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SECOND VERSION OF THE HUNGARIAN AGRICULTURAL MODEL (HAM-2)

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PREFACE

Because the food production is one of the most obcentilized activities of mankind, the focal point in the Food and Agriculture Program at IIASA is the modelling of various national food and agriculture systems. The international and East-West characteristics of IIASA offer a good opportunity for the appropriate modelling of market oriented as well as centrally planned agricultural systems.

As a first step in realization of IIASA's objectives in the modellings of centrally planned agricultural systems, the Hungarian Horticultural Model (HAM) as a prototype model for EMEA countries has been developed. First the general structure of the model and its mathematical description were completed*. As a second stage of the HAM project, the first relatively aggregated version of the model (HAM-1) was elaborated and implemented in both IIASA and Hungarian computers.** Now, after two years of work, the second and final, more disaggregated version of the model (HAM-2) has been constructed. In this paper, the general features and mathematical structure of HAM-2 are discussed including a short report on actual use and validation procedure.

*C. Csåki, A Jonås, S. Meszaros: Modellings of centrally planned food and agriculture systems. A framework for a national policy model for the Hungarian food and agriculture sector RM-78-11. March 1978.

**C. Csåki: First version of the Hungarian Agricultural Model (HAM-1) RM-78-38, August 1978

ACKNOWLEDGMENTS

The main contributors to the development of HAM-2 are as follows:

C. Csaki (IIASA): overall model structure and linkages, mathematical formulation of the model and coordination of the whole project.

C. Forgacs (MKKE): data collection for consumption module.

A. Jonas (OT TGI): government planning and economic analysis submodel, analysis of results.

K. Kelemen (OT TGI): mathematical structure of the entire model.

L. Kleininger (MEM AKI): data collection for production block.

S. Meszaros (MEM AKI): data base for production block.

I. Monori (MEM AKI): data collection for production block.

A. Por (IIASA): estimation of parameters.

M. Sebestyen (MKKE): data base of the whole model, economic analysis and consumption trade block, parameter undating.

J. Strehn (MEM AKI): data base for food processing module.

L. Zeöld (OT TGI): development of the basic computer program and computation.

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INTRODUCTION

The development of the Hungarian Agricultural Model (HAM), as a prototype of models of centrally planned economies, has reached its third stage. In 1977 the general structure of the model and its detailed mathematical structure were completed (RM-78-11). The second step in the HAM project was the first, relatively aggregated version of the model (HAM-1) (RM-78-38). Now, after almost two years of work using the experiences gained with this more aggregated model version, the second and final version of HAM has been constructed.

The development of the second version of the Hungarian Agricultural Model (HAM-2) is a joint undertaking of FAP at IIASA and three institutes in Hungary (the Research Institute for National Planning of the National Planning Bureau (OT TGI), the Research Institute for Agricultural Economics of the Ministry of Food and Agriculture (MEM AKI), and the Department of Agricultural Economics at the K. Marx University of Economic Sciences (MKKE)).

Working groups of HAM-2 in Hungary were led by A. Jónás, K. Kelemen, S. Mészáros, M. Sebestyén and L. Zeöld. The whole work was coordinated by C. Csaki.

In this paper the general features and mathematical structure of HAM-2 are discussed, with a short report on the actual model use. Questions related to the computation of the model, and the computer program of HAM-2 are not included in this study and the model's data base is also not discussed here in detail.

The working group of HAM is grateful to Prof. Ferenc Rabar, Michiel Keyzer and Günther Fisher of IIASA for their continuous support and comments on the entire work. In the elaboration of HAM-2, the conclusions of several discussions with Soviet, Bulgarian, Czechoslovakian, and Polish scientists on the entire modelling framework have also been utilized.

MAIN FEATURES OF HAM-2

The major objective of the HAM project at IIASA is to develop a general modelling framework for the study of centrally-planned food and agriculture systems, and to prove the appropriateness of our approach by developing a detailed prototype model. HAM-2 is actually the first really detailed system simulation model describing the Hungarian food and agriculture sector. The model is constructed according to the basic characteristics of IIASA's general model structure for centrally-planned food and agriculture systems*, representing a concrete example of the utilization of this framework.

HAM-2

- -- is consistent and comparable with other parts of IIASA's food and agriculture model system,
- -- incorporates the basic features of CMEA member countries' economies,
- -- describes the specific features of the Hungarian economy and food and agriculture as well,
- -- is detailed enough to be used as an experimental tool for actual planning and forecasting purposes.

