economy and the actual needs of the national planning bureaus and other planning authorities. Since the first attempts in the late 1950's development has taken place in three periods.

Most of the last decade can be considered the period of pioneer work. In the majority of the countries the first macro-models of agriculture were constructed then. The solution of basic methodological problems was emphasized, and the work had mainly experimental and scientific characteristics. Therefore, the contribution of these models to policy decisions was very small.

In the early 1970's more sophisticated and detailed models were built and mathematical methods became an accepted element of the techniques used for the preparation of important agricultural decisions. But on the whole the mathematical models of agriculture played only a partial role in the actual planning procedure.

Recently the elaboration and implementation of computer-based planning and information systems** has begun in the majority of the centrally planned countries. The modelling of agriculture is coordinated with this task and the agricultural sector of the national economy is treated as one of the most important elements of this system, serving as a framework for a set of more detailed agricultural models (e.g. sectoral, regional, enterprise).

In most cases the modelling of agriculture has been connected with the elaboration of the national five year and long-range (15-20 year) plans. The main objective of these models is to aid decision making on:

resource allocation, production structure of agriculture, regional allocation of production, and policy instruments (targets, prices, tax system, subsidies, etc.).

The models generally cover the agricultural production sector, but one can find models including the food processing sphere, too. The remaining part of the national economy is taken exogenously. In a few cases the agricultural model was connected with an aggregated model of the whole national economy (two-level planning).

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* European CMEA member countries.

** These systems are called automated management systems (ASU) in the CMEA member countries.

The methodology used is mostly linear programming. A static deterministic and normative approach is common, supplying results for the end year of the time period. Random factors (weather, world market, etc.) are introduced by running the model with different assumptions. Recently multi-period models have also been developed for long-range planning purposes. The objectives of planning efforts could basically be fulfilled by these methods. Econometric models and simulation technique have only been used in a few special cases, but until now no detailed macro-models of the whole agriculture have been completed based on the latter methods.

The most important features of the linear programming models developed now follow.

Agricultural production is modelled in a very detailed way. The production variables are generally differentiated according to:

- production sectors (state farms, cooperative farms, private and household plots);

- production regions;

- soil categories;

- technologies (e.g. irrigated and dry, partly or fully mechanized), and

- most important crop and animal varieties.

The resource requirements are calculated under the assumption of fixed coefficients. These and all other coefficients of the model are adjusted figures that are projected based on the trend of technological development and the evaluation of the present situation. The inputs are represented by fertilizer, labor (annual or peak requirements), machinery, buildings, feed (according to main type), and water. The available resources for agriculture or its sectors, regions, and products are mostly given in physical units. In certain cases the lower bounds of their usage are also restricted (for example, a minimum level of employment must be given to the members of the cooperative farms).

In the agricultural models consumer and industrial demand are handled exogenously. Fixed production requirements are given based on the targets for standard of living and industry. Substitution is often permitted among agricultural products, especially foods required according to the structure of the models. Foreign trade is represented by export and import variables given separately for Western, Socialist and Third World markets. By upper and lower bounds the foreign trade variables are also restricted. The changes in stocks are modelled as well.

The models use a set of different prices (producer prices, export prices, etc.). All the prices are fixed and exogenous. Most of the models contain a set of financial balances for the modelling of financial flows connected with agricultural production. The financing of investments is described in this module, and these equations have a very important role in the planning of economic regulators. The allocation of investments is restricted by a set of constraints (lower or upper bounds are given according to product(s), region(s), etc.).

In the objective function the main agricultural policy goals are expressed, as:

- maximization of gross domestic product from agriculture;

- maximization of national income of agriculture;

- maximization of foreign balance of payment;

- maximization of foreign exchange earnings from agriculture, and

- minimization of production expenses with a required level of production and positive balance of payment.

Using the experiences gained from this modelling work, we would like to develop a new model structure, which is:

- to incorporate the basic economic features of CMEA member countries;

- to be consistent with other parts of IIASA's Food and Agriculture model system;

- to be detailed enough to be used as an experimental tool for investigations connected with the development of food and agriculture;

- to contribute to the further development of techniques applied in the planning and management of food and agriculture.

The most important feature of IIASA's model for the centrallv planned agricultural systems are shown by Table 1, in a comparison with the characteristics of the former modelling work. Unlike the normative agricultural models that have been developed, this model has a descriptive character. It reflects the operation of the food production system and therefore the present decision making practices and economic management of the government are described. At the same time government decisions and published plan targets, influencing the projected operation of the system, are also considered.

The main objective of this modelling effort is not a straightforward optimization, but to make a tool that offers opportunities for a better understanding of the national agricultural system, its elements and their interactions, and that can also be used for mid-and long-range projections.

In the model we try to endogenize a large part of the economic surroundings and the most important factors of food production. Food and agriculture is modelled as a disaggregated part of an economic system closed at the national as well as the international level.

Unlike former agricultural models, the closed model has the following features:

- the food consumption sphere is incorporated;
- the nonfood production sectors of the economy are represented assuming that they produce only one homogeneous commodity;
- the economic, technical, biological, and human aspects of food production are covered;
- both the production of agricultural raw materials and food processing are modelled;
- under "other" agricultural production and food processing, all products not individually represented are aggregated, and
- financial equilibrium is maintained.

The overall methodology used by the model is a simulation technique. For the description of subsystems suitable techniques, e.g. linear programming and econometric methods, are employed.

The model is dynamic, with a one year basic time increment. Subperiods within the year are not considered. The time horizon of the analysis will be 15-20 years. Random effects of weather and animal disease conditions are also considered.

As the first step in the realization of IIASA's objectives in modelling of centrally planned agricultural systems (CPAS) we have begun work on the Hungarian Agricultural Model (HAM) as a pilot model for the modelling of CMEA countries. We hope the experiences gained with this model can be used for further work in the area. Work has already begun on modelling the Bulgarian and Czechoslovakian food and agriculture systems.

SOME FEATURES OF HUNGARIAN AGRICULTURE

Agriculture plays a traditionally important role within the Hungarian national economy. Although the share of agriculture in the production of national income has considerably decreased, agriculture still remains a very important national economic sector. An area of 6769.9 thousand hectares of land, over 70% of the total territory, was under cultivation in Hungary in 1974. Arable lands represent 53.5% of national territory which is one of the highest ratios known in the world. In 1976, there were 2.0 million cattle, 7.2 million pigs, 2.0 million sheep and 41 million poultry.

Table 1

IIASA's Approach in Modelling Centrally Planned Agricultural Systems

	Existing Models	IIASA Model
Objectives:	To find an optimal structure for the system.	To investigate the operation of the system.
Basic Issue:	Planning at the National Level.	Planning and realization.
Coverage:	Food production.	The whole economy with disaggregated food production and consumption sector.
Methodology:	o Linear programming o Static o Deterministic	o Simulation o Multi-period o With certain random elements
International Market:	Exogenous	Possibility to endogenize.

In 1974, some 16.2% of the Hungarian national income was produced by, and 20.4% of the working population of 10.5 million, employed in agriculture.

The per capita value of agricultural production is higher in Hungary than in other centrally planned countries and in certain respects it exceeds the levels reached by countries of the European Community. In 1975, the per capita annual meat production in Hungary was 140 kg while the average for the EC countries was only 71 kg, and for the USA 109 kg. In 1975, Hungary produced 25.9% of the total corn production of the CMEA countries. In addition to satisfying to a high degree the food demands of the population (in 1975, 3242 cal and 100 g protein consumed daily), the Hungarian agricultural sector is also a considerable and regular supplier of products for export.

In 1974, agricultural products and foodstuffs represented about 23% of total Hungarian export. For several years now, Hungary's foreign trade turnover figures for agricultural products has shown a significantly positive balance with both socialist and nonsocialist countries.

In the last few years, Hungarian agriculture developed relatively rapidly. The annual rate of development was 2.8% between 1966 and 1970 and 4.8% between 1971 and 1975*. In recent years, progress was accomplished by increased yields of cereal fodder, mainly wheat and maize, and poultry and pig breeding. Recently, the government adopted a program to accelerate the development of cattle breeding. The most important characteristics of Hungarian agriculture are described in Tables 2, 3, and 4.

Table 2

Major Resources of Hungarian Agriculture

Item	1971	1972	1973	1974	1975
Cultivated area (1000 ha)	6855	6846	6835	6783	6770
Irrigated area (1000 ha)	465	485	482	482	487
Tractor capacity in 1000 HP	3238	3257	3342	3399	3504
Fertilizer used (kg/ha)	171	183	216	243	276
Labour force (1000 person)	1167	1142	1110	1063	1039

* During the last five years, 12-13% of the national investment funds have been used in agriculture.

Table 3

Global Production of Major Agricultural

Commodities in Hungary (1000 tons)

Item	1971	1972	1973	1974	1975
Wheat	3922	4095	4502	4971	4007
Barley	785	807	874	899	701
Corn	4732	5554	5963	6247	7172
Sugarbeet	2023	2909	2754	3708	4089
Oilseeds	263	215	244	192	244
Tobacco	16	17	20	17	17
Potatoes	1797	1349	1355	1720	1630
Vegetables	1682	1860	1845	1962	1632
Fruits	1231	1369	1466	1472	1355
Grapes	745	844	1016	690	813
Meat*	1554	1626	1549	1689	1848
Milk (million liters)	1749	1756	1898	1959	1920
Wool (kg)	88	83	76	83	84
Eggs (millions)	3475	3217	3258	3628	4001

* All meat excluding fish.

Table 4

The Yields of the Major Agricultural

Commodities in Hungary (g/ha)

Item	1971	1972	1973	1974	1975	CMEA average in 1975
Wheat	30.7	31.0	34.8	37.5	32.0	12.8
Barley	26.2	27.6	30.4	33.1	27.2	13.4
Corn	35.4	39.8	40.5	42.4	50.2	33.4
Sugarbeet	277.7	370.1	297.9	377.0	322.2	210.0
Potatoes	115.7	110.9	109.4	125.9	126.4	128.0
Milk (l/cow)	2354	2363	2458	2478	2446	---
Eggs (no./hen)	118	141	138	140	144	---
Wool (kg/animal)	4.5	4.7	4.4	4.7	4.4	---

Relatively large scale farms are characteristic of Hungarian agriculture. The socialist sector of agriculture, i.e., the cooperative farms (including also the household plots* of their members) and state farms together were responsible for 96.7% of the total agricultural production in 1974. The first cooperative farms were established in Hungary in the late 1940's but final organization of cooperative farms was only completed in 1961. 1742 cooperative and 150 state farms were active in the country in 1975; the average land of a farm represented 3078 and 6327 hectares, resepectively.

State farms represent the most advanced agricultural enterprises in Hungary. Yields and average outputs surpass both the average national level and the cooperative farms. Their equipment, of course, and also their assets are superior to the average level in the country. Cooperative farms are organized on the basis of self-management and self-finance. Their management is secretly elected by the members. The most important decisions are taken by the members' assembly and the board of directors. The level of personal earnings depends directly upon the gross income realized by the farm. As a result of this, although a certain minimum income level is guaranteed by the state, one can find considerable differences in the level of personal earnings of cooperative farm members. The income distribution of cooperative farms as well as the increase of personal income are regulated by taxes.

The major agricultural policy goals are fixed by the five-year and long range plans of agricultural development. Under the present (fifth) five-year plan (1976-80) the development of animal husbandry, in particular cattle and pig production, and the food processing industry as well as the increase of foreign exchange earnings from the export of food stuffs are emphasized.** As mentioned, these targets are realized through the implementation of indirect economic means. The cooperative and state farms and other enterprises have a relatively wide economic independence; they do not get any obligatory plan targets for their production activities.

GENERAL STRUCTURE OF THE HUNGARIAN AGRICULTURAL MODEL

A very brief overview of the general model structure is given in Figure 1. Two spheres are differentiated within the system. The economic management and planning submodel describes the decision making and control of the socialist state following the ideas of central planning of the economy. The submodel of real sphere covers the whole national economy including the disaggre-

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* Household farming still plays an important role especially in animal husbandry. In 1975, 28.8% of the total pig stock and 25.9% of the total cattle stock were kept on household plots.

** The planned annual growth rate of agricultural production is 3.4.%.

gated food production sector. The major blocks of the latter submodel are related to production, consumption and trade, as well as updating available resource and model parameters. The model obviously reflects the operation of the centrally planned agricultural systems, but its outline has been developed in interaction with IIASA's methodological research on general structure and linkage of national food and agriculture models (see M. Keyzer's papers: *Linking of National Models of Agriculture: An Introduction*, RM-77-2, and *Analysis of a National Model with Domestic Price Policies & Quota on International Trade*, RM-77-19 and work on other national policy models, *A Model of the EC Agricultural Sector*, by J.V. Schrader and *A Framework for an Agricultural Policy Model for India*, RM-77-59 by K.S. Parikh).

As mentioned, HAM has a descriptive and dynamic (recursive, with a one year time increment) character. Besides the disaggregated agricultural and food production sector the rest of the economy is also considered. The commodity coverage of the study is shown by Annex 1.

Long range government objectives such as the growth of the whole economy, the growth rate of food production, meeting the increasing consumer demand, a given relation of consumption to accumulation, and a given positive balance of payment in food and agriculture are considered as they are determined by the long range development plan of the national economy. HAM is focused on the development of food and agriculture, (production structure, investments) and its interaction with the rest of the economy. Based on the model first of all the realization of major policy goals and plan targets and their main alternatives can be investigated. For example, the key factors and bottlenecks of the realization, the considerations for a faster growth, the expected labor outflow from agriculture, and the feasibility of the goals may be analyzed.

Linking with other national models, HAM is suitable to study the adjustments and reactions of the Hungarian food and agriculture system to a changing international market. For example, export and import structure, the desired level of specialization or self-sufficiency, and the reaction of domestic to world market may be investigated.

Finally, HAM is designed to be useful for the further development of the Hungarian economic management system, since the model can analyze the efficiency of policy instruments, the impacts of the new instruments, and the areas of additional control requirements.

HAM is, in fact, a system of interconnected models. The various submodels, blocks, modules and their interaction are shown in Figure 1 and 2 and we now describe major steps of the solution.

Government Objectives derived from Long Range Plans, Block GM-P

The major economic goals of government, the targets for consumption, government objectives on the structure of food production, and the direct government investments and subsidies for investments in food and agriculture are determined in this block. The major economic goals of government for the given time period are calculated based on the exogenously given long-range objectives (module GM-P-1) and then the consumption targets are settled (module GM-P-2).

The desired structure of food production, exports, imports, and the investment targets are calculated by a linear programming model maximizing the positive balance of foreign payments of food and agriculture, using the world market prices of the previous period with constraints on the available resources (module GM-P-3). This model supplies the guidelines for the analysis at the end of the simulation process (module GM-A), and the investment subsidies calculated by this model will be introduced as constraints in the producer's decision models.

Output of Nonagricultural Sector: Module P-1

Based on the available production capacities and labor force, outputs are determined by a production function. The output of the rest of the economy is handled as one homogeneous commodity.

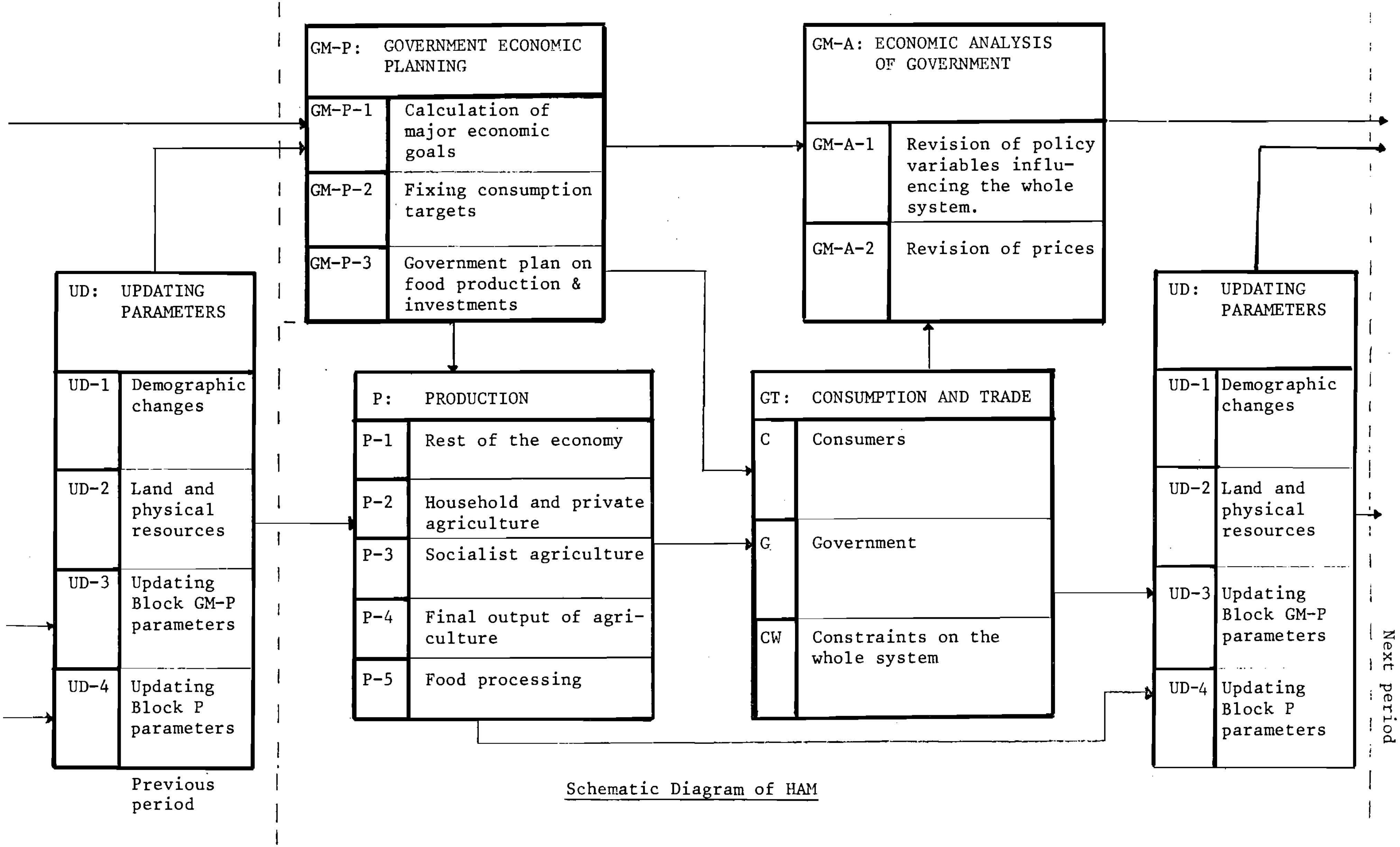
Production and Investment Decisions of Household and Private Agriculture: Module P-2

Production and investment decisions of the household and private sector are made on the basis of past prices and producer prices announced for period (t). The scale and the output of cattle production are determined by a supply function with a diminishing trend in time. A nonlinear optimization model is used to describe the producer's decisions on the rest of the commodities and investments. This model incorporates resource constraints on land, buildings, and labor availability. In the objective function the gross income is maximized. The outputs of crop production (except certain feeds) calculated here are subject to random effects of weather.