As is with other elements of IIASA's food and agriculture model system, in the case of HAM-2, our main goal is not straightforward optimization; but rather to make a tool that offers opportunities for a better understanding of the dynamic behaviour of the Hungarian agricultural system and the interactions of their elements, so that the model can also be used for mid and long-range projections. Unlike the normative agricultural models that have been developed, this model has a

*for information on the general modelling framework see studies C. Csáki, A. Jónás, S. Mészáros: Framework for a National Policy Model for the Hungarian Food and Agriculture sector. IIASA RM-78-11
C. Csáki: First version of the Hungarian Agricultural Model (HAM-1) IIASA RM-78-38

descriptive character. It reflects the present operation of the centrally planned food production systems and, therefore, the present decision-making practices and economic management of the government are described. At the same time, various normative elements, such as government decisions and published plan targets influencing the projected operation of the system, are also considered.

In the model we try to endogenize a large part of the economic environment and the most important factors of food production. The food and agriculture is modelled as a disaggregated part of an economic system closed at the national as well as at the international level. Therefore, HAM-2 has the following features:

-- the food consumption sphere is incorporated,
-- the nonfood production sectors of the economy are represented by assuming that they produce only one aggregated 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,
-- 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, non-linear optimization economic methods, are employed. The model is dynamic, with a one-year time increment. Subperiods within the year are not considered. The time horizon of the analysis is 15-20 years. Random effects of weather and animal disease conditions can also be considered.

HAM-2 is constructed according to the basic characteristics of the centrally-planned economies in general, and the Hungarian food and agriculture specifically. Therefore, the model has certain specific features compared with other elements of the model system. The most important specific features are as follows:

1. Long-range government objectives, such as the growth of the whole economy, the growth rate of food production and consumption, a given relation of consumption to accumulation, and a given positive balance of payments in food and agriculture, are considered exogenously as

they are determined by the long-range development plan of the national economy.

2. According to the real structure of agricultural production in these fields, various sectors (state, cooperative, household,* and private farms) are considered. Besides agriculture, food processing is handled separately and it is not aggregated with the rest of the economy.
3. In central-planning, the government has a crucial role in the system; therefore, the model has to include a detailed description of the government's economic management activities.
4. The domestic market included in HAM-2 is not directly related to the world market. The effects of the international market are filtered by the government's budget.
5. Four types of prices are distinguished in the model: the domestic consumer and producer, as well as international dollar and rubel prices; the domestic prices express government policy objectives instead of being related to a certain market equilibrium.
6. The inter-CMEA trade is considered as a separate segment of the international market.
7. In Hungary, the overall targets for food and agriculture are primarily realized using indirect economic means (price, tax, and subsidies); therefore HAM-2 represents a decentralized version of IIASA's model structure for CMEA countries, where producer's decisions play quite an important role.

The major characteristics of HAM-2 are summerized in Table 1. HAM-2 has obviously been designed to be an element of the IIASA agricultural model system under development and as such it will be linked with other national models and used for global investigations. Furthermore, HAM has been constructed as an <u>experimental tool for investigations connected with the development of Hungarian food and agriculture</u> in the following ways:

-- Based on the model, the realization of major policy goals and plan targets and their main alternatives can be investigated. For example, the key factors and bottlenecks of 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 for studying 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 the domestic to the 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

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* <u>Household farm</u>: private farming activity of cooperative farms members mainly around their houses.

Table 1. General Features of CMEA Models

COMMON FEATURES	SPECIFIC FEATURES
- DESCRIPTIVE	- GOVERNMENT PLANNING SUBMODEL
- DYNAMIC	- VARIOUS PRODUCTION SECTORS
- CONSUMPTION IS INCORPORATED	- INDEPENDENT DOMESTIC MARKET
- REST OF THE ECONOMY AS ONE AGGREGATED SECTOR	- SEPARATED INTER-CMEA TRADE
- SYSTEM MODEL	- CRUCIAL ROLE OF GOVERNMENT BUDGET
- FINANCIAL EQUILIBRIUM	- SPECIAL EXCHANGE MODULE
- UNIFIED COMMODITY COVERAGE	

instruments, the impacts of the new instruments, and the areas of additional control requirements.

We hope that by developing the HAM structure, and by offering possibilities for the investigation outlined above, we can contribute to the further development of the techniques of planning and economic management in Hungary. The HAM project can also be considered as an important part of the efforts for the introduction and more efficient usage of computers in policy analysis and macro-level decision making.

STRUCTURE AND OPERATION OF HAM-2

HAM-2 has been constructed in accordance with IIASA's general modelling principles for centrally-planned food and agriculture systems. Figure 1. shows the structure of the final version of the model. HAM-2 is in fact a system of interconnected models. Two spheres are differentiated within the system. The economic management and planning submodel descibes the decision-making and control activities of the government. The submodel of real sphere

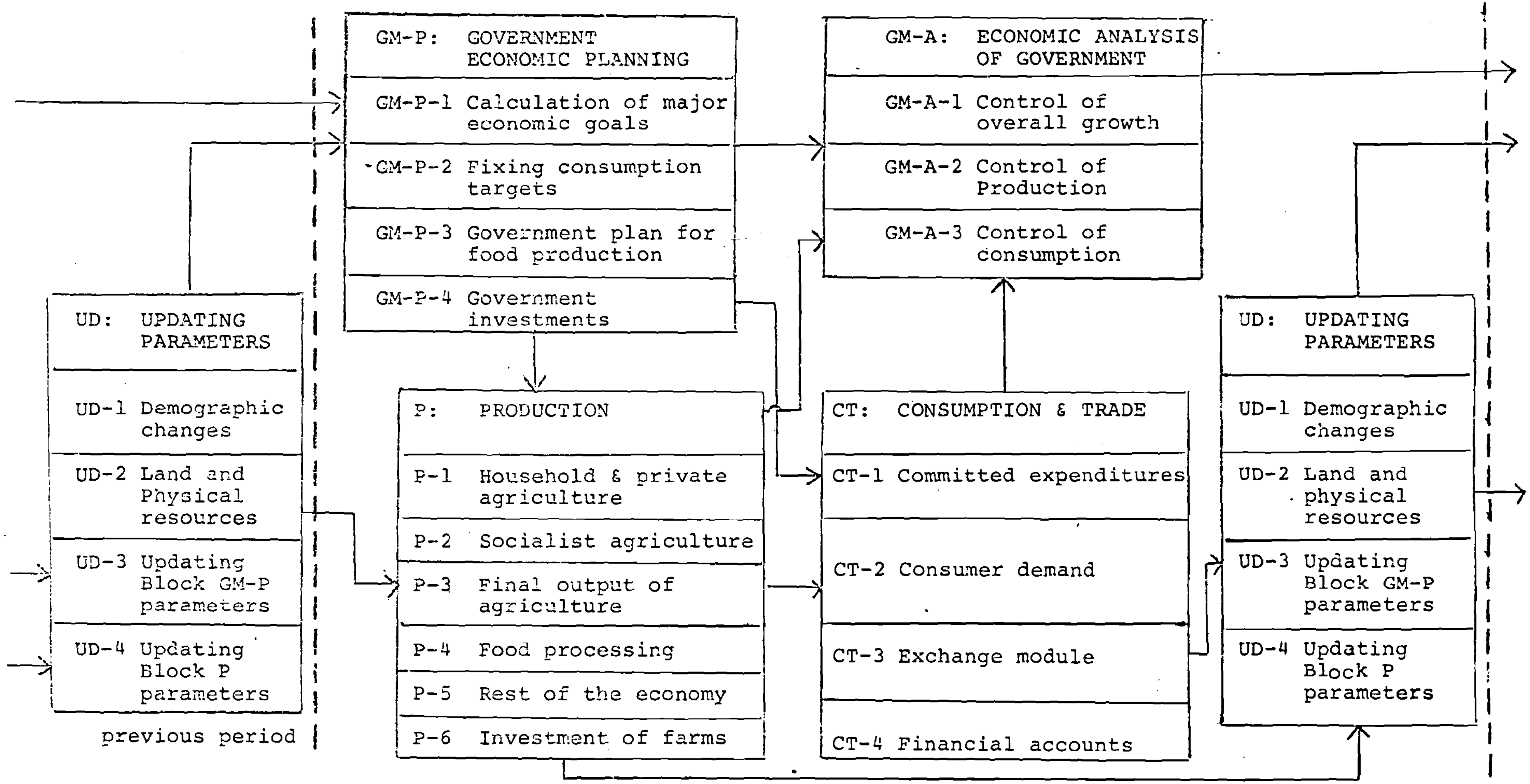

Figure 1. Schematic structure of the second version of the Hungarian Agricultural Model.

covers the whole national economy, including the disaggregated 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.

For the description of various subsystems, different mathematical formulation have been used. As far as the methodology of the model is concerned, first of all our attempts to describe the agricultural policy-making and planning activities of the government have to be pointed out. In HAM-2 the implementation of given policy objectives is fully endogenized. As was already mentioned, long-range government objectives are taken as determined by central planners. Government plan targets on food and agriculture are determined by a linear programming model. The investment decisions of the government and the adjustments of overall objectives and policy instruments are modelled by heuristic routines. This is one of the first attempts at a mathematical description of the pricing mechanism is a centrally-planned economy.

The food and agriculture production is modelled according to producing sectors. The socialist agriculture (state and cooperative farms) is modelled by a linear programming model, the behavior of private and household farms is described by supply functions and a separated, non-optimization heuristic type of model block is related to the food processing. A heuristic type of model is constructed to describe the investment decisions of producing firms. The output of the nonfood producing part of the economy is calculated by a Cobb-Douglas type function.

The Exchange Module is a crucial part of the whole system. As was already mentioned, an equilibrium type of model has been constructed to reach the balance of trade equilibrium and adjust to changing international market conditions. A special version of the extended linear expenditure systems has been estimated to describe consumer behavior.