Production and Investment Decisions of Socialist Agriculture: Module P-3

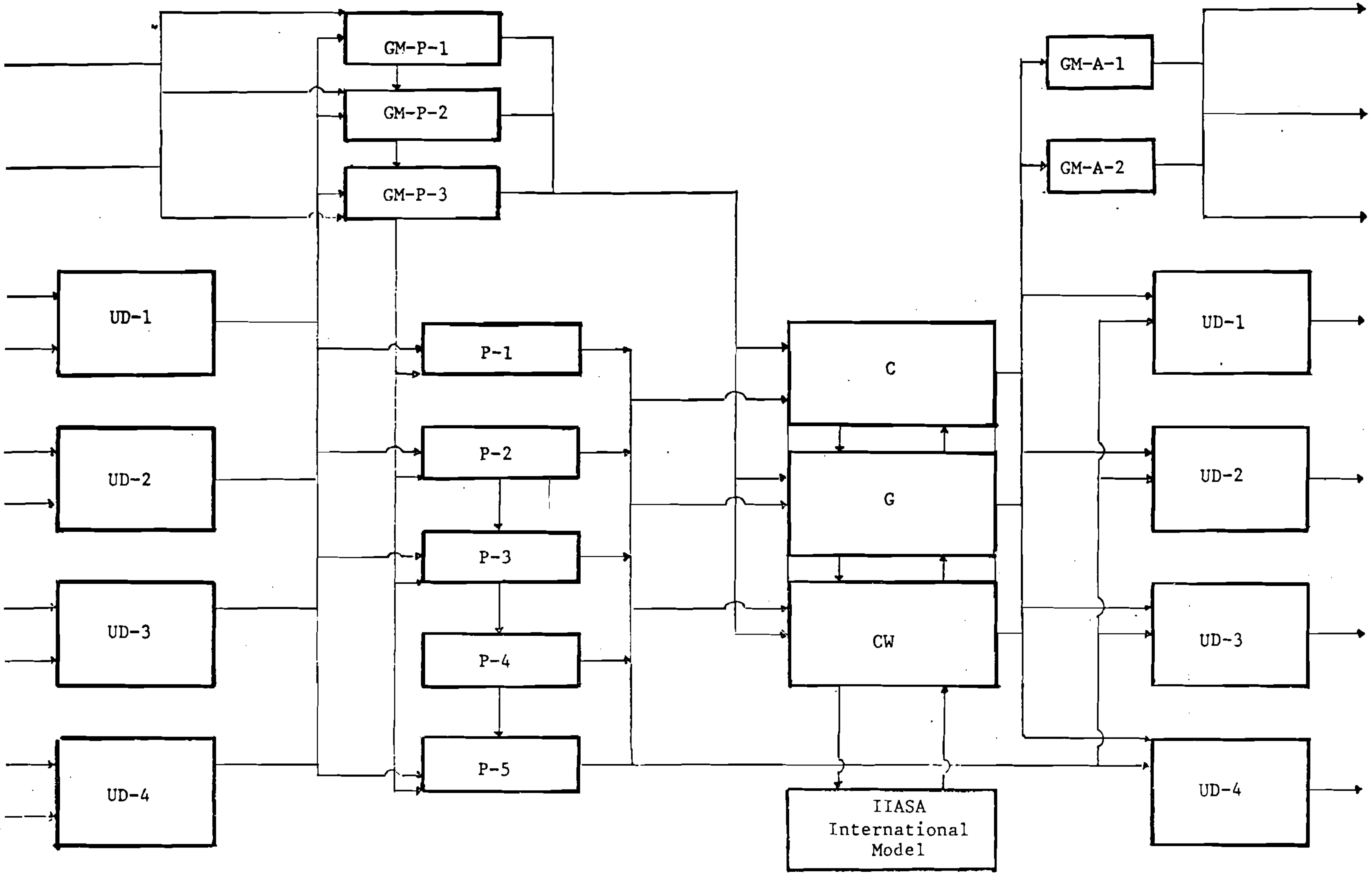
A linear programming model is constructed to describe the decisions of socialist agricultural enterprises (cooperative and state farms) on production structure and investments. For most of the commodities two or three production technologies are considered and the inputs to different products are taken as parameters determined in Block UD. The linear programming model is structured according to resource utilization, commodity

Figure 1



Schematic Diagram of HAM

Figure 2



General Overview of Model Linkages

utilization, investment, and financial subsystems. The socialist sector maximizes its expected profit, while the producer prices, and wages and tax coefficients are given by (GM-A) Block of (t-1) period. Except for fresh fruits and vegetables the producer's prices are not subject to changes during the simulated year, but crop yields are influenced by the weather disturbance factor, as in household and private production. The availability of investment subsidy is supplied by Module GM-P-3 in addition to the enterprise's own investment funds from period (t-1).

Outputs of Agriculture: Module P-4

The final output of agricultural production is calculated here based on Module P-2 and P-3 with consideration of the random effects of weather on yields of annual and perennial crops except nonmarketable feeds, and meadows and pastures. Obviously the output of animal husbandry is taken as calculated in Module P-2 and P-3. If an agricultural commodity can be processed or directly consumed, the available raw materials for processing are also determined in this module using exogenous rules.

Output of Processed Food Commodities: Module P-5

As the outputs of agriculture are known, the output and investment of the food processing industry can be determined. We assume that the food procesing industry utilizes its resources and sets the structure of its output to maximize its net income. The available raw materials have to be processed until the level of existing capacities and raw materials for processing cannot be imported.

Computation of Private and Government Consumption, Export and Import Requirements: Block C-T

The output and consumption of production sector and the income of consumers are determined in Block P. Then private and government consumption and export import vectors are generated. Consumers maximize their utilities within the income constraints of given endowment; the government tries to realize its objectives (keeping a proportion between investments and private consumption and maintaining a set of consumer and producer prices) with given world prices. First consumption and export import vectors are calculated using the world market prices of the previous period. If no solution can be obtained, a set of modifications (e.g. changes in stock targets, government, public expenditures, government investments, certain producer prices) are applied until all of the given conditions are satisfied. When a new world market price is obtained the C-T Block is solved again. The solution associated with the final set of world market prices is the actual result for the given time period.

The Revision of Government Policy Instruments: Block GM-A

As the final results for a given year are obtained, government policy instruments are revised based on the analysis of the performance of the whole system. From the actual growth rate of the economy the consumption fund for the next period is determined. The share of food and agriculture in investment is related to the growth rate of food and agriculture. The revision of income tax rates is based on the actual income situation and the change in total savings. The determination of unit wages for the next period is based on the actual growth rate of gross and net national product. The producer's prices are changed by a comparison of the actual and planned production on a three year basis. The consumer prices are modified when the difference between producer or world market and consumer price exceeds a given level.

Updating of Parameters for the Next Period: Block UD

The final step in the simulation for one year is the updating of parameters for the next period. The available labor force and changes in population are calculated from existing demographic prognoses, similarly to basic land resources, when the annual decrease of plowed land is taken as an exogenous parameter. The information for updating physical resources on investments are supplied by Block P and CT. The technical coefficients of production variables in GM-P-3 module are calculated as a weighted average of the various production technologies that appear in production decisions for the actual period. The yield and output coefficients of P-2, P-3, P-4 modules are settled as a function of biological and technical development. The fertilizer usage is calculated from response functions. The other input coefficients are selected from the exogenously given set of parameters determined by experts for each technology considered and for each level of output.

Data Requirement and the Development of HAM

The quantity of data required for HAM is considerable. However, the model is structured considering the type of data that can be obtained and the development of the actual model is based on a relatively large scale of data collection and most of this work will be done by the supporting Hungarian organizations. Official Hungarian statistics will be used but we expect data from FAO and certain technological parameters will be estimated by experts of the related Hungarian research institutions.

After completion of the model structure, a simplified version of the model will be elaborated. The final version of HAM will be constructed only after analyzing the experiences gained by this simpler model and discussion of its structure with the scientists of other CMEA countries.

MATHEMATICAL DESCRIPTION OF THE MODEL

For each model block and module the detailed mathematical structure of the various equations are now described in order of computation. The system of symbols used follows (the symbols of HAM are listed in Annex 2):

Superscripts:

h, s, p, n	producer sector (household and private agriculture, socialist sector of agriculture, food processing, rest of the economy)
c, pr, w	price categories (consumer, producer, world market)
*	yields affected by weather
g	government
po	population
i, e	import, export
in, l, wa, so	type of tax
'	lower limit
"	upper limit

Subscripts:

i	agricultural commodity i
f	processed food commodity f
n	the n-th commodity
j	technology j
k	resource k
l	land resource
m	the additional activities
g	general management and overhead activities
-	denotes symbol over which to sum

In parenthesis:

(t)	time period
(a, b, ...)	argument of function

Symbols:

a, $a^{(t)}$, etc.	lower case Latin letters refer to exogenous and policy variables
α, β, γ, etc.	Greek letters refer to model coefficients
SP, LPHN, etc.	capital letters refer to model variables

MODELLING OF GOVERNMENT ECONOMIC PLANNING ACTIVITY (GM-P)

As Figure 1 shows, the Government Economic Management Submodel (GM) is devoted to the simulation of policy making and planning (GM-P), and, economic analysis and fixing of policy instruments (GM-A) by the government of the centrally planned socialist state. Ours is one of the first attempts to give a mathematical description of this very complex area. Therefore the final formulation of this submodel, especially those parts related to policy instruments, may require further work on the system.

In CMEA countries and in Hungary as well, the basic framework of economic development is determined by the central planning activity of the government. Therefore the first block of HAM has to be devoted to the government economic planning. As was mentioned, the basic long-range government objectives are taken as exogenous parameters in HAM. Further government planning activities are represented by the Government Planning Block (GM-P) of HAM which includes three modules; the calculation of major economic goals of government (GM-P-1), the fixing of food consumption targets (GM-P-2), and the planning of food production, foreign trade and investments (GM-P-3).

Calculation of Major Economic Goals (GM-P-1)

In the centrally planned countries, a certain rate of growth is considered as a minimum requirement for the economy. GM-P-1 is concerned with the determination of these requirements. In HAM the desired level of gross national product of food and agriculture and the required positive balance of payments related to agriculture and food processing* are fixed based on the exogenous long range objectives, as follows:

$$DGNP^{(t)} = aGNP^{(t-1)}$$

$$DGNPA^{(t)} = bGNPA^{(t-1)}$$

$$DPBA^{(t)} = \frac{\sum_{t_1=t-3}^{t-1} PBA^{(t_1)}}{3}$$

* Balance of payments may be given separately for Socialist (ruble) and other ($) markets.

where:

$DGNP^{(t)}$	is the desired gross national product in period (t);
$GNP^{(t-1)}$	is the GNP in period (t-1);
$DGNPA^{(t)}$	is the desired GNP related to food and agriculture in period (t);
$GNPA^{(t-1)}$	is the GNP related to food and agriculture in period (t-1);
$DNNPA^{(t)}$	is the desired net national product related to food and agriculture in period (t);
$NNPA^{(t-1)}$	is the net national product related to food and agriculture in period (t-1);
$DPBA^{(t)}$	is the desired positive balance of payments of food and agriculture in period (t);
$PBA^{(t)}$	is the positive balance of payments of food and agriculture in period (t);
a	is the desired growth rate of GNP; and
b	is the desired growth rate of GNP related to food and agriculture.

In addition to the determination of major economic goals, the planned accumulation fund available for food and agriculture is also calculated in GM-P-1:

$$PNNP^{(t)} = eNNP^{(t-1)}$$

$$(1-f^{(t)})PNNP^{(t)} = PAF^{(t)}$$

$$g^{(t)}PAF^{(t)} = PAFA^{(t)}$$

$$PAFN^{(t)} = (1-g^{(t)})PAF^{(t)}$$

where:

$PNNP^{(t)}$	is the planned net national product in period (t);
$NNP^{(t)}$	is the actual net national product of period (t);
$PAF^{(t)}$	is the planned accumulation fund in period (t);
$PAFA^{(t)}$	is the planned accumulation in food and agriculture in period (t);
$PAFN^{(t)}$	is the planned investment accumulation of the rest of the economy;

e is the growth rate of NNP related to the growth rate of GNP;

$f^{(t)}$ is the share of consumption in net national product given for period (t); and

$g^{(t)}$ is the share of food and agriculture in the total planned accumulation in period (t).

Consumption Targets (GM-P-2)

The food consumption targets are set by GM-P-2 based on trends given exogenously. These trends express the government's objectives in the development of per capita consumption.

The total amount of consumption of commodity i is determined as follows:

$$PCP_i^{(t)} = cp_i^{(t)} CP_i^{(t-1)}$$

$$PTC_i^{(t)} = tp^{(t)} PCP_i^{(t)}$$

where:

$PTC_i^{(t)}$ is the planned total consumption of agricultural commodity i in period t;

$CP_i^{(t)}$ is the exogenously given trend value for the consumption of commodity i;

$PCP_i^{(t)}$ is the planned per capita consumption for period (t);

$tp^{(t)}$ is the total population in period (t); and

$CP_i^{(t-1)}$ is the actual per capita consumption in period (t-1).

The consumption targets of processed food and nonagricultural commodities are calculated similarly. The planned total consumption is restricted by the planned target on total consumption.

$$f^{(t)}\ PNNP^{(t)} \geq \sum_i p_i^{pr(t)} PTC_i^{(t)} + \sum_f p_f^{pr(t)} PTC_f^{(t)} + p_n^{pr(t)} PTC_n^{(t)}$$

where:

$PTC^{(t)}$ is the planned total consumption of processed commodity f;

$PTC_n^{(t)}$ is the planned total consumption of nonfood commodities; and

$p_i^{pr(t)}$, $p_f^{pr(t)}$, $p_n^{pr(t)}$ are the producer prices in period (t).

If the planned total consumption is greater than the plan target on total consumption, the value of $PTC_n^{(t)}$ is decreased to the desired level.

Government Plan on Food Production and Investments (GM-P-3)

The most important element of the GM-P block is the third (GM-P-3) module, which is actually a linear programming model for fixing central (government) plan targets on food production, exports, imports, and investments. These are the basis for the analysis of the performance in a given year. The investment decisions limit the available government subsidies for the production block.

In the GM-P-3, commodity balances are given for each agricultural and processed food commodity listed in Annex 1. The foreign trade (exports and imports)* and the stock variables are restricted according to the desired level of self-sufficiency and the exogenously given world market constraints (e.g. bilateral agreements). For example the commodity balance for agricultural commodity i:

$$PP_i^{(t)} - \Big(\sum_{\underline{i}} \alpha_{\underline{i}i}^{(t)} PP_{\underline{i}}^{(t)} + PTC_i^{(t)} + \sum_f \alpha_{fi}^{(t)} PP_f^{(t)}$$

$$+ \alpha_{ni}^{(t)} PP_n^{(t)} + \sum_k \alpha_{ki}^{(t)} RI_k^{(t)} + PE_i^{(t)} + PS_i^{(t)} \Big)$$

$$+ PI_i^{(t)} + S_i^{(t-1)} = 0 \quad ,$$

$$c_i^{e(t)'} \leq PE_i^{(t)} \leq c_i^{e(t)''} \qquad d_i^{(t)'} \leq PS_i^{(t)} \leq d_i^{(t)''}$$

$$c_i^{i(t)'} \leq PI_i^{(t)} \leq c_i^{i(t)''} \quad ,$$

where:

$PP_i^{(t)}$ is the planned total production of agricultural commodity i in period (t);

$PP_f^{(t)}$ is the planned production of processed commodity f;

$PP_n^{(t)}$ is the planned production of the rest of the economy;

$PE_i^{(t)}$ is the planned export of commodity i;

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* Export and import variables as well as quotas will be given separately for socialist and other markets.

$PI_i^{(t)}$ is the planned import of commodity i;

$PS_i^{(t)}$ is the planned stock of commodity i in period t;

$S_i^{(t-1)}$ is the stock of commodity i in period (t-1);

$\alpha_{ii}^{(t)}$, $\alpha_{fi}^{(t)}$, $\alpha_{ni}^{(t)}$, $\alpha_{ki}^{(t)}$, are unit input coefficients from commodity i in period (t);

$c_i^{e(t)'}$, $c_i^{e(t)''}$ are the export quotas of commodity i;

$c_i^{i(t)'}$, $c_i^{i(t)''}$ are the import quotas of comodity i; and

$d_i^{(t)'}$, $d_i^{(t)''}$ are the lower and upper bounds given for the stock of commodity i.

The planned production of the rest of the economy is calculated as:

$$PP_n^{(t)} = aP_n^{(t-1)} \quad .$$

In this optimization model only the major physical resources of food production are considered. In case of resource k in agriculture the constraints are formulated as:

$$\sum_i \alpha_{ik}^{(t)} PP_i^{(t)} \leq R_k^{(t)} \quad ,$$

where:

$\alpha_{ik}^{(t)}$ is the unit requirement of resource k for production of commodity i in period (t); and

$R_k^{(t)}$ is the available stock of resource k of agriculture in period (t).

In the case of machinery, where the time lag in investments is not considered:

$$\sum_i \alpha_{ik}^{(t)} PP_i^{(t)} \leq R_k^{(t)} + RI_k^{(t)} \quad ,$$

where:

$RI_k^{(t)}$ is the increase of available stock of resources k of agricultural production in period (t).

The land constraints are formulated according to land categories (plowland, plantations, meadows and pastures) as follows:

$$\sum_i \alpha_{il}^{(t)} PP_i^{(t)} \leq LS^{(t)} + LGH^{(t)} \quad ,$$

where:

$LS^{(t)}$ is the available plowland in period (t);

$LGH^{(t)}$ is the household garden land;

$$\sum_i \alpha_{il}^{(t)} PP_i^{(t)} \leq LPS_i^{(t)} + LPH_i^{(t)} \quad ,$$

where:

$LPS_i^{(t)}$ are plantations of type i in the socialist sector of agriculture; and

$LPH_i^{(t)}$ plantations of type i in the household and private sector;

$$\sum_i \alpha_{il}^{(t)} PP_i^{(t)} \leq LMS^{(t)} \quad ,$$

where:

$LMS^{(t)}$ are the meadows and pastures of the socialist sector.

The resource utilization coefficients ($\alpha_{ik}^{(t)}$, $\alpha_{fk}^{(t)}$) are generated from the production block of the previous period in Module UD-3. Besides the physical resources in module GM-P-3 the previous year's actual labor requirements of agriculture are given as an upper bound for labor usage.

$$\sum_i \beta_i^{(t)} PP_i^{(t)} = ALR^{(t)} \quad ,$$

$$la^{(t)'} \leq ALR^{(t)} \leq SLR^{(t-1)} + k^h LA^{(t-1)} \quad ,$$

$$LA^{(t)} = \frac{ALR^{(t)}}{(k^s + k^h)} \quad ,$$

$$\sum_f \beta_f^{(t)} PP_f^{(t)} = PPLR^{(t)} \quad ,$$

$$LAF^{(t)} = LA^{(t)} + PPLR^{(t)} \quad ,$$

where:

$ALR^{(t)}$	is the planned labor requirement of agricultural production in period (t);
$la^{(t)'}$	is the exogenous coefficient expressing the allowed maximum decrease of agricultural population;
$PPLR^{(t)}$	is the planned labor requirement of food processing;
$\beta_i^{(t)}, \beta_f^{(t)}$	are the labor input coefficients;
$LA^{(t)}$	is the agricultural labor force;
$LAF^{(t)}$	is the total labor requirement of food and agriculture;
k^s	is the daily average amount of work per capita in socialist agriculture, and
k^h	is the daily average amount of work per capita in household farming.

In Hungary two forms of investment in food and agriculture are differentiated. The development of irrigation systems, infrastructures, and of some of the large investments in food processing are financed directly by the government. However, most of the investment decisions are made at the enterprise level. These investments are financed by the firm's own resources and government investment subsidy. The rate of subsidy may vary according to the types of investments. In HAM the present investment subsidy rates are considered. The total amount of subsidy available for a specific type of investment (e.g. buying machinery, construction of cow barns) is given by the national plan. In module GM-P-3, the latter limits are fixed. Therefore in GM-P-3 the following formulation is applied related to investments in food and agriculture:

The direct government investment in food and agriculture:

$$PDGNIA^{(t)} = hPAFA^{(t)} \quad .$$

The available fund for subsidizing investment in food and agriculture:

$$PGINS^{(t)} = PAFA^{(t)} - (PDGNIA^{(t)} + IFES^{(t-1)} + IFEP^{(t-1)}) + DES^{(t-1)} + DEP^{(t-1)} \quad ,$$

where:

$PDGNIA^{(t)}$	are the planned direct government investments in food and agriculture;
$PGINS^{(t)}$	is the planned total investment subsidy for food and agriculture;
$IFES^{(t-1)}$	are the investment funds of agricultural enterprises from period (t-1);
$IFEP^{(t-1)}$	is the investment fund of food processing firms from period (t-1);
h	is the exogenously given rate of centralized investments in total accumulation of food and agriculture;
$DES^{(t-1)}$	is the amortization of socialist agriculture in period (t-1); and
$DEP^{(t-1)}$	is the amortization of food processing in period (t-1).

The value of investments in agriculture:

$$PIN_k^{(t)} = \Big(\sum_i p_i^{pr(t)} \alpha_{ki}^{(t)} + p_n^{pr(t)} \alpha_{kn}^{(t)}\Big) RI_k^{(t)} ,$$

where:

$\alpha_{ki}^{(t)}$, $\alpha_{kn}^{(t)}$	are the input coefficients of investments in resource k.

In the case of investment where a time lag of more than one year is considered (plantations).

$$PIN_k^{(t)} = \Big(\sum_i p_i^{pr(t)} \alpha_{ki}^{(t)} + p_n^{pr(t)} \alpha_{kn}^{(t)}\Big) RI_k^{(t)}$$

$$+ \sum_{t_1=1}^{n_k} \Big(\sum_i p_i^{pr(t)} \alpha_{ki}^{(t)} + p_n^{pr(t)} \alpha_{kn}^{(t)}\Big) RI_k^{(t - t_1)} ,$$

where:

n_k	is the time required to finish investment in resource k.

The utilization of the enterprise's own resources, assuming that funds realized in period (t-1) are spent in period (t), and investment takes place in agriculture:

$$\sum_k (1-m_k^s)PIN_k^{(t)} \leq IFES^{(t-1)} + IFEP^{(t-1)} \quad ,$$

where:

$PIN_k^{(t)}$ is the planned value of investment in resource k of agriculture in period (t); and

m_k^s is the rate of government subsidy given to investments in resource k.

A similar method is used to determine the investment in food processing ($PINP_k^{(t)}$), and the utilization of planned subsidies.

$$\sum_k m_k^s PIN_k^{(t)} + \sum_k m_k^p PINP_k^{(t)} \leq PGINS^{(t)} \quad .$$

The available subsidy for investment in resource k of agriculture:

$$SA_k^{(t)} = m_k^s PIN_k^{(t)}$$

The available subsidy for investment in resource k of food processing:

$$m_k^p PINP_k^{(t)} = SAP_k^{(t)} \quad ,$$

where:

$SA_k^{(t)}$ is the available government subsidy for investment in resource k of agriculture; and

$SAP_k^{(t)}$ is the available government subsidy for investment in resource k of food processing.

The major economic goals fixed by module GM-P-1 appear in the GM-P-3 module as follows:

The required gross national product from food and agriculture:*

$$\sum_i p_i^{pr(t)} PP_i^{(t)} + \sum_f p_f^{pr(t)} PP_f^{(t)} \geq PGNPA^{(t)} \quad ,$$

$$PGNPA^{(t)} \geq DGNPA^{(t)}$$

* Applied if positive balance of payments of food and agriculture is maximized.

The required positive balance of payments of food and agriculture:*

$$\sum_i p_i^{w(t-1)}\left(PE_i^{(t)} - PI_i^{(t)}\right) + \sum_f p_f^{w(t-1)}\left(PE_f^{(t)} - PI_f^{(t)}\right) = PBPA^{(t)} \quad ,$$

$$PBPA^{(t)} \geq DBPA^{(t)} \quad ,$$

where:

$PGNPA^{(t)}$	is the planned gross national product from food and agriculture in period (t);
$PBPA^{(t)}$	is the planned positive balance of payment of food and agriculture;
$p_i^{w(t-1)}$	is the world market price of agricultural commodity i in period (t-1); and
$p_f^{w(t-1)}$	is the world market price of processed commodity f in period (t-1).

For module GM-P-3, alternative goal functions can be considered like the maximization of gross national product from food and agriculture:

$$\max\left(PGNPA^{(t)} + \sum_k \omega_k^t RI_k^{(t)}\right) \quad ,$$

where:

$\omega_k^{(t)}$	is the expected efficiency of investments;

or the maximization of positive balance of payment from food and agriculture:

$$\max\left(PBPA^{(t)} + \sum_k \omega_k^{(t)} RI_k^{(t)}\right) \quad .$$

The Hungarian government operates mainly by indirect economic regulators. Therefore the production plan targets generated by module GM-P-3 do not appear directly in the production block. The government's objectives are transferred mainly through policy variables (prices, subsidies) and a set of assumptions of the production models expressing long range government requirements towards producers (e.g. cow stock cannot be decreased, the food processing capacities have to be utilized to the level of available resources). Of course, one may construct a model in which government plan targets appear directly in the production block. The latter case fits the practice of those

* Applied if gross national product from food and agriculture is maximized.

CMEA member countries having centralized economic management systems.

MODELLING OF PRODUCTION SPHERE (PRODUCTION BLOCK [P])

The production block of HAM consists of five modules:

- nonfood production (P-1),
- household and private agriculture (P-2),
- socialist (state and cooperative) agriculture (P-3),
- generation of the final output of agriculture (P-4), and
- food processing (P-5).

Nonfood Production (P-1)

The nonfood production part of the economy is modelled in an aggregated way. In HAM the so-called n-th commodity represents the rest of the economy including industrial production and all types of services. The scale of the n-th sector is determined by the available labor and assets as follows:

$$P_n^{(t)} = f(LAN^{(t)}, RVN^{(t)}) \quad ,$$

where:

$P_n^{(t)}$	is the production of the n-th commodity in period (t);
$LAN^{(t)}$	is the labor available for the n-th sector in period (t), and
$RVN^{(t)}$	are the assets available for sector n in period (t).

Full employment within the community is guaranteed by the following equation:

$$LAN^{(t)} = wp^{(t)} - LAF^{(t)} \quad .$$

Household and Private Agricultural Production (P-2)

The second module of the production block (P-2) is devoted to the household and private sector of agriculture. In the formation of the production decision model for the household and private sector, the following main assumptions are applied:

- As well as the household plots of cooperative farm members, private types of agricultural production, e.g. private farms and hobby farms, are considered.
- Most of the resources for household and private production are given as reminders of former private farming and the extension of production to a given level does not require investment.
- Household farming is closely linked with the socialist sector of agriculture, in that a given amount of work is required by cooperative farms, most of the basic production operations of household crop production are executed by the machinery of cooperative farms, and the socialist agricultural sector supplies feed regularly for the animal husbandry of the household and private sector.

Due to the present situation, the young generation generally does not keep cattle at home; cattle production is handled separately. The milk and beef production of the household sector is modelled by a supply function reflecting a diminishing trend in time:

$$HP_i^{(t)} = f(p_i^{pr(t)}, p_k^{pr(t)}) \quad ,$$

where:

$HP_i^{(t)}$ is the production of i-th (milk or beef) commodity of household farms in period (t);

$p_i^{pr(t)}$ is the producer price of commodity i in period (t); and

$p_k^{pr(t)}$ is the producer price of the most important k input (e.g. certain feed) for production of commodity i in period (t).

The labor, feed, and other input requirements as well as the expenses and production value of household cattle appear in the nonlinear optimization model used to describe the producer's decisions as the rest of the commodities. This model incorporates resource constraints of land, buildings, and labor availability.

In the household and private production decision model, three land categories are distinguished:

Plow land given to the cooperative farm members and state farm employee from the territory of the large scale farms on an annual basis:

$$LH^{(t)} = 1^{h}LA^{(t)} ,$$

$$\sum_{i} \alpha_{il}^{h(t)} HP_{i}^{(t)} \leq LH^{(t)} ,$$

where:

$LH^{(t)}$ is the size of household and private plow land in period (t);

1^{h} is the per capita size of household plow land.

$\alpha_{il}^{h(t)}$ is the land input coefficient of the household and private agricultural commodity i; and

$HP_{i}^{(t)}$ is the scale of production of commodity i in the household and private sector in period (t).

The so-called gardens are owned by the agricultural population and used mainly for the production of vegetables. Assuming that the i-th variable represents vegetable production in agricultural gardens:

$$\alpha_{il}^{h(t)} HP_{i}^{(t)} \leq LGH^{(t)} - \sum_{i} LPHN_{i}^{(t)} ,$$

where:

$LGH^{(t)}$ is the size of private gardens in period (t); and

$LPHN_{i}^{(t)}$ are new plantations of type i in the household and private sector in period (t).

Plantations also are owned privately. Therefore assuming that i,...,m variables are related to perennial crops:

$$\sum_{i}^{m} \alpha_{il}^{h(t)} HP_{i}^{(t)} = LPH_{i}^{(t)}$$

where:

$LPH_{i}^{(t)}$ is the size of mature plantations of type i.

The labor usage in household and private agriculture is restricted by a minimum requirement for leisure time and work done in the socialist sector:

$$\sum_{i} \beta_{i}^{h(t)} HP_{i}^{(t)} \leq k^{h}LA^{(t)}$$

where:

$\beta^{h(t)}$ is the labor input coefficient of commodity i in the household and private sector in period (t); and

k^h is the time available for household and private agricultural production after work in the socialist sector.

Production is limited by the available buildings and other physical resources:

$$\sum_i \alpha_{ik}^{h(t)} HP_i^{(t)} \leq RH_k^{(t)} ,$$

where:

$\alpha_{ik}^{h(t)}$ is the resource input coefficient related to the i-th commodity and the k-th resource in period (t).

In several cases the physical resources of the socialist agriculture sector, e.g. tractors or products of food processing, are required:

$$\sum_i \alpha_{ik}^{h(t)} HP_i^{(t)} = RHN_k^{(t)} ,$$

where:

$RHN_k^{(t)}$ is the k-th resource of the household and private agricultural sector in period (t).

The feed deficit of the household and private sector is also supplied by the socialist sector, as we can see in the example of commodity i:

$$\gamma_i^{h(t)} HP_i^{(t)} - \sum_{\underline{i}} \alpha_{\underline{i}i}^{h(t)} HP_i^{(t)} - PRHN_i^{(t)} = 0 ,$$

where:

$\gamma_i^{h(t)}$ is the expected unit output in production of commodity i in the household and private sector in period (t);

$\alpha_{\underline{i}i}^{h(t)}$ is the input coefficient related to the usage of i-th commodity in the production of commodity i in the household and private sector in period (t); and

$PRHN_i^{(t)}$ is the expected deficit of the household and private sector in commodity i (feed) in period (t).

In general the expected total physical output of commodity i is described as:

$$\gamma_i^{h(t)} HP_i^{(t)} - \sum_{\underline{i}} \alpha_{i\underline{i}}^{h(t)} HP_{\underline{i}}^{(t)} - \sum_k \alpha_{ki}^{h(t)} RIH_k^{(t)} = PPH_i^{(t)} \quad ,$$

where:

$\alpha_{ki}^{h(t)}$ is the commodity i input coefficient of investment in resource k in period (t);

$RIH_k^{(t)}$ is the investment of the household and private sector in resource k in period (t); and

$PPH_i^{(t)}$ is the expected output of commodity i from the household and private sector in period (t).

The requirements for industrial goods and services are:

$$\sum_i \alpha_{in}^{h(t)} HP_i^{(t)} + \sum_k \alpha_{kn}^{h(t)} RIH_k^{(t)} = RHN_n^{(t)} \quad ,$$

where:

$RHN_n^{(t)}$ is the total requirement of the household and private sector for commodity n in period (t).

The investments of the household sector are mostly spent on the increases in animal stocks and plantations assuming that other assets are available. The upper limit of household investments is derived from the savings of the rural population:

$$INH_k^{(t)} = \left(p_n^{p(t)} \alpha_{kn}^{h(t)} + p_i^{p(t)} \alpha_{ki}^{h(t)}\right) RIH_k^{(t)} \quad ,$$

where:

$INH_k^{(t)}$ is the value of investment in resource k in period (t).

$$\sum_k INH_k^{(t)} \leq s^h SAP^{(t-1)} \quad ,$$

where:

s^h is the estimated ratio of rural savings to total savings; and

$SAP^{(t-1)}$ are the total savings in period (t-1).

Except for the new plantations, a one year time lag is considered for investments. Because the development of perennial crop production requires several years we apply $LPHN_i^{(t)}$ instead of $RIH_k^{(t)}$ and the total annual value of investments in this area can be described as follows:

$$INH_i^{(t)} = \left(p_n^{pr(t)} \alpha_{in}^{h(t)} + \sum_{\underline{i}} p_{\underline{i}}^{pr(t)} \alpha_{i\underline{i}}^{h(t)}\right) LPHN_i^{(t)}$$

$$+ \sum_{t_1=1}^{n_i} \left(p_n^{pr(t)} \alpha_{in}^{h(t)} + \sum_{\underline{i}} p_{\underline{i}}^{pr(t)} \alpha_{i\underline{i}}^{h(t)}\right) LPHN_i^{(t-t_1)} \quad ,$$

where:

$INH_i^{(t)}$ are investments in plantation type i in period (t) by the household and private sector; and

$LPHN_i^{(t-t_1)}$ nonmature plantations of type i planted n_i years ago.

The expenses of household farming excluding labor costs and amortization are:

$$\sum_i \left(\sum_k p_k^{pr(t)} \alpha_{ik}^{h(t)} + \sum_{\underline{i}} p_{\underline{i}}^{pr(t)} \alpha_{i\underline{i}}^{h(t)} + p_n^{pr(t)} \alpha_{in}^{h(t)}\right) HP_i^{(t)}$$

$$+ t^l\left(LH^{(t)} + LGH^{(t)} + \sum_i LPH_i^{(t)}\right) = HPE^{(t)} \quad ,$$

where:

$p_k^{pr(t)}$ is the price charged by the socialist agricultural sector for the use of physical resource k in period (t);

t^l is the land tax coefficient; and

$HPE^{(t)}$ are total expense of household and private agricultural production in period (t).

$$LTH^{(t)} = t^l \left(LH^{(t)} + LGH^{(t)} + \sum_i LPH_i^{(t)}\right) \quad ,$$

where:

$LTH^{(t)}$ is the land tax paid by the household and private sector.

The projected gross production value of household and private farming* is:

$$\sum_i P_i^{pr(t)} \gamma_i^{h(t)} HP_i^{(t)} = HAPP^{(t)} \quad ,$$

where:

$HAPP^{(t)}$ is the projected gross production value of household and private agriculture in period (t).

The projected gross income of household and private agriculture is:

$$HAPP^{(t)} - HPE^{(t)} = HAIP^{(t)} \quad ,$$

where:

$HAIP^{(t)}$ is the projected gross income of household and private agriculture in period (t).

In the objective function, the gross income of household and private farming is maximized. The nonlinear objective function will be specified later on, and the introduction of a risk element is also subject to further investigation in the household production decision model.

Socialist Sector of Agriculture (P-3)

Obviously the most important part of the production block is the production and investment decision model of the socialist agricultural sector. As far as the methodology is concerned, two options have been considered, namely, a nonlinear optimization model with production functions for each commodity, and a linear programming model with different technologies for each commodity.

Because of the lack of data required for the estimation of production functions and certain features of a farm's decision making on inputs, the first version of HAM will include a linear programming model to describe the behavior of state and cooperative farms. The possibilities of a more sophisticated mathematical representation of this sector are subject to further investigation.

Unlike the GM-P-3 model, this model is structured according to production activities and not products or commodities as with the household and private agriculture (P-2). The production of most of the commodities is represented by two production variables which express two possible technologies of production; namely, a "typical" present-day technology and a more capital intensive

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* The final gross production value and gross income are calculated after considering the random effects of weather (see later).

and advanced so-called "future" technology. The irrigated production is represented by a third production variable.

The technological coefficients of production variables are updated annually from the exogenously given trend of biological development. The speed of the shift from the present "typical" technology to the "future" technology is restricted for each commodity.

In the linear programming model, the additional (mainly construction) activities of state and cooperative farms and the general management and overhead activities are treated by separate variables similar to production variables.

Resource utilization subsystem:

In the linear programming model of the socialist agricultural sector the resource constraints are first formulated. Four land categories are considered:

Plow land:

$$\sum_i \sum_j \alpha_{ij1}^{s(t)} SP_{ij}^{(t)} \leq LS^{(t)} - LH^{(t)} - \sum_i^m LPSN_i^{(t)} ,$$

where:

$\alpha_{ij1}^{s(t)}$ is the land input coefficient related to the i-th commodity and the j-th technology in period (t);

$SP_{ij}^{(t)}$ is the size of the production of commodity i by technology j in the socialist sector in period (t);

$LS^{(t)}$ is the available plow land of the socialist sector in period (t); and

$LPSN_i^{(t)}$ are new plantations of the perennial crop type i in period (t).

Plantations:

$$\sum_j \alpha_{ij1}^{s(t)} SP_{ij}^{(t)} = LPS_i^{(t)} ,$$

where:

$LPS_i^{(t)}$ is the size of plantation type i in period (t) in the socialist agricultural sector.

Meadows and pastures:

$$\sum_i \sum_j \alpha^{s(t)}_{ijl} SP^{(t)}_{ij} = LMS^{(t)} \quad ,$$

where:

$LMS^{(t)}$ are the available meadows and pasture in the socialist agriculture in period (t).

Irrigated land assuming that the j-th technologies are irrigated:

$$\sum_i \alpha^{s(t)}_{ijl} SP^{(t)}_{ij} \leq LIS^{(t)} \quad ,$$

where:

$LIS^{(t)}$ is the irrigated land of the socialist sector in period (t).

Other physical resources (buildings, machinery, constraints):

$$\sum_i \sum_j \alpha^{s(t)}_{ijk} SP^{(t)}_{ij} + \alpha^{s(t)}_{mk} SP^{(t)}_{m} + \alpha^{s(t)}_{gk} SGM^{(t)}$$

$$+ RHN^{(t)}_k \leq RS^{(t)}_k + RIS^{(t)}_k$$

or time lag in investment:

$$\sum_i \sum_j \alpha^{s(t)}_{ijk} SP^{(t)}_{ij} + \alpha^{s(t)}_{mk} SP^{(t)}_{m} + \alpha^{s(t)}_{gk} SGM^{(t)} + RHN^{(t)}_k \leq RS^{(t)}_k ,$$

where:

$\alpha^{s(t)}_{ijk}$ is the input coefficient of resource k related to commodity i and technology j in period (t);

$RS^{(t)}_k$ is the available resource k in the socialist sector;

$RIS^{(t)}_k$ is the investment in the k-th resource in period (t);

$SP^{(t)}_m$ is the scale of additional nonagricultural activities of the socialist sector in period (t);

$\alpha^{s(t)}_{mk}$ is the resource k input coefficient related to additional activities in period (t);

$SGM^{(t)}$ are the general management and overhead activities of the socialist sector, in period (t); and

$\alpha_{gk}^{s(t)}$ is the resource k input coefficient related to general management and overhead activities in period (t).

The use of the labor force is expressed in the following way:

$$\sum_i \sum_j \beta_{ij}^{s(t)} SP_{ij}^{(t)} + \beta_m^{s(t)} SP_m^{(t)} + \beta_g^{s(t)} SGM^{(t)} = SLR^{(t)}$$

$$SLR^{(t)} \leq k^{s(t)} LA^{(t)}$$

$$SLR^{(t)} \geq u' k^{s(t)} LA^{(t)} \quad ,$$

where:

$\beta_{ij}^{s(t)}$ is the labor input coefficient related to commodity i and technology j in period (t);

$\beta_m^{s(t)}$, $\beta_g^{s(t)}$ are labor input coefficients related to the additional and general management activities of the socialist sector in period (t);

$SLR^{(t)}$ is the labor requirements of the socialist sector in period (t);

u' is the minimum requirement for labor force utilization.