The demographic changes and available resources are updated based on trend and depreciation functions. The production block parameters are actualized by using yield functions expressing the trends of biological development. Input coefficients are calculated based on production functions. The coefficients in the government economic planning module are updated based on the production block of the previous period.

The various blocks and modules of the model are interlinked through a relatively complicated system of relations and feedback loops. The major steps of HAM-2's solution are given below.

1. The Overall Objectives of the Government: Module GM-P-1

The first step is the setting of major economic goals of the government for a given period of simulation, i.e.:

-- the desired consumption fund,
-- the desired growth of the whole economy,
-- the desired gross production of food and agriculture,
-- the related indicators of total investment funds in the rest of the economy and in food and agriculture,
-- and the desired state of the balance of payments of the country,

are determined based on the targets on longe range plan of the government on desired growth of consumption, the whole economy and food and agriculture, as well as the share of food and agriculture in total investments. (The major interrelationships of the Government Economic Planning Block can be seen in Figure 2.)

2. Plan Targets for Private Consumption: GM-P-2 Module

Based on the target value of total consumption and consumer prices updated at the end of the previous period, the planned structure of private consumption, as well as the planned total consumer's needs towards individual commodities, are determined. Government objectives on the change in the consumption structure are considered and an extended linear expenditure system is used as the methodology of the calculation.

3. Plan for Food and Agriculture: Module GM-P-3

The desired structure of food production (agriculture and food processing) and related exports and imports are calculated next. The desired gross output of food and agriculture (from GM-P-1) and certain minimum production requirements (based on the consumers' needs from GM-P-2) are considered as lower