Commodity Utilization

The outputs of the socialist sector can be determined by commodity balances assuming that there is no planned inflow of agricultural raw materials into the socialist sector:

$$\sum_j \gamma_{ij}^{s(t)} SP_{ij}^{(t)} - \sum_{\underline{i}} \sum_j \alpha_{\underline{i}ji}^{s(t)} SP_{\underline{i}j}^{(t)} - \sum_k \alpha_{ki}^{s(t)} RIS_k^t - PRHN_i^{(t)} = PPS_i^{(t)} \quad ,$$

where:

$\gamma_{ij}^{s(t)}$ is the expected output (yield) of commodity i by technology j in the socialist sector in period (t);

$\alpha_{iji}^{s(t)}$, $\alpha_{ki}^{s(t)}$ are input coefficients; and

$PPS_i^{(t)}$ is the projected output of commodity i from the socialist sector in period (t).

Plan targets may be given for the output of the socialist sector by the government:

$$PTS_i^{'(t)} \leq PPS_i^{(t)} \leq PTS_i^{''(t)} ,$$

where:

$PTS_i^{(t)}$ is the plan target for production of commodity i in period (t).

The plan target may be given for the full utilization of resources (e.g. cow stock cannot be decreased) as follows:

$$\sum_i \sum_j \alpha_{ijk}^{s(t)} SP_{ij}^{(t)} \geq RS_k^{(t)} .$$

Some inputs, e.g. grain concentrates, are supplied by food processing as represented by the following equations in which the needs for the f-th processed commodity is expressed:

$$\sum_i \sum_j \alpha_{ijf}^{s(t)} SP_{ij}^{(t)} + RHN_f^{(t)} = RSN_f^{(t)} ,$$

where:

$RSN_f^{(t)}$ is the commodity f need of the socialist and household agricultural sectors from food processing.

The requirements for the n-th commodity:

$$\sum_i \sum_j \alpha_{ijn}^{s(t)} SP_{ij}^{(t)} + \alpha_{mn}^{s(t)} SP_m^{(t)} + \alpha_{gn}^{s(t)} SGM^{(t)}$$

$$+ \sum_k \alpha_{kn}^{s(t)} RIS_k^{(t)} = RSN_n^{(t)} ,$$

where:

$\alpha_{ijn}^{s(t)}$, $\alpha_{kn}^{s(t)}$, $\alpha_{mn}^{s(t)}$, $\alpha_{gn}^{s(t)}$ are input coefficients from the n-th commodity in the socialist sector; and

$RSN_n^{(t)}$ is the need for the n-th commodity in socialist agriculture in period (t).

The requirements for industrial goods and services can be disaggregated according to the main group of industrial inputs (e.g. fertilizers, fuel, pesticides, etc.).

Introduction of New Technologies and Investments

The introduction of "future" technologies is limited. The full substitution of traditional technologies by future ones is allowed for only in the last third of the 15 year time period considered. Assuming that the j-th technology is a "typical" one and j+1 is the so-called "future" one, these restrictions are formulated as follows:

$$SP_{ij}^{(t-1)} \geq SP_{ij}^{(t)}$$

$$SP_{ij+1}^{(t)} \leq z_i^{(t)''} \left(SP_{ij}^{(t)} + SP_{ij+1}^{(t)}\right) ,$$

where:

$z_i^{(t)''}$ is the coefficient expressing the upper limit of the application of technology (j+1) in period (t).

The investments of the socialist sector are differentiated according to major resources. The equation summarizing investments in resource k is:

$$INS_k^{(t)} = \left(p_n^{pr(t)} \alpha_{kn}^{s(t)} + \sum_i p_i^{pr(t)} \alpha_{ki}^{s(t)} + p_m^{pr(t)} \alpha_{km}^{s(t)}\right) RIS_k^{(t)}$$

where:

$INS_k^{(t)}$ is the value of investments in resource k in period (t) in the socialist sector; and

$p_m^{pr(t)}$ is the price charged for additional activities of the socialist sector.

The development of perennial crops requires several years, therefore a similar solution of module P-2 has to be applied:

$$INS_i^{(t)} = \left(p_n^{pr(t)} \alpha_{in}^{s(t)} + \sum_{\underline{i}} p_{\underline{i}}^{pr(t)} \alpha_{i\underline{i}}^{s(t)} + p_m^{pr(t)} \alpha_{im}^{s(t)}\right) LPSN_i^{(t)}$$

$$+ \sum_{t_1=1}^{n_i} \left(p_n^{pr(t)} \alpha_{in}^{s(t)} + \sum_{\underline{i}} p_{\underline{i}}^{pr(t)} \alpha_{i\underline{i}}^{s(t)} + p_m^{pr(t)} \alpha_{im}^{s(t)}\right) LPSN^{(t-t_1)}$$

where:

$INS_i^{(t)}$ is the investment of the socialist agricultural sector in perennial crop i in period (t); and

$LPSN_i^{(t-t_1)}$ are nonmature plantations of type i planted n_i years ago in the socialist agricultural sector.

The investments of the socialist sector are financed from the enterprise's own resources and by government subsidies:

$$\sum_k (1-m_k) INS_k^{(t)} + IFER^{(t)} = IFES^{(t-1)}$$

$$m_k^s INS_k^{(t)} \leq SA_k^{(t)}$$

$$\sum_k m_k^s INS_k^{(t)} = GINSA^{(t)} \quad ,$$

where:

$IFER^{(t)}$ is the unused investment fund of the socialist sector in period (t); and

$GINSA^{(t)}$ is the government investment subsidy to socialist agriculture in period (t).

The construction work connected with the investment of socialist agricultural sector is partly done by the farms themselves. Therefore the scale of these activities is related to the investments of the socialist sector:

$$SP_m^{(t)} = \sum_k \alpha_{km}^{s(t)} RIS_k^{(t)}$$

where:

$\alpha_{km}^{s(t)}$ is the requirement for the services of additional activities represented by production variable m in period (t);

<u>Financial Subsystem of Socialist Agriculture</u>

To formulate the objective function of socialist agricultural decision-making model the financial results of farming have to be determined. The financial subsystem of the linear programming model is designed for this purpose.

The expenses of socialist agricultural production consists of several elements:

Labor expenses:

$$w^{a(t)} SLR^{(t)} = WES^{(t)}$$

where:

$w^{a(t)}$ is the unit wage for agricultural labor in period (t); and

$WES^{(t)}$ is the total wages paid by socialist agriculture in period (t).

To encourage the development of labor productivity in Hungary a special tax, the so-called wage tax, is applied. In our model the wage tax also includes the contribution to the expenses of the National Health Care and Social Security System paid by enterprises:

$$(1 + t^{wa(t)})\ WES^{(t)} = LES^{(t)} \quad ,$$

where:

$t^{wa(t)}$ is the wage tax rate in period (t); and

$LES^{(t)}$ are the total labor expenses in the socialist sector in period (t).

The material expenses:

$$\sum_i \sum_j \left(\sum_{\underline{i}} p_{\underline{i}}^{pr(t)} \alpha_{ij\underline{i}}^{s(t)} + p_n^{pr(t)} \alpha_{ijn} \right) SP_{ij}^{(t)}$$

$$+ \left(\sum_i p_i^{pr(t)} \alpha_{mi}^{s(t)} + p_n^{pr(t)} \alpha_{mn}^{s(t)} \right) SP_m^{(t)}$$

$$+ p_n^{pr(t)} \alpha_{gn}^{s(t)} SGM^{(t)} = MES^{(t)} \quad ,$$

where:

$MES^{(t)}$ are the total material expenses of the socialist sector in period (t).

The amortization:

$$dr^s RVS^{(t)} = DES^{(t)} \quad ,$$

where:

dr^s is the depreciation coefficient applied for all fixed assets in period (t);

$RVS^{(t)}$ is the value of assets of the socialist sector in period (t); and

$DES^{(t)}$ is the total amortization of socialist agriculture in period (t).

The land tax:

$$t^1\left(LS^{(t)} + \sum_i LPS_i^{(t)} + LMS^{(t)}\right) = LTS^{(t)} ,$$

where:

t^1 is the land tax coefficient; and

$LTS^{(t)}$ is the land tax paid by the socialist agricultural sector in period (t).

The gross production value planned by the socialist sector:

$$\sum_i \sum_j p_i^{pr(t)} \gamma_{ij}^{s(t)} SP_{ij}^{s(t)} + p_m^{pr(t)} SP_m^{(t)} + p_k^{pr(t)} RHN_k^{(t)} = SAAP^{(t)} .$$

where:

$SAAP^{(t)}$ is the planned gross production value of socialist agriculture in period (t).

The scale of general management and overhead activities is calculated based on the planned gross production value of the socialist sector:

$$SGM^{(t)} = g^{s(t)} SAAP^{(t)} ,$$

where:

$g^{s(t)}$ expresses the connection between the scale of production, and general management and overhead activities in the socialist sector in period (t).

In the objective function of the socialist agricultural sector model the projected net income of farming is maximized as follows:

$$\max \left(SAAP^{(t)} - (LES^t + MES^{(t)} + DES^{(t)} + LTS^{(t)}) + \omega_k^{s(t)} RIS_k^{(t)}\right)$$

where:

$\omega_k^{s(t)}$ is the expected efficiency of investment in resource k.

Calculation of Final Outputs of Agriculture (P-4)

The available agricultural commodities are calculated from the producer's decision models (P-2, P-3) with consideration for the random effects on yields of weather on annual and perennial crop production. Our main assumptions in introducing weather uncertainties into HAM are as follows:

- no random effects are considered on the yields of non-marketable feeds (e.g. green feeds, scraps), pastures, and meadows;
- only the outputs are modified by random effects therefore the inputs are not affected;
- the methodology used for projecting weather effects on agriculture is similar to that applied in other national agricultural policy models at IIASA and will be specified later on;
- with commodities that can be directly consumed, exported, or processed, after the calculation of agricultural output the quantity available for processing is also determined here.

The weather effects on yield and the final output of agriculture are calculated in the P-4 module.

The random effects of weather on the yields of commodity i:

$$\gamma_i^{h(t)*} = \gamma_i^{h(t)} \theta_i^{h(t)}$$

$$\gamma_{ij}^{s(t)*} = \gamma_{ij}^{s(t)} \theta_{ij}^{s(t)} \quad ,$$

where:

$\gamma_i^{h(t)*}$, $\gamma_{ij}^{s(t)*}$ are the actual yields in period (t); and

$\theta_i^{h(t)}$, $\theta_{ij}^{s(t)}$ express the effects of weather on yield.

Based on $\gamma_i^{h(t)*}$ and $\gamma_{ij}^{s(t)*}$, the final outputs of agriculture can be calculated. First the outputs of the household and private sector are determined:

$$\gamma_i^{h(t)*} HP_i^{(t)} - \sum_{\underline{i}} \alpha_{\underline{i}i}^{h(t)} HP_i^{(t)} - \sum_k \alpha_{ki}^{h(t)} RIH_k^{(t)} \pm PH_i^{(t)} = 0 \quad ,$$

or in the case of feed deficit:

$$\gamma_i^{h(t)*} HP_i^{(t)} - \sum_{\underline{i}} \alpha_{\underline{i}i}^{h(t)} HP_i^{(t)} + RHN_i^{(t)} = 0 \quad ,$$

where:

$RHN_i^{(t)}$ is the final feed demand of type i in the household and private sector in period (t); and

$PH_i^{(t)}$ is the final output (or demand) of commodity i in the household and private sector in period (t).

Then the outputs of the socialist agricultural sector are calculated:

$$\sum_j \gamma_{ij}^{s(t)*} SP_{ij}^{(t)} - \sum_{\underline{i}} \sum_j \alpha_{\underline{i}ji}^{s(t)} SP_{\underline{i}j}^{(t)} - \sum_k \alpha_{ki}^{s(t)} RIS_k^{(t)} - PSA_i^{(t)} = 0 \quad ,$$

where:

$PSA_i^{(t)}$ is the output (or deficit) of an agricultural commodity in the socialist sector in period (t).

If $PS_i^{(t)}$ and $PH_i^{(t)}$ can be either consumed or processed one of the following rules is applied to each commodity assuming that no stocks are formed from these commodities, and export targets for the GM-P-3 module are fulfilled:

Processing has the priority:

$$ARM_i^{(t)} = \left(PSA_i^{(t)} + PH_i^{(t)}\right) - PE_i^{(t)} \quad ;$$

Consumption has the priority:

$$ARM_i^{(t)} = \left(PSA^{(t)} + PH_i^{(t)}\right) - PCP_i^{(t)} - PE_i^{(t)} \quad ;$$

There is no priority:

$$ARM_i^{(t)} \leq \left(PSA_i^{(t)} + PH_i^{(t)} - PE_i^{(t)}\right) \frac{\sum_i \alpha_{fi} PP_f^{(t)}}{\sum_i \alpha_{fi}^{(t)} PP_f^{(t)} + PCP_i^{(t)}} \quad ,$$

where:

$ARM_i^{(t)}$ is the amount of commodity i available for processing in period (t); and

$PP_f^{(t)}$ is the planned production size of processed commodity f.

If a given commodity can be utilized only through processing, then obviously:

$$ARM_i^{(t)} = PSA_i^{(t)} + PH_i^{(t)} \quad .$$

Food Processing (P-5)

In the fifth module of the production block, food processing is modelled by a linear programming model. In line with present practice, we assume that the available raw materials are processed to the level of existing capacities and raw materials for processing are not imported. Therefore in the model, the utilization of food processing capacities, the structure of output, and the investments in new processing capacities are optimized.

The processing is determined by available raw materials:

$$\sum_f \sum_{\underline{i}} \alpha_{f\underline{i}i}^{p(t)} PF_{fi}^{(t)} \leq ARM_i^{(t)} \quad ,$$

where:

$\alpha_{fi}^{p(t)}$ is the raw materials input coefficient in period (t) in processing; and

$PF_{fi}^{(t)}$ is the scale of production of processed commodity f from raw material i.

The available physical resource capacities for the food processing sector are fixed by:

$$\sum_f \sum_i \alpha_{fik}^{p(t)} PF_{fi}^{(t)} + \alpha_{gk}^{p(t)} PGM^{(t)} \leq RP_k^{(t)} \quad ,$$

where:

$RP_k^{(t)}$ is the available k-th resource capacity in period (t); and

$\alpha_{fik}^{p(t)}$, $\alpha_{gk}^{p(t)}$ are input coefficients related to resource k.

The labor force requirement is:

$$\sum_f \sum_i \beta_{fi}^{p(t)} PF_{fi}^{(t)} + \beta_g^{p(t)} PGM^{(t)} = PLR^{(t)} \quad .$$

The upper limit of labor force use in processing is given by:

$$PLR^{(t)} \leq LAF^{(t)} - SLR^{(t)} \quad ,$$

where:

$PLR^{(t)}$ is the labor requirement for food processing in period (t); and

$\beta_{fi}^{p(t)}$, $\beta_g^{p(t)}$ are labor input coefficients.

The requirement for the n-th commodity in food processing:

$$\sum_f \sum_i \alpha_{fin}^{p(t)} PF_{fi}^{(t)} + \alpha_{gn}^{p(t)} PGM^{(t)} + \sum_k \alpha_{kn}^{p(t)} RIP_k^{(t)} = RPN_n^{(t)} \quad ,$$

where:

$\alpha_{fin}^{p(t)}$, $\alpha_{gn}^{p(t)}$, $\alpha_{kn}^{p(t)}$, are input coefficients related to commodity n;

$RIP_k^{(t)}$ is the investment in resource k by the processing industry in period (t); and

$RPN_n^{(t)}$ is the need of the processing industry for commodity n in period (t);

The output of the food processing industry:

$$\sum_i \gamma_{fi}^{p(t)} PF_{fi}^{(t)} - \sum_{\underline{f}} \sum_i \alpha_{\underline{f}if}^{p(t)} PF_{\underline{f}i}^{(t)} - RPN_f^{(t)} - PFP_f^{(t)} = 0 \quad ,$$

where:

$PFP_f^{(t)}$ is the output of commodity f in period (t).

The outputs of the food processing industry can be influenced by plan targets, as follows:

$$PTP_f^{(t)'} \leq PFP_f^{(t)} \leq PTP_f^{(t)''} \quad ,$$

where:

$PTP_f^{(t)}$ is the plan target for output of commodity f in period (t).

The investments of food processing industry are handled similarly to those of the socialist sector of agriculture. All investments have a one year time lag. They are modelled according to major resources:

$$INP_k^{(t)} = p_n^{pr(t)} \alpha_{kn}^{p(t)} RIP_k^{(t)} \quad ,$$

where:

$INP_k^{(t)}$ is the value of investments in resource k by the food processing industry in period (t).

The resources of enterprises and government subsidies are the financial sources for investments in the food processing industry also:

$$\sum (1-m_k^p) INP_k^{(t)} + IFERP^{(t)} = IFEP^{(t-1)} \quad ,$$

$$m_k^p INP_k^{(t)} \leq SAP_k^{(t)} \quad ,$$

$$\sum_k m_k^p INP_k^{(t)} = GINSP^{(t)} \quad ,$$

where:

$IFERP^{(t)}$ is the unused investment funds of the food processing industry in period (t); and

$GINSP^{(t)}$ is the government investment subsidy for the food processing industry in period (t).

The expenses of food processing are:

Labor expenses:

$$w^{p(t)} PLR^{(t)} = WEP^{(t)} \quad ,$$

where:

$w^{p(t)}$ is the unit wage in food processing in period (t);

$WEP^{(t)}$ are the total wages paid by the food processing industry in period (t).

$$(1 + t^{w(t)}) WEP^{(t)} = LEP^{(t)}$$

where:

$LEP^{(t)}$ are the total labor expenses of the food processing industry in period (t).

Material expenses:

$$\sum_f \sum_i \sum_{\underline{i}} p_{\underline{i}}^{pr(t)} \alpha_{fi\underline{i}}^{p(t)} PF_{fi}^{(t)} + \sum_f \sum_i p_n^{pr(t)} \alpha_{fin}^{p(t)} PF_{fi}^{(t)}$$

$$+ p_n^{pr(t)} \alpha_{gn}^{p(t)} PGM^{(t)} = MEP^{(t)} \quad ,$$

where:

$MEP^{(t)}$ are the total material expenses of the food processing industry in period (t).

Amortization:

$$dr^p RVP^{(t)} = DEP^{(t)} \quad ,$$

where:

dr^p is the depreciation coefficient applied for all fixed assets of the food processing industry in period (t);

$DEP^{(t)}$ is the total depreciation of food processing in period (t); and

$RVP^{(t)}$ is the value of fixed assets belonging to the food processing industry in period (t).

The gross production value of the food processing industry:

$$\sum_f \sum_i p_f^{pr(t)} \gamma_{fi}^{p(t)} PF_{fi}^{(t)} = PAP^{(t)} \quad ,$$

where:

$PAP^{(t)}$ is the gross production value of the food processing industry in period (t).

The general management and overhead expenses are determined based on the gross production value similarly to the socialist agricultural sector:

$$PGM^{(t)} = g^{P(t)} PAP^{(t)} \quad ,$$

where:

g^p expresses the share of general management and overhead expenses for the gross production value of food processing.

The objective function describes the maximization of net income:

$$\max \left(PAP^{(t)} - (LEP^{(t)} + MEP^{(t)} + DEP^{(t)}) + \omega_k^{p(t)} RIP^{(t)} \right) ,$$

where:

$\omega_k^{p(t)}$ is the expected efficiency of investment in resource k.

CONSUMPTION - TRADE BLOCK (CT)*

The output of the production sector is determined in the production block. The consumption of the production sphere is also calculated there. Based on the Consumption and Trade Block, the private and government consumptions, and the export-import vector are calculated. The flow of goods is regulated by the government. We assume that the consumer maximizes his utility function while the government attempts to realize its objectives given the world market prices.

During the discussion of the Consumption - Trade Block we first present those modules related to consumers and government consumption. These are followed by the constraints on the whole system.

Consumers

Private consumption is modelled by the maximization of the consumer's utility function, with the following assumptions:

- no income classes and groups are considered;
- the per capita consumption of certain goods is subject to rationing expressing the government plan targets on development of consumption;
- the government attempts to keep the consumer prices unchanged within one simulated time period;
- only a few commodities (fresh fruits and vegetables) have relatively free prices in the system.

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* The structure of the Consumption - Trade Block has been developed from a methodological suggestion of Michel Keyzer.

The utility function will be estimated in the form of a complete demand system based on the data of household expenditure surveys:

$$\max \quad U_i(TC_i^{(t)})$$

Based on the utility function, the total consumption of commodity i ($TC_i^{(t)}$) can be determined. The per capita consumption of some commodities ($CP_i^{(t)}$) is subject to government rationing:

$$CP_i^{(t)} = \frac{TC_i^{(t)}}{tp^{(t)}}$$

and

$$y_i CP^{(t-1)} \leq CP_i^{(t)} \leq PCP_i^{(t)} \quad \text{(if applied)} \quad .$$

where:

y_i is a coefficient expressing the allowed decrease of per capita consumption of commodity i in one time period.

Consumption is restricted by the income of consumers.

The income of the population:

$$INCPO^{(t)} = WES^{(t)} + WEP^{(t)} + WEN^{(t)} + HAI^{(t)} + BS^{(t)} + BP^{(t)} + BN^{(t)} + GS^{(t)} \quad ,$$

where:

$INCPO^{(t)}$ is the total income of the population in period (t);

$WEN^{(t)}$ are the wages paid by the n-th sector in period (t);

$HAI^{(t)}$ is the income from household farming in period (t);

$BS^{(t)}$, $BP^{(t)}$, $BN^{(t)}$ are the bonuses as paid by the three production sectors in period (t);

$GSP^{(t)}$ is the social income from the government budget (e.g. pensions) in period (t);

and

$$WEN^{(t)} = w^{n(t)} LAN^{(t)} \quad ,$$

where:

$w^{n(t)}$ is the unit wage paid by the n-th sector in period (t), and

$$HAI^{(t)} = \sum_i p_i^{pr(t)} \gamma_i^{h(t)*} HP_i^{(t)} - HPE^{(t)} \quad .$$

The expenditures of the population:

$$TXPO^{(t)} = (t^{in,po(t)} + t^{so,po(t)}) \; INCPO^{(t)} \quad ,$$

$$TPE^{(t)} = INCPO^{(t)} - TXP^{(t)} - SAP^{(t)} \quad ,$$

where:

$TXPO^{(t)}$ are the taxes paid by the population in period (t);

$t^{in,po(t)}$ is the income and other tax rate in period (t);

$t^{so,po(t)}$ is the employee's contribution to superannuation;

$TPE^{(t)}$ are the total possible consumption expenditures in period (t).

The amount of savings is expressed as a function of the income of population and amount of accumulated savings:

$$SAP^{(t)} = f(INCPO^{(t)}, SAT^{(t-1)}) \quad ,$$

where:

$SAT^{(t-1)}$ are the total savings at the end of period (t-1).

The total amount of savings is calculated as:

$$SAT^{(t)} = SAP^{(t)} + SAT^{(t-1)} \quad .$$

The value of consumption has to be equal to the amount available for private consumption:

$$\sum_i p_i^{c(t)} TC_i^{(t)} = TPE^{(t)} \quad .$$

The utility maximization is obviously subject to the above mentioned constraints.

Government

The overall and long range objectives of government (a given growth rate of economy, development of consumption, positive balance of payments of food and agriculture) are expressed by exogenous parameters in the model. HAM is developed to analyze the feasibility and realization of these goals, therefore the government's objectives considered in the CT block are connected with the means of realization and are to:

- maintain a certain balance between investments and private consumption;
- maintain a set of domestic producer and consumer prices;
- reach the target level of government investments, consumption, and stocks;
- keep a certain balance between government budget and balance of payments (upper limits for debts).

These objectives can be realized subject to the various constraints on the elements of government budget (incomes and expenditures).

Income of the government

The income of the government comprises:

- income tax on enterprises and the population;
- land tax;
- labor tax and employee contributions to superannuation;
- concentrated amortization from production sectors;
- tariff receipts on export-import and consumer prices; and
- income from stocks.

The total tax receipts of the government:

$$GT^{(t)} = TXS^{(t)} + TXP^{(t)} + TXN^{(t)} + TXPO^{(t)} + LTH^{(t)} \quad .$$

The taxes paid by the socialist agriculture sector ($TXS^{(t)}$):

$$\sum_i \sum_j p_i^{s(t)} \gamma_{ij}^{s(t)*} SP_{ij}^{(t)} - (LES^{(t)} + MES^{(t)} + DES^{(t)} + LTS^{(t)}) = INCS^{(t)} \quad ,$$

where:

$INCS^{(t)}$ is the net income of socialist agriculture in period (t),

and:

$$IFEAS^{(t)} \quad [1 - (t^{in,s(t)} + v^{s(t)})]INCS^{(t)} \quad ,$$

$$BS^{(t)} = v^{s(t)} INCS^{(t)} \quad ,$$

where:

$t^{in,s(t)}$ is the income tax rate applied in the socialist agriculture sector in period (t);

$v^{s(t)}$ is the rate of bonus paid to an employee in socialist agriculture;

$IFEAS^{(t)}$ are the accumulated investment funds of socialist agriculture in period (t);

and:

$$TXS^{(t)} = t^{in,s(t)} INCS + t^{wa(t)} WES^{(t)} + LTS^{(t)} \quad .$$

The taxes paid by food processing industry:

$$INCP^{(t)} = PAP^{(t)} - (LEP^{(t)} + MEP^{(t)} + DEP^{(t)}) \quad ,$$

where:

$INCP^{(t)}$ is the net income of the food processing industry,

and

$$IFEAP^{(t)} = [1 - (t^{in,p(t)} + v^{p(t)})]INCP^{(t)} \quad ,$$

$$BP^{(t)} = v^{p(t)} INCP^{(t)} \quad ,$$

where:

$t^{inp(t)}$ is the income tax rate applied in food processing;

$v^{p(t)}$ is the rate of bonus paid to an employee in food processing;

$IFEAP^{(t)}$ is the accumulated investment fund of food processing;

and

$$TXP^{(t)} = t^{in(t)} INCP^{(t)} + t^{wa(t)} WEP \quad .$$

The taxes paid by the rest of the economy are:

$$INCN^{(t)} = p_n^{pr(t)} P_n^{(t)} - \Big(p_n^{pr(t)} \alpha_{nn}^{(t)} P_n^{(t)} + \sum_i p_i^{pr(t)} \alpha_{ni}^{n(t)} P_n^{(t)} + \sum_f p_f^{pr(t)} \alpha_{nf}^{n(t)} P_n^{(t)} + LEN^{(t)} + dr^n RVN^{(t)} \Big)$$

and:

$$BN^{(t)} = v^{n(t)} INCN^{(t)} \quad ,$$

$$LEN^{(t)} = (1 + t^{wa(t)}) WEN^{(t)} \quad ,$$

where:

$INCN^{(t)}$ is the net income of the rest of the economy;

$\alpha_{nn}^{n(t)}, \alpha_{ni}^{n(t)}$ are input coefficients related to the n-th commodity;

$LEN^{(t)}$ are total labor expenses of the rest of the economy;

dr^n is the depreciation coefficient related to the fixed assets of the rest of the economy;

$RVN^{(t)}$ are assets of the rest of the economy in period (t).

and:

$$IFEAN^{(t)} = \Big(1 - (t^{in,n(t)} + v^{n(t)}) \Big) INCN^{(t)} \quad ,$$

where:

$IFEAN^{(t)}$ is the accumulated investment fund of the rest of the economy;

$t^{in,n(t)}$ is the income tax rate applied in food processing,

and:

$$TXN^{(t)} = t^{inn(t)}INCN^{(t)} + t^{wa(t)}WEN^{(t)} \quad .$$

The amortization paid into the government buget:

$$GD^{(t)} = dc^{s}DES^{(t)} + dc^{p}DEP^{(t)} + dc^{n}DEN^{(t)} \quad ,$$

$$DEN^{(t)} = dr^{n}RVN^{(t)} \quad ,$$

where:

$GD^{(t)}$ is a part of the amortization concentrated in the government budget;

dc^{s}, dc^{p}, dc^{n} are coefficients expressing the part of amortization concentrated by the government; and

$DEN^{(t)}$ is the amortization related to the rest of the economy.

The tariff receipts of the government on exports, imports, and consumer prices ($GTRP^{(t)}$):

Tariff receipts on exports:

$$TREP^{(t)} = \sum_{i} \left(p_i^{w(t)} - p_i^{pr(t)}\right) E_i^{(t)}$$

where:

$TREP^{(t)}$ are tariff receipts of the government on export $\left(p_i^{w(t)} > p_i^{pr(t)}\right)$; and

$E_i^{(t)}$ is the export of commodity i.

Tariff receipts on imports:

$$TRIP^{(t)} = \sum_{i} \left(p_i^{pr(t)} - p_i^{w(t)}\right) I_i^{(t)} \quad ,$$

or if the commodity is not produced at all within the system:

$$TRIP^{(t)} = \sum_{i} \left(p_i^{c(t)} - p_i^{w(t)}\right) I_i^{(t)} \quad ,$$

where:

$TRIP^{(t)}$ are tariff receipts on imports $(p_i^{pr(t)} > p^{w(t)})(p_i^{c(t)} > p_i^{w(t)})$; and

$I_i^{(t)}$ is the import of commodity i.

Government receipts on consumer prices:

$$TRCP^{(t)} = \sum_i \left(p_i^{c(t)} - p_i^{pr(t)}\right) TC_i^{(t)} \quad ,$$

where:

$TRCP^{(t)}$ are government receipts on consumer prices.

The total amount of tariffs receipts:

$$GTRP^{(t)} = TREP^{(t)} + TRIP^{(t)} + TRCP^{(t)} \quad .$$

The government income from stocks:

$$GSR^{(t)} = \sum_i p_i^{pr(t)} S_i^{(t-1)} \quad ,$$

where:

$GSR^{(t)}$ is the government income on available stocks.

The income of government:

$$GI^{(t)} = GT^{(t)} + GD^{(t)} + GTRP^{(t)} + GSR^{(t)} \quad .$$

Government Expenditures

The expenditures of government comprises:

- government public expenditures on government and lcoal administration, education, health care, defense, etc.,
- social expenditures to population (e.g. pension),
- government price subsidies,
- government investment subsidies,
- direct government investments,
- expenditures on stock formation.

The government public expenditures:

$$GPE^{(t)} = ep^{g(t)} GPE^{(t-1)} \quad ,$$

where:

$ep^{g(t)}$ are coefficients expressing the trend of increase in public expenditures.

They are updated for each (t) period and in case of an unfavorable government budget situation:

$$ep^{g(t)} = 1.$$

The social expenditures on the population:

$$GSP^{(t)} = es^{g(t)} GSP^{(t-1)} \quad ,$$

where:

$es^{g(t)}$ is a coefficient expressing the increase of social expenditures.

Government price subsidies:

Export subsidies:

$$GES^{(t)} = \sum_i \left(p_i^{pr(t)} - p_i^{w(t)}\right) E_i^{(t)} \quad ,$$

where:

$GES^{(t)}$ are the government export subsidies, $(p_i^{pr(t)} > p_i^{w(t)})$.

Government import subsidies:

$$GIS^{(t)} = \sum_i \left(p_i^{w(t)} - p_i^{pr(t)}\right) I_i^{(t)} \quad ,$$

where:

$GIS^{(t)}$ are the government import subsidies $(p_i^{w(t)} > p_i^{pr(t)}, p_i^{c(t)})$.

Government subsidy for consumer prices:

$$GCS^{(t)} = \sum_i \left(p_i^{pr(t)} - p_i^{c(t)}\right) TC_i^{(t)} \quad ,$$

where:

$GCS^{(t)}$ are the government subsidies for consumer prices $(p_i^{pr(t)} > p_i^{c(t)})$.

The total government price subsidies:

$$GP^{(t)} = GES^{(t)} + GIS^{(t)} + GCS^{(t)} \quad ,$$

where:

$GP^{(t)}$ are the government price subsidies.

One of the most important elements of the government expenditure system is concerned with investment subsidies and direct government investments. The amount of investment subsidy requirements in food and agriculture are determined in the Production Block.

$$GINS^{(t)} = GINSA^{(t)} + GINSP^{(t)} \quad ,$$

where:

$GINS^{(t)}$ are the government investment subsidies for food and agriculture in period (t).

Direct government investments in food and agriculture are planned in the GM-P-3 module as $PDGNIA^{(t)}$. The total government expenditures on investments in food and agriculture:

$$GINA^{(t)} = GINS^{(t)} + PDGNIA^{(t)} \quad ,$$

where:

$GINA^{(t)}$ are the government expenditures on investments in food and agriculture.

In the rest of the economy we do not distinguish between centralized and enterprise level investments, therefore the required government contribution to the development of the rest of the economy can be described as follows:

$$GINN^{(t)} = PAFN^{(t)} - IFEAN^{(t)} + (1 - dc^h) DEN^{(t)} \quad ,$$

where:

$GINN^{(t)}$ are the government expenditures on investments in the rest of the economy;

dc^n is the coefficient expressing the part of amortization concentrated by the government;

$DEN^{(t)}$ is the amortization related to the rest of the economy.

Government expenditures on stocks:

$$GSE^{(t)} = \sum_i p_i^{pr(t)} s_i^{(t)} ,$$

where:

$GSE^{(t)}$ are the government expenditures on stocks.

The total expenditures of the government:

$$GE^{(t)} = GPE^{(t)} + GSP^{(t)} + GP^{(t)} + GINA^{(t)} + GINN^{(t)} + GSE^{(t)}$$

The incomes and the expenditures of the government obviously have to be compared:

In the case of $GI^{(t)} < GE^{(t)}$:

$$GI^{(t)} + GID^{(t)} = GE^{(t)} ,$$

$$GID^{(t)} \leq FCB^{(t)} + SAGO^{(t)} ,$$

where:

$GID^{(t)}$ is the deficit in the government's budget;

$FCB^{(t)}$ is the negative balance of foreign loans, credits, and repayments;

$SAGO^{(t)}$ are the savings of the population used to finance the budget deficit;

and:

$$x^{(t)} SA^{(t)} \geq SAGO^{(t)} + SAG^{(t-1)} ,$$

$$SAG^{(t)} = SAGO^{(t)} + SAG^{(t-1)} - GSRP^{(t)} ,$$

where:

$x^{(t)}$ is the maximum share in savings that can be used to finance the government's budget deficit;

$SAG^{(t-1)}$ is the savings used to finance the government's budget deficit in previous years; and

$GSRP^{(t)}$ is the repayment to savings.

In the case of $GI^{(t)} > GE^{(t)}$:

$$GI^{(t)} = GE^{(t)} + GISU^{(t)}$$

$$GISU^{(t)} \geq FC^{(t)} + GSRP^{(t)} \quad ,$$

where:

$GISU^{(t)}$ is the government's budget surplus; and

$FC^{(t)}$ are the foreign credits given by the country.

Constraints on the Whole System

The determination of private and government consumption is also subject to various other constraints incorporating some stability and equilibrium requirements for the whole economy:

- quantity equilibrium of production and consumption;
- equilibrium of foreign trade;
- stability of foreign loans, credits, and repayments;
- balanced development of consumption and accumulation;
- balanced development of investments in food and agriculture and in the rest of the economy.

The production, consumption, stocks, and trade of various commodities have to be balanced:

Agricultural commodities:

$$S_i^{(t-1)} + PH_i^{(t)} + PSA_i^{(t)} - \Big(\sum_f \alpha_{fi}^{p(t)} PF_{fi}^{(t)} + TC_i^{(t)} + \alpha_{ni}^{n(t)} P_n^{(t)}$$

$$+ \alpha_i^{g(t)} GPE^{(t)} + \alpha_i^{g(t)} PDGINA^{(t)}\Big) + I_i^{(t)} - E_i^{(t)} - S_i^{(t)} = 0 \quad .$$

$PH^{(t)}$ and $PSA_i^{(t)}$ may express the absolute deficit of the household and private sector and the socialist agriculture sector. In the case of feeds the excess needs of the household and private sector are modelled through the socialist sector.

Processed foodstuffs:

$$S_f^{(t-1)} + PFP_f^{(t)} - \Big(TC_f^{(t)} + \alpha_{nf}^{n(t)} P_n^{(t)} + \alpha_f^{g(t)} GPE^{(t)}\Big)$$

$$+ I_f^{(t)} - E_f^{(t)} + S_f^{(t)} = 0 \quad .$$

The n-th commodity:

$$S_n^{(t-1)} + P_n^{(t)} - \left(\alpha_{nn}^{n(t)} P_n^{(t)} + RHN_n^{(t)} + RSN_n^{(t)} + TC_n^{(t)}\right.$$

$$\left. + \alpha_n^{g(t)} GPE^{(t)} + \alpha_n^{g(t)} PDGINA^{(t)} + \alpha_n^{n(t)}(GINN^{(t)} + IFEN^{(t)})\right)$$

$$+ I_n^{(t)} - E_n^{(t)} - S_n^{(t)} = 0 \quad .$$

where:

$IFEN = IFEAN^{(t)} + (1 - dc^n) DEN^{(t)}$, and

IFEN is the total investment fund of the rest of the economy.

The export and import variables may be given according to socialist and other markets. They and the stock variables are restricted by the same lower and upper bounds as in the GM-P-3 module. Restrictions on commodity i:

$$c_i^{i(t)'} \leq I_i^{(t)} \leq c_i^{i(t)''} \quad ,$$

$$c_i^{e(t)'} \leq E_i^{(t)} \leq c_i^{e(t)''} \quad ,$$

$$d_i^{(t)'} \leq S_i^{(t)} \leq d_i^{(t)''} \quad .$$

The balance of foreign payments:

$$\sum p_i^{w(t)} \left(E_i^{(t)} - I_i^{(t)}\right) + \sum p_f^{w(t)} \left(E_f^{(t)} - I_f^{(t)}\right) + p_n^{w(t)} \left(E_n^{(t)} - I_n^{(t)}\right)$$

$$+ FLR^{(t)} - FCR^{(t)} = 0 \quad ,$$

where:

$FLR^{(t)}$ are foreign loans taken by the country and credit repayments; and

$FCR^{(t)}$ are foreign credits given by the country and loan repayments.

Balance of payments from food and agriculture:

$$\sum p_i^{w(t)} \left(E_i^{(t)} - I_i^{(t)}\right) + \sum_f p_f^{w(t)} \left(E_f^{(t)} - I_f^{(t)}\right) = PBPA^{(t)} \quad .$$

Foreign loan balance (debt situation):

$$FD^{(t-1)} + FL^{(t)} - lr^{(t)}FD^{(t-1)} = FD^{(t)}$$

$$FD^{(t)} \leq fd^{(t)''} \quad ,$$

where:

$FD^{(t)}$ are total foreign debts;

$FL^{(t)}$ is new borrowing in period (t);

$lr^{(t)}$ is the loan repayment coefficient; and

$fd^{(t)''}$ are the upper limits of foreign debts.

Foreign credits given by the country:

$$FB^{(t-1)} + FC^{(t)} - cr^{(t)}FB^{(t-1)} = FB^{(t)} \quad ,$$

where:

$FB^{(t)}$ are the total credits given by the country;

$FC^{(t)}$ are new credits given in period (t); and

$cr^{(t)}$ is a credit repayment coefficient.