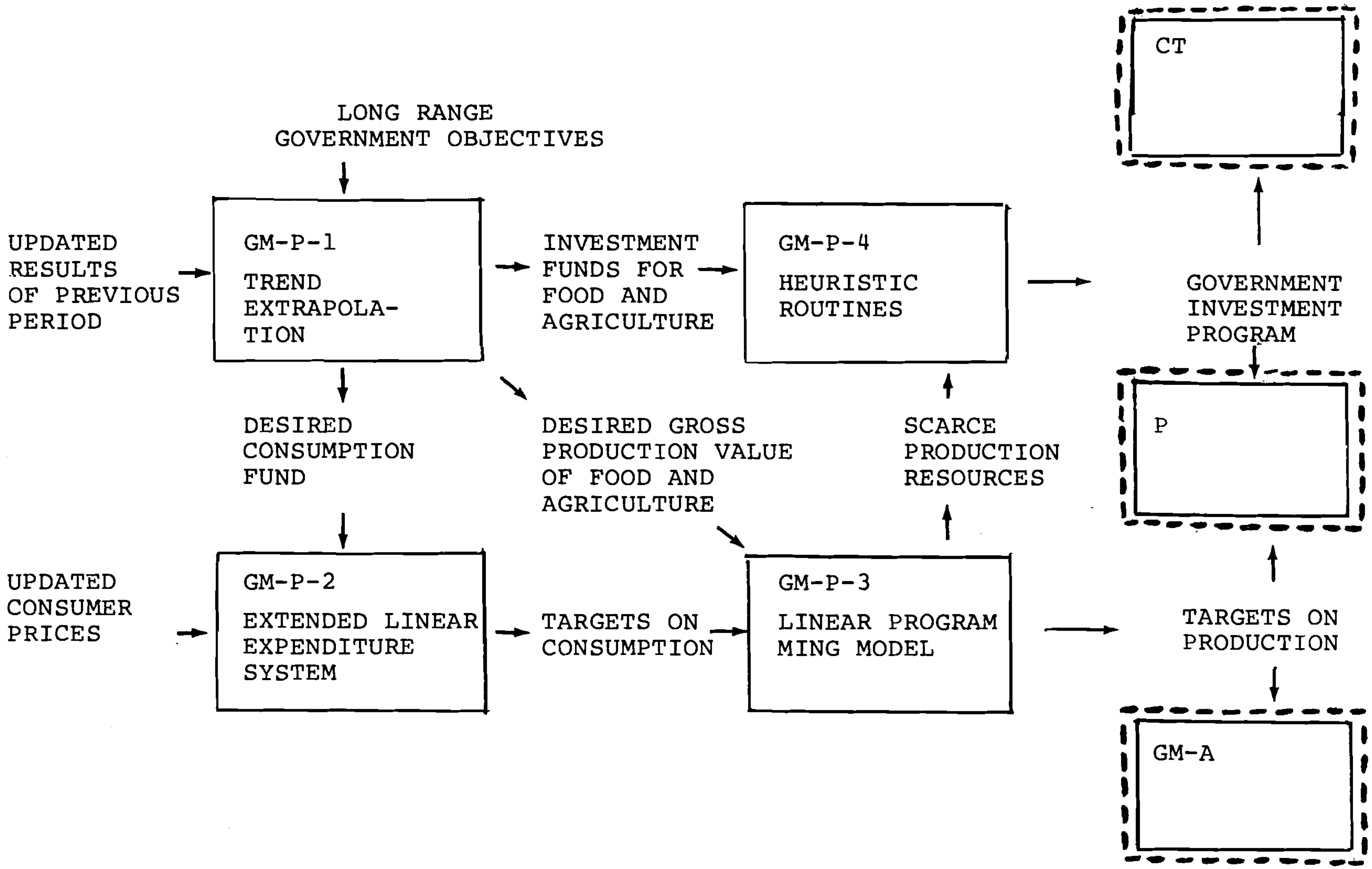

Figure 2. Role of government economic analysis block in HAM-2.

bounds in the linear programming model. Similarly to the required positive balance of payment from food and agriculture (also from GM-P-1). We assume that central-planners want to reach the most efficient structure of foreign trade of food and agriculture products, maximizing the net export returns on domestic production expenditures, using the international prices and production expenditures of the previous period. This model supplies the guidelines for the analysis at the end of the simulation of each year (module GM-A-1), and information on scarce resources where investments might be required.

4. Government's Plan on Investments in Food and Agriculture: Module GM-P-4

The government's investment plan is elaborated by using heuristic routines. The investment program is settled based on the shadow prices of GM-P-3 Module's solution and considering the scale requirements of various investments. In the case of food processing, the decisions on new investments are partly centralized in Hungary, therefore they are modelled by GM-P-4. As far as agricultural investments and the rest of the investments in food processing are considered, only a desired program is calculated and is used to distribute available government subsidies to firms' investments; however, the decisions on these kind of investments are modelled within the Production Block.

5. Production Decisions of Household and Private Agriculture: Module P-1

We assume that production decisions of the household and private sector are based on producer prices announced for the given period, expected yields, available land, and labor force. Separate supply functions have been estimated for plant and animal production. Firstly the available land is distributed among various crops having no constraint on labor, secondly the rest of the labor force after deduction for plant production needs, is used as the major limit on the volume of animal husbandry.

The total amount of labor available for household and private agriculture is determined in the Updating Module. The outputs of crop production calculated here might be subject to the random effects of the weather.

6. Production Decisions of Socialist Agriculture: Module P-2

A linear programming model is constructed to describe the decisions of socialist agricultural enterprises (cooperative and state farms) on production structure. For most of the commodities, two or three production technologies are considered and a relatively wide range of inputs to different products are taken as parameters determined in Block UD. The linear programming model is structured according to resource utilization, commodity utilization, and financial subsystems. The socialist sector maximized its expected profit, while the producer prices, wages and tax coefficients are given by (GM-A) Block of (t-1) period. The producer's prices are not subject to changes during the simulated year, but crop yields might be influenced by the weather disturbance factor, as is household and private production. To avoid extreme solutions the change of production structure from one period to the other is constrained. These upper and lower bounds are determined based on the analysis of structural changes in the past. (The major interrelations of Production Block as well as the role of Module P-2 can be seen in Figure 3.)

7. Outputs of Agriculture: Module P-3

The final output of agricultural production is calculated here, based on Module P-1 and P-2. The random effects of weather on yields of annual and perennial crops can be considered here. Obviously the output of animal husbandry is taken as calculated in Module P-1 and P-2. If an agricultural commodity can be processed or directly consumed, the available raw materials for processing are also determined in this model using exogenous rules, considering government preferences in the utilization of raw products (processing versus export or fresh consumption).