And we can now define:

$$FLR^{(t)} = FL^{(t)} + lr^{(t)}FB^{(t-1)} \quad ,$$

$$FCR^{(t)} = FC^{(t)} + cr^{(t)}FD^{(t-1)} \quad .$$

The consumption and accumulation have to be balanced according to long-range government objectives. Therefore the net national product has to be accounted:

$$\Big(\sum_i p_i^{pr(t)} \gamma_i^{h(t)*} HP_i^t + \sum_i \sum_j p_i^{pr(t)} \gamma_{ij}^{s(t)*} SP_{ij}^{(t)}$$

$$+ \sum_f \sum_i p_f^{pr(t)} \gamma_{fi}^{p(t)} PF_{fi}^{(t)} + p_n^{pr(t)} P_n^{(t)}\Big)$$

$$- \Big(MES^{(t)} + MEH^{(t)} + MEP^{(t)} + \Big(p_n^{pr(t)} \alpha_{nn}^{n(t)} + \sum_i p_i^{pr(t)} \alpha_{ni}^{n(t)}\Big) P_n^{(t)}\Big)$$

$$- \Big(DES^{(t)} + DEP^{(t)} + DEN^{(t)}\Big) - NNP^{(t)} = 0 \quad ,$$

where:

$NNP^{(t)}$ is the net national product realized in period (t);

and:

$$CONP^{(t)} \leq f^{(t)}(NNP^{(t)} + FLR^{(t)} - FCR^{(t)}) \quad ,$$

$$CONP^{(t)} = \sum_i p_i^{pr(t)} TC_i^{(t)} + \sum_f p_f^{pr(t)} TC_f^{(t)} + p_n^{pr(t)} TC_n^{(t)} \quad ,$$

where:

$CONP^{(t)}$ is the value of the private consumption on producer prices.

Constraints on investments:

$$\sum_k INS_k^{(t)} + \sum_k INP_k^{(t)} + PDGINA^{(t)} + GINN^{(t)} + IFEAN^{(t)}$$

$$+ \sum_i p_i^{pr(t)} \left(S_i^{(t)} - S_i^{(t-1)}\right) + \sum_f p_f^{pr(t)} \left(S_f^{(t)} - S_f^{(t-1)}\right)$$

$$+ p_n^{pr(t)} \left(S_n^{(t)} - S_n^{(t-1)}\right) \leq NNP^{(t)} + FLR^{(t)} - FCR^{(t)}$$

$$- CONP^{(t)} + DES^{(t)} + DEP^{(t)} + DEN^{(t)} \quad .$$

Constraints on accumulation in food and agriculture:

$$\sum_k INS_k^{(t)} + \sum_k INP_k^{(t)} + PDGINA^{(t)} - DES^{(t)} + DEP^{(t)})$$

$$+ \sum_i p_i^{pr(t)} \left(S_i^{(t)} - S_i^{(t-1)}\right) + \sum_f p_f^{pr(t)} \left(S_f^{(t)} - S_f^{(t-1)}\right)$$

$$\leq g^{(t)}(NNP^{(t)} + FLR^{(t)} - FCR^{(t)}) - CONP^{(t)} \quad ,$$

$$CON^{(t)} = \sum_i p_i^{c(t)} TC_i^{(t)} + \sum_f p_f^{c(t)} TC_f^{(t)} + p_n^{c(t)} TC_n^{(t)} \quad ,$$

where:

$CON^{(t)}$ is the effect of private consumption on consumer prices.

The Solution of the Consumption and Trade Block

As can be noticed in HAM, three types of prices are distinguished:

- producer prices } domestic prices
- consumer prices }
- world prices (export and import prices).

The commodities produced by the household and private sector as well as those produced by the socialist agriculture, food processing, and n-th sector are sold via the producer prices. The inputs of producers can be purchased also on producer prices. These prices are also applied to investment goods. Except for fresh fruits and vegetables, the producer prices are not subject to any changes within one simulated time period. Fresh fruits and vegetables have two producer prices:

- the first one is fixed similarly to other producer prices between producers and the food processing industry,

- the second one is a free market price where the producer price is equal to the consumer price and where:

$$p_i^{pr(t)} = p_i^{w(t)} - ta_i^{(t)} \quad ,$$

$$p_i^{pr(t)} \geq p_i^{pr(t)'} \quad ; \qquad p_i^{pr(t)} = p_i^{c(t)} \quad ,$$

where:

$ta_i^{(t)}$ is the fixed government tariff on commodity i; and

$p_i^{pr(t)'}$ is the minimum price for commodity i.

Consumer prices are applied to private consumption, and except for the prices of fresh fruit and vegetables, are also fixed. However some may be changed during the solution of the Consumption and Trade Block. The world market prices are taken from the international market model of IIASA's Food and Agriculture model system.

The CT Block of HAM is first solved using the world market prices of the previous year. If no solution can be reached within the framework of the given constraints, the following modifications may be applied through an iterative procedure until all of the given conditions are satisfied:

- The upper and lower limits for stocks ($d^{(t)'}$, $d_i^{(t)''}$) are modified (stock adjustment).

- The government public expenditure are decreased to the level of the previous year ($ep^{g(t)} = 1$)
- The investments are modified to the level allowed by actual $NNP^{(t)}$ and foreign balance of payment. In food and agriculture, $PDGINA^{(t)}$ (planned direct government investments in food and agriculture) is subject to change. The last value of $PDGINA^{(t)}$ is taken as $DGINA^{(t)}$ = the value of direct government investments in food and agriculture. In the rest of the economy $GINN^{(t)}$ (government investments in the rest of the economy) is subject to change. Obviously the exogenously given share of n-th sector in the total investment accumulation has to be kept.
- The consumption is adjusted to the level allowed by the actual situation. The modification of consumption is achieved through changes in selected consumer prices.

When a new world market price is obtained* the CT Block is solved again and the procedure outlined above is repeated until the desired situation is reached. The solution associated with the final set of world market prices is the actual result for the given time period.

ECONOMIC ANALYSIS OF GOVERNMENT (GM-A)

After the final results are obtained for a given year based on an analysis of the performance of the whole system some of the policy instruments of government are revised. Other policy variables remain unchanged for the whole planning horizon.

Revision of Policy Variables Influencing the Whole System (GM-A-1)

The Actual Growth Rate of the Economy

$$\frac{GNP^{(t)}}{GNP^{(t-1)}} \frac{1}{\bar{p}^{pr(t)}} = a^{(t)}$$ is investigated. If for the

simulated time period $a^{(t)} < a'$, the share of consumption in the net national product is decreased:

$$f^{(t+1)} = f(a - a^{(t)}) \quad .$$

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* For the determination of world market prices for given periods see M. Keyzer's papers, *Linking of National Models of Agriculture: An Introduction*, (RM-77-2) and *Analysis of a National Model with Domestic Price Policies and Quota on International Trade* (RM-77-19).

If $a^{(t)} > a''$, the share of consumption in the net national product is increased:

$$f^{(t+1)} = f(a^{(t)} - a) \quad ,$$

where:

a' is the lowest acceptable growth rate of the economy;

a'' is the highest acceptable growth rate of the economy; and

$p^{pr(t)}$ is the producer price index for period (t).

The value of the gross national product is determined by:

$$\sum_i \sum_j p_i^{pr(t)} \gamma_{ij}^{s(t)*} SP_{ij}^{(t)} + \sum_i p_i^{h(t)} \gamma_i^{h(t)*} HP_i^{(t)}$$

$$+ \sum_f \sum_i p_f^{pr(t)} \gamma_{fi}^{p(t)} PF_{fi}^{(t)} + p_n^{pr(t)} P_n^{(t)} = GNP^{(t)} \quad .$$

The Gross Rate of Food and Agriculture

$\dfrac{GNPA^{(t)}}{GNPA^{(t-1)}} \dfrac{1}{\bar{p}_{i,f}^{pr(t)}} = b^{(t)}$ is also investigated. Similarly to $GNP^{(t)}$ if for three simulated time periods, $b^{(t)} < b'$, the share of food and agriculture in total investment accumulation is increased:

$$g^{(t+1)} = f(b - b^{(t)}) \quad ,$$

if $b^{(t)} > b''$, the share of food and agriculture in total investment accumulation is decreased:

$$g^{(t+1)} = f(b^{(t)} - b) \quad ,$$

where:

b' is the lowest acceptable growth rate of food and agriculture;

b'' is the highest acceptable growth rate of food and agriculture; and

$\bar{p}_{i,f}^{pr(t)}$ is the price index for food and agriculture commodities.

The value of the gross national product of food and agriculture is calculated as:

$$\sum_i \sum_j p_i^{pr(t)} \gamma_{ij}^{s(t)*} SP_{ij}^{(t)} + \sum_i p_i^{n(t)} \gamma_i^{n(t)*} HP_i^{(t)}$$

$$+ \sum_f \sum_i p_f^{pr(t)} \gamma_{fi}^{p(t)} PF_{fi}^{(t)} = GNPA^{(t)} \quad .$$

<u>In the GM-A Block the unit wages are modified</u>.

This modification is related to the growth rate of the gross national product and the net national product. Two different cases are considered:

If $a' < a^{(t)} < a''$ (desired growth), the wage rates are changed as the growth rate of the net national product:

$$w^{s(t+1)} = o^{(t)} w^{s(t)} ; \qquad w^{p(t+1)} = o^{(t)} w^{p(t)} ;$$

$$w^{n(t+1)} = o^{(t)} w^{n(t)} ;$$

$$\frac{NNP^{(t)}}{NNP^{(t-1)}} \frac{1}{\bar{p}^{pr(t)}} = o^{(t)}$$

If $a^{(t)} < a'$; $a^{(t)} > a''$ (slower or faster growth than desired), the wage rate's increase is less or more than the growth of the net national product according to the new share of consumption in net national product:

$$w^{s(t+1)} = \frac{f^{(t+1)}}{f^{(t)}} o^{(t)} w^{s(t)} \quad ,$$

$$w^{p(t+1)} = \frac{f^{(t+1)}}{f^{(t)}} o^{(t)} w^{p(t)} \quad ,$$

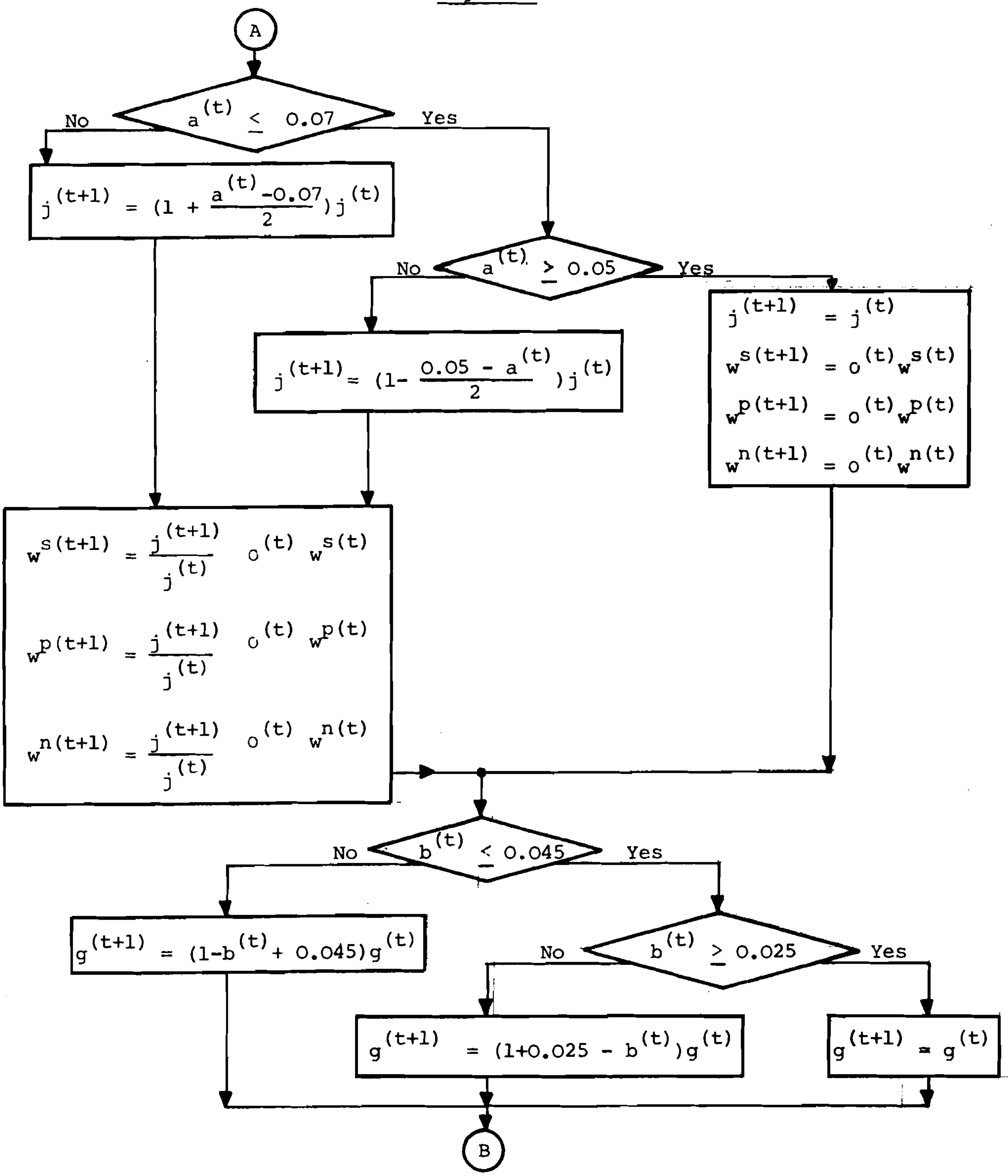
$$w^{n(t+1)} = \frac{f^{(t+1)}}{f^{(t)}} o^{(t)} w^{n(t)} \quad ,$$

where:

$o^{(t)}$ is the growth rate of the net national product.

The procedure used to revise basic policy variables is also shown in Figure 3.

Figure 3



REVISION OF BASIC POLICY VARIABLES

The Revision of Income Tax Rates of Producers

These are based (see Figure 4) on the analysis of the actual income situation of the different sectors, as we represent by the example of socialist agriculture:

$$\frac{INCS^{(t)}}{SAAP^{(t)}} = i^{s(t)} \quad .$$

If $i^{s(t)} < i'$, the income tax rate of socialist agriculture is decreased:

$$t^{in,s(t+1)} = f(i' - i^{s(t)}) \quad ,$$

where:

$SAAP^{(t)}$ is the planned gross production value of socialist agriculture.

If $i^{s(t)} > i''$, the income tax rate of socialist agriculture is increased:

$$t^{in,s(t+1)} = f(i^{s(t)} - i'') \quad ,$$

where:

$i^{s(t)}$ is the rate of net income in gross production value of socialist agriculture; and

i', i'' are the lower and upper limits of desired income rate of socialist agriculture.

Revision of Prices (GM-A-2)

The most complicated module of the GM-A Block is concerned with the revision of producer and consumer prices. The producer prices of food and agricultural commodities are revised based on the comparison of the actual and planned production on a three year basis. The producer prices may be modified if:

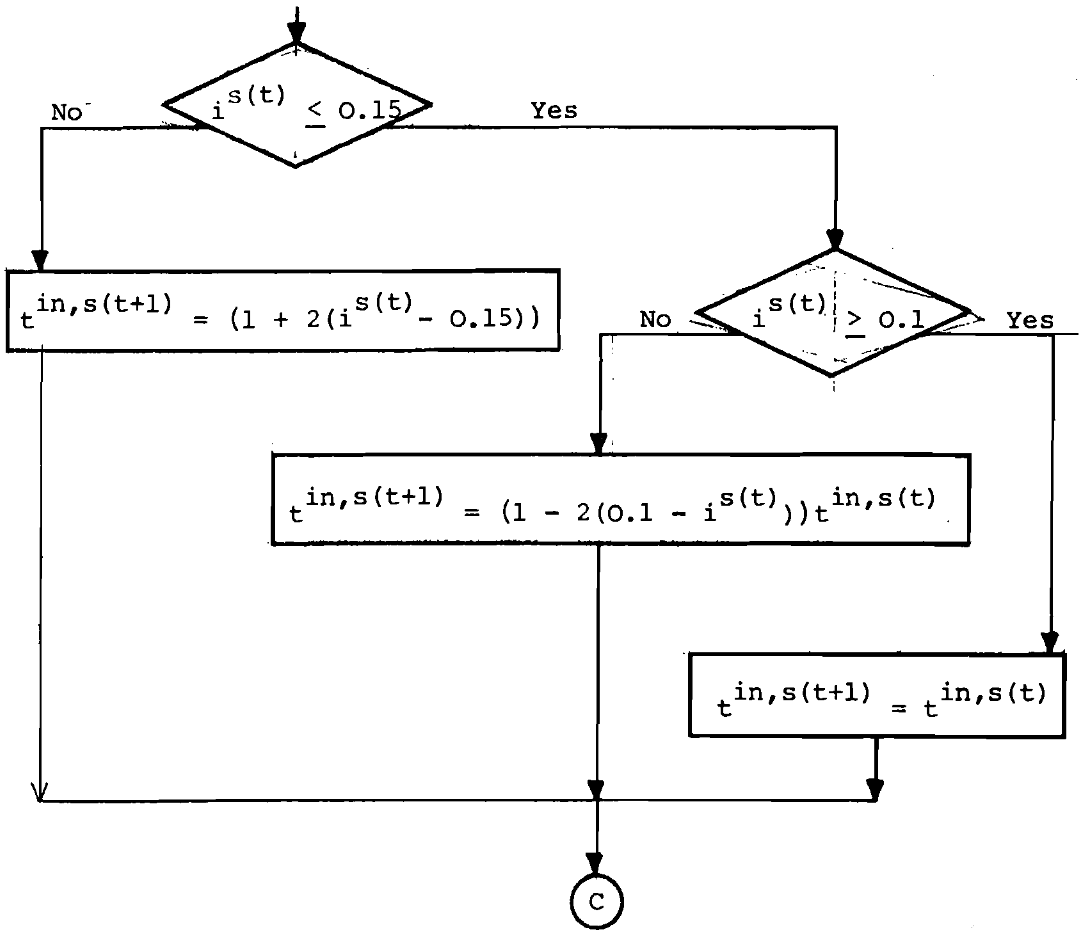
$$P_i^{(t)} < z_i' PP_i^{(t)} \quad \text{or} \quad P_i^{(t)} > z_i'' PP_i^{(t)} \quad ,$$

$$P_i^{(t)} = \sum_j \gamma_{ij}^{s(t)} * SP_{ij}^{(t)} + \gamma_i^{h(t)} * HP_i^{(t)} \quad ,$$

or if:

$$P_f^{(t)} < z_f' PP_f^{(t)} \quad \text{or} \quad P_f^{(t)} > z_f'' PP_f^{(t)} \quad ,$$

Figure 4



REVISION OF INCOME TAX RATE PAID BY SOCIALIST AGRICULTURE

$$P_f^{(t)} = \sum_i \gamma_{fi}^{p(t)*} PF_{fi}^{(t)} ,$$

where:

$P_i^{(t)}$ is the actual production of agricultural commodity i;

$P_f^{(t)}$ is the actual production of processed food commodity f;

z_i', z_f' are the acceptable lower levels of the deviation from plan targets; and

z_i'', z_f'' are the acceptable upper levels of the deviation from plan targets.

In the case of changes in producer prices of agricultural commodities, the producer prices of the processed food commodities are increased or decreased to the same extent.

The rate of price change:

$$\frac{p_i^{pr(t)}}{p_i^{pr(t+1)}} = q_i^{(t)} ,$$

where:

$q_i^{(t)}$ is the rate of price increase or decrease of commodity i.

The same method is applied to the case of processed foods. Besides that, the increase of agricultural raw material prices are also expressed in processed food prices.

The price of the n-th commodity is adjusted based on the increase in world market prices. The price is modified if a permanent (at least three years) increase or decrease is observed.

The increase of the producer's price level is limited:

$$\bar{p}^{pr(t)} \leq \bar{q}^{pr(t)''} ,$$

where:

$\bar{q}^{pr(t)''}$ is the upper limit of the producer's price increase.