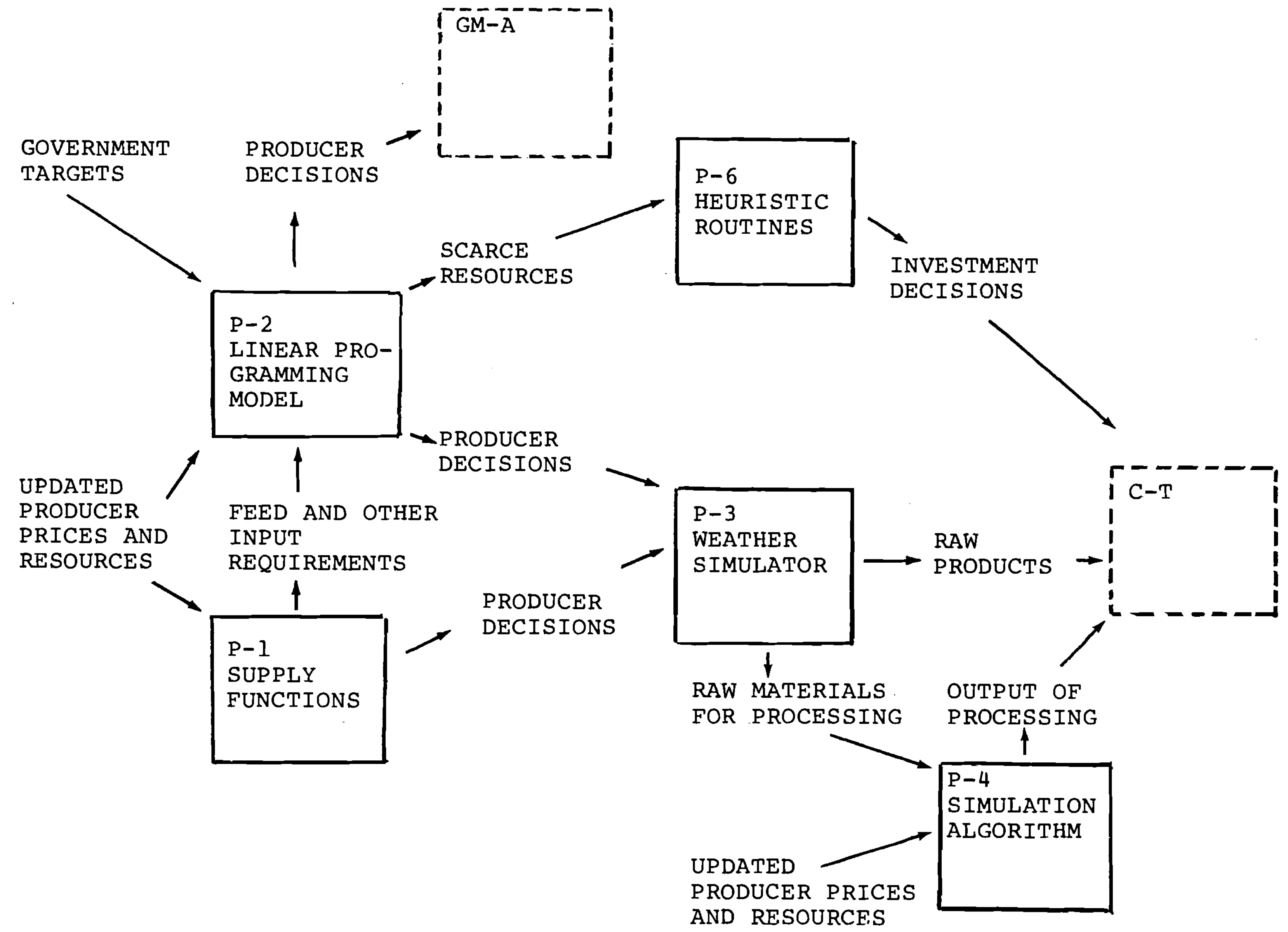

Figure 3. Major interrelationships in modelling food and agricultural production in HAM-2

8. Output of Processed Food Commodities: Module P-4

As the outputs of agriculture are known, the output of the food processing industry can be determined. We assume that the food processing industry aims at the utilization of its resources based on a given supply of raw materials. We also assume that materials have to be processed until the level of existing capacities as well as raw materials for processing (except protein foods) cannot be imported.

9. Output of the Non-agricultural Sector: Module P-5

Based on the available production capacities and labor force, outputs are determined by a Cobb-Douglas type of production fucntion. We assume that all of the remaining labor force, other than the needs of food and agriculture, is fully utilized in this sector. The rest of the economy is handled as one homogenous commodity.

10. Investment Decisions of Producing Firms: Module P-6

The investment program of agricultural firms, and food processing enterprises is determined by a methodology similar to that used in government investment decisions. The investment program is based on the shadow prices of the LP model in the P-2 Module and resource utilization in the P-4 Module. Scaling of investments is also considered. Obviously investments are constrained by available funds at the firms as well as by government subsidies.

11. Calculations of Committed Expenditures: Module CT-1

First of all, in Module CT-1 the so-called committed expenditures, which cannot be further modified, are summarized. A simple calculation takes place based on former model elements to determine:

- -- intermediate inputs actually used in production,
- -- the income and income utilization of producing enterprises (socialist agriculture, food processing, and the rest of the economy) including total committed demands (intermediate inputs plus certain investments),

-- the endowments and committed expenditures of the population (private consumers),
-- the government's income from producers and population, and the government's committed expenditures.

12. Modelling of Consumers Demands: Module CT-2

Module CT-2 describes private consumption. The role of Module CT-2 is to determine the per capita consumer demands, assuming that the endowment of consumers after the deduction of savings is fully spent for buying various commodities. Therefore, the consumer demands for a specific commodity are influenced by the consumer prices and the level of endowment.

13. Calculation of Non-Committed Demands and Exports-Imports: Module CT-3

Module CT-3 (Exchange Module) is a crucial part of the entire model, where the final level of private and government consumption, as well as stocks satisfying balance of trade equilibrium conditions, are determined. It is important to note that the reaction mechanism of domestic demands to new world market conditions (prices) is described in this module.