The consumer prices are compared with the producer prices. Price increase or decrease takes place when the difference exceeds a given level. The increase of the producer's price level is also restricted:

$$\bar{p}^{c(t)} \leq \bar{q}^{c(t)"} ,$$

where:

$\bar{p}^{c(t)}$ is the consumer price index; and

$\bar{q}^{c(t)"}$ is the upper limit of consumer price increase.

The decrease of the consumer price is not limited.

In all cases where the price is not modified in the GM-A Block the price of (t+1) period is equal to the price of period (t).

$$p_i^{pr(t)} = p_i^{pr(t+1)}; \qquad p^{pr(t)} = p_f^{pr(t+1)}$$

$$p_i^{c(t+1)} = p_i^{c(t+1)}; \qquad p_f^{c(t)} = p_f^{c(t+1)} .$$

Figure 5 shows the scheme of price revision.

UPDATING THE MODEL'S PARAMETERS (UD)

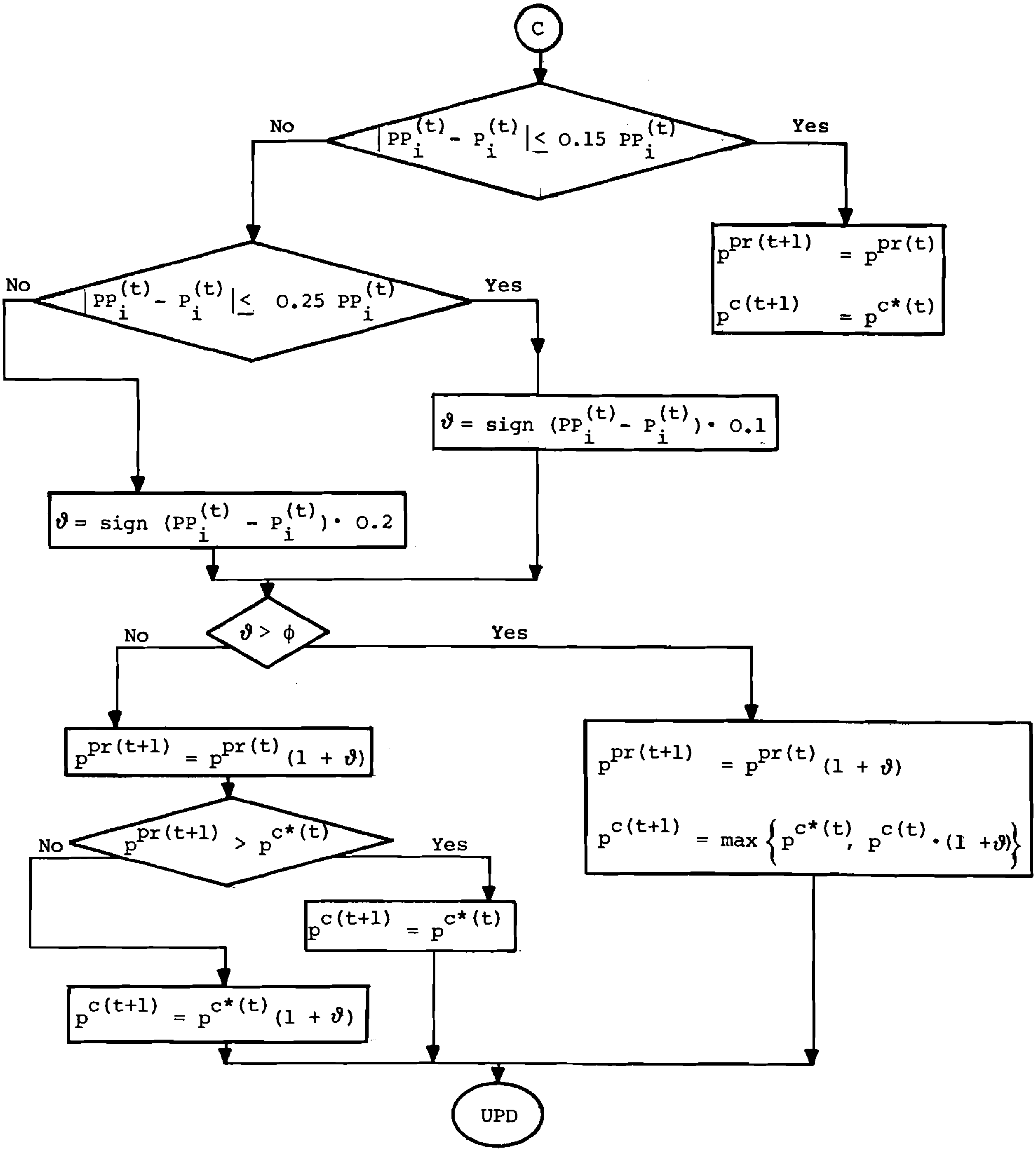
The last block of HAM serves for the updating of parameters of the other model blocks -- the last task during the modelling of a given time period. The UD Block incorporates four modules:

- calculation of demographic changes (UD-1);
- updating of available land and physical resources (UD-2);
- calculation of new parameters for the Government planning model (UD-3); and
- updating of parameters for the Production Block (UD-4).

Demographic Changes (UD-1)

HAM does not include a demographic submodel. The available labor force, and changes in population are calculated from demographic prognoses elaborated by the Hungarian Central Statistical Bureau. The period of large scale migration within the country ended in the late 1960's. Therefore only a projected maximum decrease of agricultural labor force is considered according to government targets, and $tp^{(t+1)}$, $wp^{(t+1)}$, $la^{(t+1)}$ are taken as exogenous parameters.

Figure 5



SCHEME OF PRICE REVISION

Land and Physical Resources (UD-2)

The available land for agricultural production purposes is accounted by land and user categories. A regular decrease of plow lands and meadows because of industrialization and urbanization is considered:

Land Resources of Socialist Agriculture

$$LS^{(t+1)} = da^{s(t)} LS^{(t)} + \sum_i (1 - dp_i^{s(t)}) LPS_i^{(t)} - \sum_i LPSN_i^{(t)} ,$$

$$LPS_i^{(t+1)} = dp_i^{s(t)} LPS_i^{(t)} + LPSN_i^{(t-t_1)} ,$$

where:

$da^{s(t)}$ is an exogenous parameter expressing the annual decrease of plow lands;

$dp_i^{s(t)}$ is an exogenous parameter expressing the annual decrease of the perennial cropland due to the age of the plantations;

and:

$$LPSN_i^{(t+1)} = \sum_{t_1=1}^{n_i} LPSN_i^{(t-t_1)} ,$$

$$LMS^{(t+1)} = dm^{s(t)} LMS^{(t)} ,$$

where:

$dm^{s(t)}$ is an exogenous parameter expressing the annual decrease of meadows and pastures due to industrialization and urbanization.

Irrigation Capacities

These are increased by direct government investments:

$$LIS^{(t+1)} = LIS^{(t)} + irDGINA^{(t)} ,$$

where:

ir is the increase of irrigated land due to government investments.

Land Resources of Household and Private Agriculture

$$LGH^{(t+1)} = LGH^{(t)} + \sum_i dp^{h(t)} LPH_i^{(t)} - \sum_i LPHN_i^{(t)} ,$$

$$LPHN_i^{(t)} = \sum_{t_1=1}^{n_i} LPHN^{(t-t_1)} ,$$

where:

$dp_i^{h(t)}$ is the annual decrease of the perennial cropland due to the age of the trees.

The increase of physical resources is mainly based on the investments of the production sectors.

In household and private agriculture:

$$RH_k^{(t+1)} = de_k^h \, RH_k^{(t)} + RIH_k^{(t)} ;$$

In socialist agriculture:

$$RS_k^{(t+1)} = de_k^s \, RS_k^{(t)} + RIS_k^{(t)} ;$$

In food processing:

$$RP_k^{(t+1)} = de_k^p RP_k^{(t)} + RIP_k^{(t)} ;$$

or because some of the physical resources (plant capacity) may be increased by direct government investments:

$$RP_k^{(t+1)} = de_k^p RP_k^{(t)} + RIP_k^{(t)} + pr_k DGINA^{(t)} .$$

The assets of the rest of the economy are:

$$RVN^{(t+1)} = de^n RVN^{(t)} + ni(IFEAN^{(t)} + GINN^{(t)}) ,$$

where:

de_k^h, de_k^s, de_k^p, de^n are the decrease of resources due to their age;

pr_k is an exogenous parameter expressing the increase of food processing capacity k based on a unit of direct government investment in food and agriculture;

ni is the increase of the assets of the rest of the economy based on the unit of investment.

The value of assets in socialist agriculture and food processing:

$$RVS^{(t+1)} = (1 - dr^{s})RVS^{(t)} + \sum_k INS_k^{(t)} \quad ,$$

$$RVP^{(t+1)} = (1 - dr^{p})RVP^{(t)} + \sum_k INP_k^{(t)} + prDGINA^{(t)} \quad ,$$

where:

pr is the share of direct government investments in food and agriculture for food processing.

Updating GM-P-3 Model Parameters (UD-3)

Food and agriculture is described at an aggregated level by the GM-P model. Technical coefficients of variables representing the production of different food and agricultural commodities are calculated based on the production block of period (t) as a weighted average of the various production options. We demonstrate this for the case of agricultural commodities:

$$\alpha_{ii}^{(t+1)} = \frac{\alpha_{ii}^{ht} HP_i^{(t)} + \sum_j \alpha_{iji}^{s(t)} SP_{ij}^{(t)}}{\gamma_i^{h(t)} HP_i^{(t)} + \sum_j \gamma_{ij}^{s(t)} SP_{ij}^{(t)}} \quad ,$$

$$\beta_i^{(t+1)} = \frac{\beta_i^{h(t)} HP_i^{(t)} + \sum_j \beta_{ij}^{s(t)} SP_{ij}^{(t)}}{\gamma_i^{h(t)} HP_i^{(t)} + \sum_j \gamma_{ij}^{s(t)} SP_{ij}^{(t)}} \quad .$$

$\alpha_{ik}^{(t+1)}$ and $\alpha_{in}^{(t+1)}$ are determined in a similar way.

The available resource capacities are calculated from the UD-2 model as:

$$R_k^{(t+1)} = RH_k^{(t+1)} + RS_k^{(t+1)} \quad ,$$

or in the case of food processing, just $RP_k^{(t+1)}$ appears in the GM-P-3 module.

The land capacities are calculated similarly. The $\omega_k^{(t+1)}$ is calculated from the shadow prices of the individual resources in the GM-P-3 model solution for period (t).

Generation of the Producer's Decision Model Parameters (UD-4)

The generation of model parameters for the household and private and the socialist agriculture is carried out by the approach outlined earlier. The yield and output coefficients are calculated from the trend functions expressing the biological development of the crops. The trends are given according to technologies taking irrigated production as a separate technology. For example:

$$\gamma_{ij}^{s(t+1)} = f(\text{time}, \gamma_{ij}^{s(t)*})$$

The inputs are determined from the projected yields and outputs. The fertilizer use is calculated from fertilizer response functions:

$$\alpha_{ijf}^{s(t+1)} = f(\gamma_{ij}^{s(t\pm1)}) \quad ,$$

where:

$\alpha_{ijf}^{s(t+1)}$ is the unit fertilizer input of commodity i by technology j.

The other input coefficients ($\alpha_{ii}^{h(t+1)}$, $\alpha_{ik}^{h(t+1)}$, $\alpha_{in}^{h(t+1)}$, $\beta_{i}^{h(t+1)}$, $\alpha_{iji}^{s(t+1)}$, $\alpha_{ijk}^{s(t+1)}$, $\alpha_{ijn}^{s(t+1)}$, $\beta_{ij}^{s(t+1)}$, are selected from exogenously given parameters determined by experts for each technology and each level of output.

The possible output coefficients of food processing are updated according to trends. The method of updating input coefficients is similar to those applied for adjusting agricultural parameters. The input parameters related to investment activities are treated similarly. The input coefficients of general management and overhead activities are not subject to any modification in the course of the projecting procedure.

The available funds of enterprises for investments in the socialist sector are described as:

$$IFES^{t} = IFEAS^{(t)} + IFER^{(t)} + (1 - dc^{s})DES^{(t)} \quad ,$$

and in food processing as:

$$IFEP^{(t)} = IFEAP^{(t)} + IFERP^{(t)} + (1 - dc^{p})DEP^{(t)} \quad .$$

The efficiency of investments ($\omega_k^{s(t)}$, $\omega_k^{p(t)}$) is determined from shadow prices gained by the solution of the previous period's models.

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APPENDIX 1. LIST OF COMMODITIES

I. Agricultural Commodities

Commodities	IIASA Commodity list	Unit in	
		GM-P-3 Module	P-2,P-3 Module
1. Wheat (wheat,rye)	1. Wheat	1000 Mt	1000 ha
2. Barley (autumn, spring, oats)	3. Coarse grains	1000 Mt	1000 ha
3. Corn	3. Coarse grains	1000 Mt	1000 ha
4. Pulses (dry peas, beans, lentils)	11. Starchy roots & vegetables	1000 Mt	1000 ha
5. Oil seeds (sunflower, rapeseed, oil flax, soyabean)	4. Vegetable oils 5. Protein feeds	1000 Mt	1000 ha
6. Sugarbeet	6. Sugar	1000 Mt	1000 ha
7. Tobacco	13. Industrial crops	1000 Mt	1000 ha
8. Lucerne (hay)	——	1000 Mt	1000 ha
9. Silo and green fodders	——	1000 Mt	1000 ha
10. Potatoes	11. Starchy roots & vegetables	1000 Mt	1000 ha
11. Field crop vegetables		1000 Mt	1000 ha
12. Other field crops	——	1 mill. Ft. prod. value	1000 ha
13. Meadows, pasture	——	1000 Mt	1000 ha
14. Grape	10. Fruits	1000 Mt	1000 ha
15. Tree fruits	10. Fruits	1000 Mt	1000 ha
16. Berries	10. Fruits	1000 Mt	1000 ha
17. Beef cattle	7. Beef and lamb	1000 Mt	1000 head complex cattle
18. Pork	8. Other meats	1000 Mt	1000 head complex pig
19. Lamb	7. Beef & lamb	1000 Mt	1000 head complex sheep
20. Poultry meat	8. Other meats	1000 Mt	1 mill. animals
21. Milk	9. Dairy Products	1000 Mt	1000 head complex cattle
22. Eggs	8. Other meats	1 mill. eggs	1 mill hens
23. Wool	13. Industr. crops	1000 m.t.	1000 head complex sheep
24. Other animal husbandry	14. Fishery product	1 mill. Ft. prod. value	1 mill. Ft. prod. value
25. Additional construct. & service activities	——	1 mill. Ft prod. value	1 mill.Ft. prod. value

LIST OF COMMODITIES

II. Processed Foods

Commodity	IIASA Commodity List	Unit in	
		GM-P-3 Module	P-5 Module
1. Beef (carcass form)	7. Beef & lamb	1000 Mt	1000 Mt
2. Pork (carcass form)	8. Other meats	1000 Mt	1000 Mt
3. Lamb (carcass form)	7. Beef & lamb	1000 Mt	1000 Mt
4. Processed meat	8. Other meats	1000 Mt	1000 Mt
5. Animal fat	4. Fats & oils	1000 Mt	1000 Mt
6. Meat mill	5. Protein feeds	1000 Mt	1000 Mt
7. Poultry meat	8. Other meats	1000 Mt	1000 Mt
8. Processed eggs	8. Other meats	1 mill. eggs	1 mill. eggs
9. Fresh milk	9. Dairy products	1000 hl	1000 hl
10. Butter	9. Dairy products	1000 Mt	1000 Mt
11. Cheese	9. Dairy products	1000 Mt	1000 Mt
12. Canned fruits	10. Fruits	1000 Mt	1000 Mt
13. Canned vegetables	11. Starchy roots & vegetables	1000 Mt	1000 Mt
14. Deep frozen fruits	10. Fruits	1000 Mt	1000 Mt
15. Deep frozen vegetables	11. Starchy roots & vegetables	1000 Mt	1000 Mt
16. Flour	1. Wheat	1000 Mt	1000 Mt
17. Concentrates	3. Coarse grains	1000 Mt	1000 Mt
18. Bread	1. Wheat	1000 Mt	1000 Mt
19. Sugar	6. Sugar	1000 Mt	1000 Mt
20. Vegetable oil	4. Fats & oils	1000 Mt	1000 Mt
21. Wine	12. Beverage crops	1000 hl	1000 hl
22. Beer	12. Beverage crops	1000 hl	1000 hl
23. Liquors	12. Beverage crops	1000 hl	1000 hl
24. Cigarettes	13. Industr. crops	1 mill. cigarettes	1 mill. cigarettes
25. Other processed foods	12. Beverage crops	1 mill. Ft. product. value	1 mill. Ft. product. value

APPENDIX 2. LIST OF SYMBOLS

Exogenous and Policy Parameters

a	desired growth rate of gross national product.
$a^{(t)}$	actual growth rate of gross national product in period (t).
a'	lowest accepted growth rate of gross national product.
a''	highest desired growth rate of gross national product.
b	desired growth rate of gross national product related to food and agriculture.
$b^{(t)}$	actual growth rate of gross national product related to food and agriculture in period (t).
b'	lowest accepted growth rate of food and agriculture.
b''	highest desired growth rate of food and agriculture.
$c_i^{e(t)'}$, $c_i^{e(t)''}$	export quotas of commodity i.
$c_i^{i(t)}$, $c_i^{i(t)''}$	import quotas of commodity i.
$cp_i^{(t)}$	exogenously given trend value for per capita consumption of commodity i.
$cr^{(t)}$	foreign credit repayment coefficient.
$d_i^{(t)'}$, $d_i^{(t)''}$	lower and upper bounds given for the stock of commodity i.
$da^{s(t)}$	exogenous parameter expressing the annual decrease of plow lands.
de_k^h	depreciation parameter expressing the decrease of the physical capacity of resource k due to the age of resource in the household and private sector.

de^n	depreciation parameter expressing the decrease of the physical capacity of resources in the rest of the economy.
de_k^p	depreciation parameter expressing the decrease of the physical capacity of resource k due to the age of the resource in the food processing industry.
de_k^s	depreciation parameter expressing the decrease of the physical capacity of resource k due to the age of resources in socialist agriculture.
dc^n	coefficient expressing the part of amortization in the rest of the economy concentrated by the government.
dc^p	coefficient expressing the part of amortization in food processing concentrated by the government.
dc^s	coefficient expressing the part of amortization in socialist agriculture concentrated by the government.
$dm^{s(t)}$	exogenous parameter expressing the annual decrease of meadows and pastures due to industrialization and urbanization.
$dp_i^{h(t)}$	parameter expressing the annual decrease of the perennial cropland in household and private agriculture due to the age of the trees.
$dp_i^{(s)(t)}$	exogenous parameter expressing the annual decrease of the perennial cropland due to the age of the plantations in socialist agriculture.
dr^n	depreciation coefficient related to the fixed assets of the rest of the economy.
dr^p	depreciation coefficient applied for all fixed assets of the food processing industry in period (t).
dr^s	depreciation coefficient applied for all fixed assets of socialist agriculture in period (t).
e	growth rate of NNP related to growth rate of GNP.
$ep^{g(t)}$	coefficient expressing the trend of increase in public expenditures.
$es^{g(t)}$	coefficient expressing the increase of social expenditures.