14. Accounting for a Given Period: Module CT-4

As the final results are obtained by Module CT-3 the detailed financial consequences of a given situation are calculated. This is the role of Model CT-4. (For connections in the C-T Module, see Figure 4.)

15. Control of the Overall Growth: Module GM-A-1

As the next step in the simulation, the basic government policy instruments influencing the overall growth of the economy 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 desired share of food and agriculture in total investment is adjusted based on the growth rate of food and agriculture. Module GM-A-1 supplies the major parameters for Module GM-P-1 for the forthcoming period.

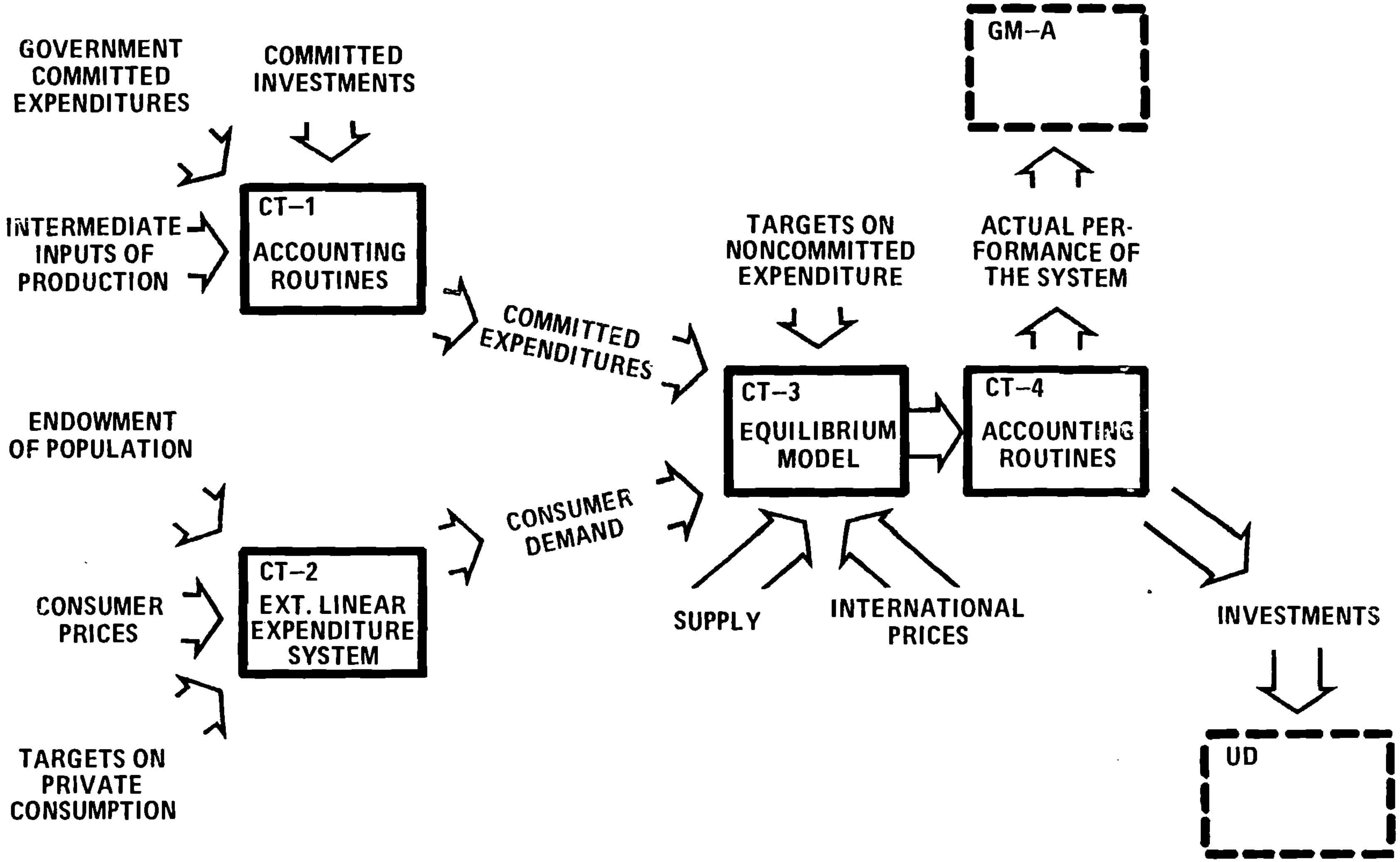

Figure 4. Major interrelationships in consumption and Trade Block of HAM-2

16. Control of Production Structure and Adjustment of Producer Prices: Module GM-A-2

The producer's prices are changed by a comparison of the actual and the planned production. The basic principles of the procedure in revising producer prices of agricultural commodities are outlined by Figure 5. The producer prices in food processing are revised by a somewhat simplified manner as Figure 6 shows. (Figure 8 outlines the basic connections of the GM-A Block).