$f^{(t)}$	rate of consumption in net national product given for period (t).
$fd^{(t)''}$	upper limits of foreign debts.
$g^{(t)}$	share of food and agriculture in total planned accumulation in period (t).
$g^{p(t)}$	coefficient expressing the share of general management and overhead expenses to gross production value of food processing in period (t).
g^{s}	coefficent expressing the connection between the scale of production and general management and overhead activities in the socialist agriculture in period (t).
h	exogenously given rate of centralized investments in total accumulation of food and agriculture.
$i^{s(t)}$	rate of net income in the gross production value of socialist agriculture.
$i^{s'}$, $i^{s''}$	lower and upper desired net income rate of socialist agriculture.
ir	parameter expressing the increase of irrigated land due to government investments.
k^{h}	parameter expressing the hours available for household farming.
k^{s}	parameter expressing the work done at socialist agriculture by a unit of agricultural labor force.
l^{h}	is a coefficient expressing the per capita size of household plow lands.
$la^{(t)'}$	exogenous coefficient expressing the decrease of agricultural population.
$la^{(t)''}$	upper bound of agricultural labor usage.
$lr^{(t)}$	foreign loan repayment coefficient.
m_k^{p}	rate of government subsidy given to investments of food processing industry in resource k.
m_k^{s}	rate of government subsidy given to investments of socialist agriculture in resource k.

ni	coefficient expressing the increase of the assets of the rest of the economy based on unit of investments.
n_k	time required to finish investment in resource k.
$o^{(t)}$	growth rate of net national product in period (t).
$p_i^{c(t)}$	consumer price of agricultural commodity i in period (t).
$p_f^{c(t)}$	consumer price of processed food commodity f in period (t).
$p_n^{c(t)}$	consumer price of the n-th commodity in period (t).
$p_f^{pr(t)}$	producer price of processed food commodity f in period (t).
$p_i^{pr(t)}$	producer price of agricultural commodity i in period (t).
$p_k^{pr(t)}$	price charged by the socialist agricultural sector for the use of their physical resource k in period (t).
$p_m^{pr(t)}$	price charged for additional activities of socialist sector.
$p_n^{pr(t)}$	producer price of the n-th commodity in period (t).
$p_f^{w(t)}$	world market price of processed food commodity f in period (t).
$p_i^{pr(t)}$	minimum price for commodity i.
$p_i^{w(t)}$	world market price of agricultural commodity i in period (t).
$p_n^{w(t)}$	world market price of the n-th commodity in period (t).
$\bar{p}^{p(t)}$	producer price index for period (t).
$\bar{p}^{c(t)}$	consumer price index for period (t).
$\bar{p}_{i,f}^{pr(t)}$	producer price index of food and agricultural commodities for period (t).
pr	coefficient expressing the share of food processing in direct government investments in food and agriculture.

pr_k	exogenous parameter expressing the increase of food processing capacity k based on a unit of direct government investments in food and agriculture.
$q_i^{(t)}$	rate of price increase or decrease of commodity i.
$\bar{q}^{c(t-1)}$	upper limit of consumer price level increase.
s^h	coefficient expresses the estimated ratio of rural savings in total savings.
$s^{po(t)}$	growth rate of total value of savings.
$s^{po'}$, $s^{po''}$	lower and upper desired growth rate of total amount of savings.
t^l	land tax coefficient.
$t^{in,\ p(t)}$	income tax rate applied in food processing.
$t^{in,\ po(t)}$	income and other tax rate of population in period (t).
$t^{in,s(t)}$	income tax rate applied in the socialist agriculture sector in period (t).
$t^{so,po(t)}$	employee's contribution to superannuation.
$t^{wa(t)}$	wage tax rate in period (t).
$ta_i^{(t)}$	fixed government tariff on commodity i.
$tp^{(t)}$	total population in period (t).
u'	coefficient expressing the minimum requirement for labor force utilization in socialist agriculture.
$v^{n(t)}$	rate of bonus in total net income paid for employee by the rest of the economy.
$v^{p(t)}$	rate of bonus in total net income for employee in food processing.
$v^{s(t)}$	rate of bonus in total net income paid for employee in socialist agriculture.
$w^{n(t)}$	unit wages paid by n-th sector in period (t).
$w^{p(t)}$	unit wages in food processing in period (t).
$w^{s(t)}$	unit wages in socialist agriculture in period (t).

$z_i^{(t)''}$ coefficient expressing the upper limit of the application of technology (j+1) related to commodities in period (t).

z_i', z_f' accepted lower level of the deviation from plan targets in production commodity i and f.

z_i'', z_f'' accepted upper level of the deviation from plan targets in production commodity i and f.

$x^{(t)}$ coefficient expressing the maximum share in savings which can be used to finance government budget deficit.

y_i coefficient expressing the allowed decrease of per capita consumption of commodity i in one time period.

Model Coefficients

$\left.\begin{array}{l}\alpha_{ii}^{(t)}, \alpha_{fi}^{(t)}, \\ \alpha_{ni}^{(t)}, \alpha_{ki}^{(t)}\end{array}\right\}$ average unit input coefficients from agricultural commodity i in period (t).

$\left.\begin{array}{l}\alpha_{if}^{(t)}, \alpha_{ff}^{(t)}, \\ \alpha_{nf}^{(t)}, \alpha_{kf}^{(t)}\end{array}\right\}$ average unit input coefficients from processed commodity f in period (t).

$\alpha_{in}^{(t)}, \alpha_{fk}^{(t)}, \alpha_{nk}^{(t)}$ average resource utilization coefficients in period (t).

$\alpha_{il}^{h(t)}$ land input coefficient of household and private agricultural commodity i.

$\alpha_{ii}^{h(t)}$ input coefficient related to the usage of i-th commodity in the production of commodity i in the household and private sector in period (t).

$\alpha_{ik}^{h(t)}$ resource input coefficient related to i-th commodity of household and private agriculture and k-th resource in period (t).

$\alpha_{ki}^{h(t)}$ commodity i input coefficient of investment in resource k in household and private agriculture in period (t).

$\alpha_{nn}^{n(t)}$, $\alpha_{ni}^{n(t)}$, $\alpha_{nf}^{n(t)}$	raw material input coefficients of production of n-th commodity in period (t).
$\alpha_{fii}^{p(t)}$	raw materials input coefficient in period (t) in food processing.
$\alpha_{fin}^{p(t)}$, $\alpha_{gn}^{p(t)}$, $\alpha_{kn}^{p(t)}$	input coefficients of food processing related to the use of commodity n.
$\alpha_{fik}^{p(t)}$, $\alpha_{gk}^{p(t)}$	input coefficients of food processing related to resource k in period (t).
$\alpha_{ijl}^{s(t)}$	land input coefficient related to i-th commodity and j-th technology of socialist agriculture in period (t).
$\alpha_{iji}^{s(t)}$	input coefficients of socialist agriculture from commodity i related to commodity i and technology j in period (t).
$\alpha_{ijk}^{s(t)}$	input coefficient of resource k related to commodity i and technology j in socialist agriculture in period (t).
$\alpha_{ijf}^{s(t)}$	unit fertilizer input of commodity i by technology j in socialist agriculture in period (t).
$\alpha_{km}^{s(t)}$	requirement for the services of additional activities represented by production variable m in period (t).
$\alpha_{gk}^{s(t)}$	resource k input coefficient related to general management and overhead activities in period (t).
$\alpha_{mn}^{s(t)}$	input coefficient from commodity n related to the additional activities of socialist agriculture in period (t).
$\alpha_{gn}^{s(t)}$	input coefficient from commodity n related to the general management and overhead activities of socialist agriculture in period (t).
$\beta_{i}^{(t)}$, $\beta_{f}^{(t)}$, $\beta_{n}^{(t)}$	average labor input coefficients in period (t).
$\beta_{i}^{h(t)}$	labor input coefficient of commodity i in household and private sector in period (t).
$\beta^{n(t)}$	labor input coefficient of the rest of the economy.

$\beta_{fi}^{p(t)}$ labor input coefficient of production commodity f from commodity i in period (t).

$\beta_{g}^{p(t)}$ labor input coefficient of general management and overhead activities of food processing in period (t).

$\beta_{ij}^{s(t)}$ labor input coefficient of commodity i and technology j in socialist agriculture.

$\gamma_{i}^{h(t)}$ expected unit output in production of commodity i in the household and private sector in period (t).

$\gamma_{fi}^{p(t)}$ unit output coefficient related to processed food commodity f from commodity i in period (t).

$\gamma_{ij}^{s(t)}$ expected output (yield) of commodity i by technology j in the socialist sector in period (t).

$\gamma_{i}^{h(t)*}, \gamma_{ij}^{s(t)}$ actual yields in period (t).

$\theta_{i}^{h(t)}, \theta_{ij}^{s(t)}$ coefficients expressing weather effects on yields.

$\omega_{k}^{(t)}$ coefficient expressing the expected average efficiency of investments.

$\omega_{k}^{p(t)}$ expected efficiency of investment in resource k in food processing.

$\omega_{k}^{s(t)}$ expected efficiency of investment in resource k in socialist agriculture.

Model Variables

$ALR^{(t)}$ planned labor requirement of agricultural production in period (t).

$ARM_{i}^{(t)}$ available commodity i for processing in period (t).

$BN^{(t)}$ bonus paid by the rest of the economy in period (t).

$BP^{(t)}$ bonus paid by food processing industry in period (t).

$BS^{(t)}$ bonus paid by socialist agriculture in period (t).

$CON^{(t)}$	value of private consumption in period (t).
$CONP^{(t)}$	value of private consumption on producer prices in period (t).
$CP_f^{(t)}$	actual per capita consumption of commodity f in period (t).
$CP_i^{(t)}$	actual per capita consumption of commodity i in period (t).
$CP_n^{(t)}$	actual per capita consumption of commodity n in period (t).
$CPE^{(t)}$	per capita possible expenditures on consumption of the population in period (t).
$DEN^{(t)}$	depreciation related to the rest of the economy in period (t).
$DEP^{(t)}$	total depreciation of the food processing industry in period (t).
$DES^{(t)}$	total depreciation of socialist agriculture in period (t).
$DGNP^{(t)}$	desired gross national product in period (t).
$DGNPA^{(t)}$	desired gross national product related to food and agriculture in period (t).
$DNNPA^{(t)}$	desired net national product related to food and agriculture in period (t).
$DPBA^{(t)}$	desired positive balance of payments of food and agriculture in period (t).
$E_i^{(t)}$	export of commodity i in period (t).
$E_f^{(t)}$	export of processed food commodity f in period (t).
$E_n^{(t)}$	export of the rest of the economy in period (t).
$FB^{(t)}$	total credits given by the country in period (t).
$FC^{(t)}$	new credits given by the country in period (t).
$FCB^{(t)}$	negative balance of foreign loans, credits and repayment in period (t).

$FCR^{(t)}$ foreign credits given by the country and loan repayments in period (t).

$FD^{(t)}$ total foreign debts in period (t).

$FL^{(t)}$ new borrowing in period (t).

$FLR^{(t)}$ foreign loans taken by the country and credit repayments in period (t).

$GCS^{(t)}$ government subsidies to consumer prices in period (t).

$GD^{(t)}$ part of the total amortization concentrated in government budget in period (t).

$GES^{(t)}$ government export subsidy in period (t).

$GID^{(t)}$ deficit of government budget in period (t).

$GINA^{(t)}$ government expenditures on investments in food and agriculture in period (t).

$GINN^{(t)}$ government expenditures on investments in the rest of the economy in period (t).

$GINS^{(t)}$ government investment subsidies for food and agriculture in period (t).

$GINSA^{(t)}$ government investment subsidy to socialist agriculture in period (t).

$GINSP^{(t)}$ government investment subsidy to food processing industry in period (t).

$GIS^{(t)}$ government import subsidies in period (t).

$GISU^{(t)}$ government budget surplus in period (t).

$GNP^{(t)}$ gross national product in period (t).

$GNPA^{(t)}$ gross national product related to food and agriculture in period (t).

$GP^{(t)}$ government price subsidies in period (t).

$GS^{(t)}$ social income of population from government budget (e.g. pensions) in period (t).

$GPE^{(t)}$ public expenditures of government in period (t).

$GSE^{(t)}$ government expenditures on stocks in period (t).

$GSP^{(t)}$	social expenditures of government in period (t).
$GSR^{(t)}$	government income on available stocks in period (t).
$GSRP^{(t)}$	repayment to savings in period (t).
$GT^{(t)}$	total tax receipts of government in period (t).
$GTRP^{(t)}$	total tariff receipts of government in period (t).
$HAI^{(t)}$	income from household and private farming in period (t).
$HAIP^{(t)}$	projected gross income of household and private agriculture in period (t).
$HAPP^{(t)}$	projected gross production value of household and private agriculture in period (t).
$HP_i^{(t)}$	scale of production of agricultural commodity i in the household and private sector in period (t).
$HPE^{(t)}$	total expenses of household and private agricultural production in period (t).
$I_i^{(t)}$	import of agricultural commodity i in period (t).
$I_f^{(t)}$	import of processed food commodity f in period (t).
$I_n^{(t)}$	import of n-th commodity in period (t).
$IFEAN^{(t)}$	accumulated investment fund of the rest of the economy in period (t).
$IFEAP^{(t)}$	accumulated investment fund of food processing in period (t).
$IFEAS^{(t)}$	accumulated investment funds of socialist agriculture in period (t).
$IFEN^{(t)}$	total investment fund of the rest of the economy in period (t).
$IFEP^{(t)}$	total investment funds of food processing firms from period (t).

$IFER^{(t)}$	unused investment fund of the socialist sector in period (t).
$IFERP^{(t)}$	unused investment fund of the food processing industry in period (t).
$IFES^{(t)}$	total investment funds of agricultural enterprises in period (t).
$INCN^{(t)}$	net income of the rest of the economy in period (t).
$INCP^{(t)}$	net income of food processing in period (t).
$INCPO^{(t)}$	total income of population in period (t).
$INCS^{(t)}$	net income of socialist agriculture in period (t).
$INH_i^{(t)}$	investments in plantation type i in period (t) by the household and private sector.
$INH_k^{(t)}$	value of investment by household and private agriculture in resource k in period (t).
$INP_k^{(t)}$	value of investments in resource k by food processing industry in period (t).
$INS_k^{(t)}$	value of investments in resource k in period (t) in the socialist agricultural sector.
$INS_i^{(t)}$	investment of socialist sector in perennial crop i in period (t).
$LA^{(t)}$	agricultural labor force in period (t).
$LAF^{(t)}$	total labor requirement of food and agriculture in period (t).
$LAN^{(t)}$	labor available for rest of the economy in period (t).
$LEN^{(t)}$	total labor expenses of the rest of the economy in period (t).
$LEP^{(t)}$	total labor expenses of food processing industry in period (t).
$LES^{(t)}$	total labor expenses of socialist sector in period (t).

$LGH^{(t)}$	size of private gardens in period (t).
$LH^{(t)}$	size of household and private plow land in period (t).
$LIS^{(t)}$	irrigated land of socialist agriculture in period (t).
$LMS^{(t)}$	available meadows and pasture in socialist agriculture in period (t).
$LPH^{(t)}$	size of mature plantation type i in household and private agriculture in period (t).
$LPHN_i^{(t)}$	new plantation of type i in household and private agriculture in period (t).
$LPHN_i^{(t-n_i)}$	nonmature plantation of type i planted n_i years ago in household and private agriculture.
$LPS_i^{(t)}$	size of plantation type i in period (t) in the socialist agricultural sector.
$LPSN_i^{(t)}$	new plantations of perennial crop type i in period (t) in socialist agriculture.
$LPSN_i^{\prime(t-n_i)}$	nonmature plantations of type i planted n_i years ago in socialist sector.
$LS^{(t)}$	available plow land in period (t).
$LTH^{(t)}$	land tax paid by household and private agriculture in period (t).
$LTS^{(t)}$	land tax paid by the socialist sector in period (t).
$MEH^{(t)}$	total material expenses of household and private agriculture in period (t).
$MEP^{(t)}$	total material expenses of food processing industry in period (t).
$MES^{(t)}$	total material expenses of socialist sector in period (t).
$NNP^{(t)}$	actual net national product of period (t).
$NNPA^{(t)}$	net national product related to food and agriculture in period (t).
$P_f^{(t)}$	actual production of processed food commodity f in period (t).

$P_i^{(t)}$ actual production of agricultural commodity i in period (t).

$P_n^{(t)}$ production of the n-th commodity in period (t).

$PAF^{(t)}$ planned accumulation fund in period (t).

$PAFA^{(t)}$ planned accumulation in food and agriculture in period (t).

$PAFN^{(t)}$ planned accumulation fund of the rest of the economy in period (t).

$PAP^{(t)}$ gross production value of food processing industry in period (t).

$PBA^{(t)}$ positive balance of payments of food and agriculture in period (t).

$PBPA^{(t)}$ planned positive balance of payment of food and agriculture in period (t).

$PCP_f^{(t)}$ planned per capita consumption of commodity f in period (t).

$PCP_i^{(t)}$ planned per capita consumption of commodity i in period (t).

$PCP_n^{(t)}$ planned per capita consumption of commodity n in period (t).

$PDGNIA^{(t)}$ planned direct government investments in food and agriculture in period (t).

$PE_f^{(t)}$ planned export of commodity f in period (t).

$PE_i^{(t)}$ planned export of commodity i in period (t).

$PE_n^{(t)}$ planned export of commodity n in period (t).

$PF_{fi}^{(t)}$ scale of production of processed commodity f from raw material i in period (t).

$PFP_f^{(t)}$ output of commodity f from food processing in period (t).

$PGINS^{(t)}$ planned total investment subsidies for socialist agriculture in period (t).

$PGNPA^{(t)}$ planned gross national product from food and agriculture in period (t).

$PH_i^{(t)}$ final output (or demand) of commodity i in household and private sector in period (t).

$PI_f^{(t)}$ planned import of commodity f in period (t).

$PI_i^{(t)}$ planned import of commodity i in period (t).

$PI_n^{(t)}$ planned import of commodity n in period (t).

$PIN_k^{(t)}$ planned value of investment in resource k of agriculture in period (t).

$PINP_k^{(t)}$ planned value of investment in resource k of food processing in period (t).

$PLR^{(t)}$ labor requirement of food processing in period (t).

$PNNP^{(t)}$ planned net national product in period (t).

$PP_f^{(t)}$ planned production of commodity f in period (t).

$PP_i^{(t)}$ planned total production of agricultural commodity i in period (t).

$PP_n^{(t)}$ planned production of the rest of the economy in period (t).

$PPH_i^{(t)}$ the expected output of commodity i from the household and private sector in period (t).

$PPLR^{(t)}$ planned labor requirement of food processing in period (t).

$PPS_i^{(t)}$ projected output of commodity i from the socialist sector in period (t).

$PRHN_i^{(t)}$ expected deficit of the household and private sector in commodity i (feed) in period (t).

$PSA_i^{(t)}$ output (or deficit) of agricultural commodity i in socialist agriculture in period (t).

$PS_f^{(t)}$ planned stock of commodity f in period (t).

$PS_i^{(t)}$	planned stock of commodity i in period (t).
$PS_n^{(t)}$	planned stock of commodity n in period (t).
$PTC_f^{(t)}$	planned total consumption of processed commodity f in period (t).
$PTC_i^{(t)}$	planned total consumption of agricultural commodity i in period (t).
$PTC_n^{(t)}$	planned total consumption of nonfood commodites in period (t).
$PTP_f^{(t)}$	plan target for output of commodity f in period (t).
$PTS_i^{(t)}$	plan target for production of commodity i in period (t).
$R_k^{(t)}$	available k-th resource of agriculture in period (t).
$RH_k^{(t)}$	available resource k in household and private agriculture in period (t).
$RHN_k^{(t)}$	k-th resource need of household and private agriculture sector in period (t).
$RHN_n^{(t)}$	the total requirement of household and private sector for commodity n in period (t).
$RI_k^{(t)}$	the increase of available stock of resource k in period (t).
$RIH_k^{(t)}$	investment of household and private sector in resource k in period (t).
$RIP_k^{(t)}$	investment in resource k by processing industry in period (t).
$RIS_k^{(t)}$	investment in k-th resource by socialist agriculture in period (t).
$RP_k^{(t)}$	available k-th resource capacity of food processing in period (t).
$RPN_n^{(t)}$	need of processing industry for commodity n in period (t).
$RS_k^{(t)}$	available resource k at the socialist sector in period (t).