17. Control of Consumption, Revision of Consumer Prices: Module GM-A-3.

The consumer prices of a given commodity is modified (see Figure 7) based on the comparison of the desired and the actual per capita consumption of the given commodity. During the revision, as Figure 7 shows, the consumer price's relation to producer price is also considered.

18. 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 (Module UD-1) similarly to basic land resources, when the annual decrease of plowed land is taken as an exogenous parameter (Module UD-2). The information for updating physical resources (Module UD-2) on investments are supplied by previous model elements. 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 (Module UD-3). The yield and output coefficients of P-1, P-2, 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 (Module UD-4).

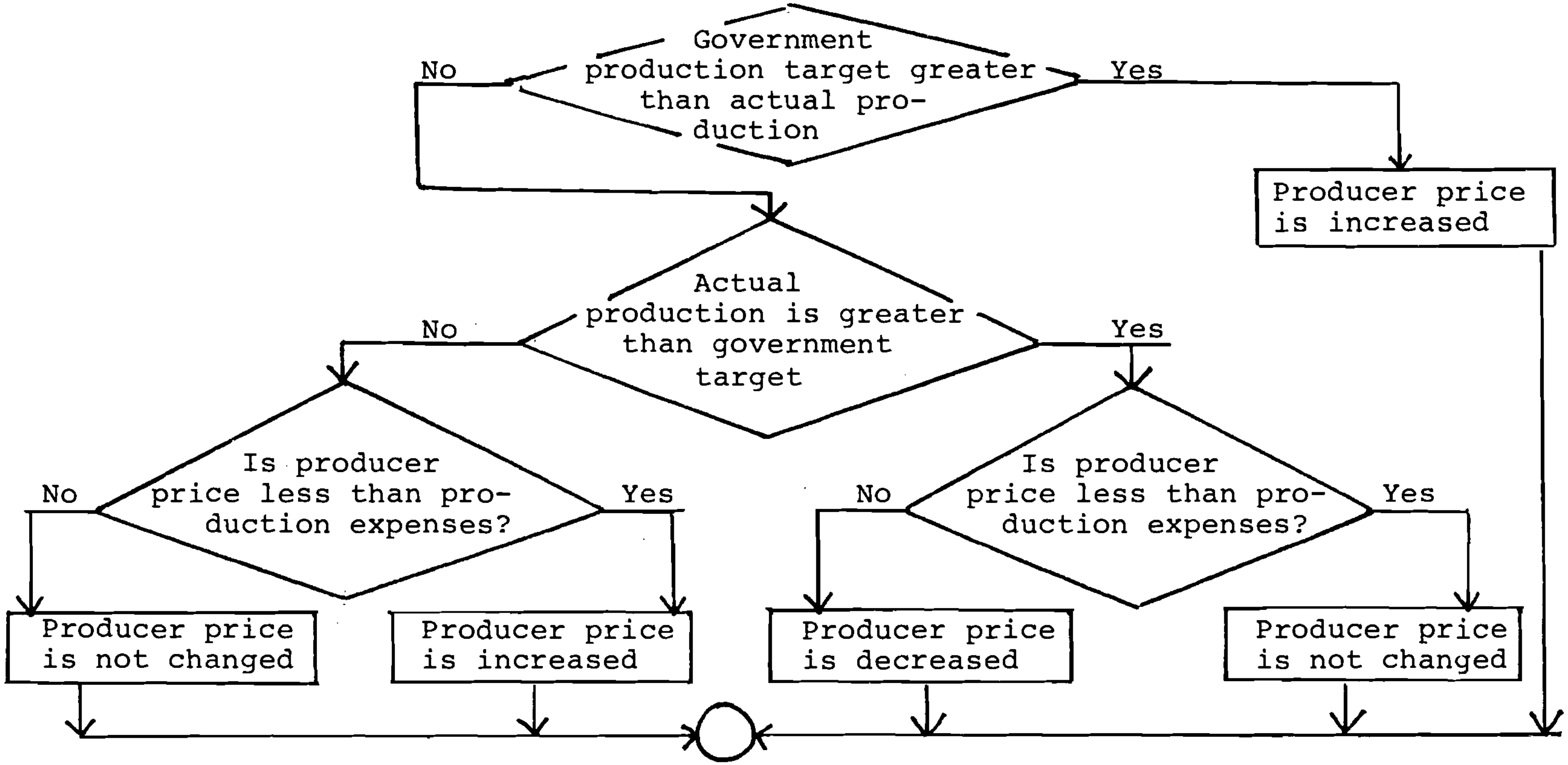

Figure 5. Adjustment of producer prices in agriculture.

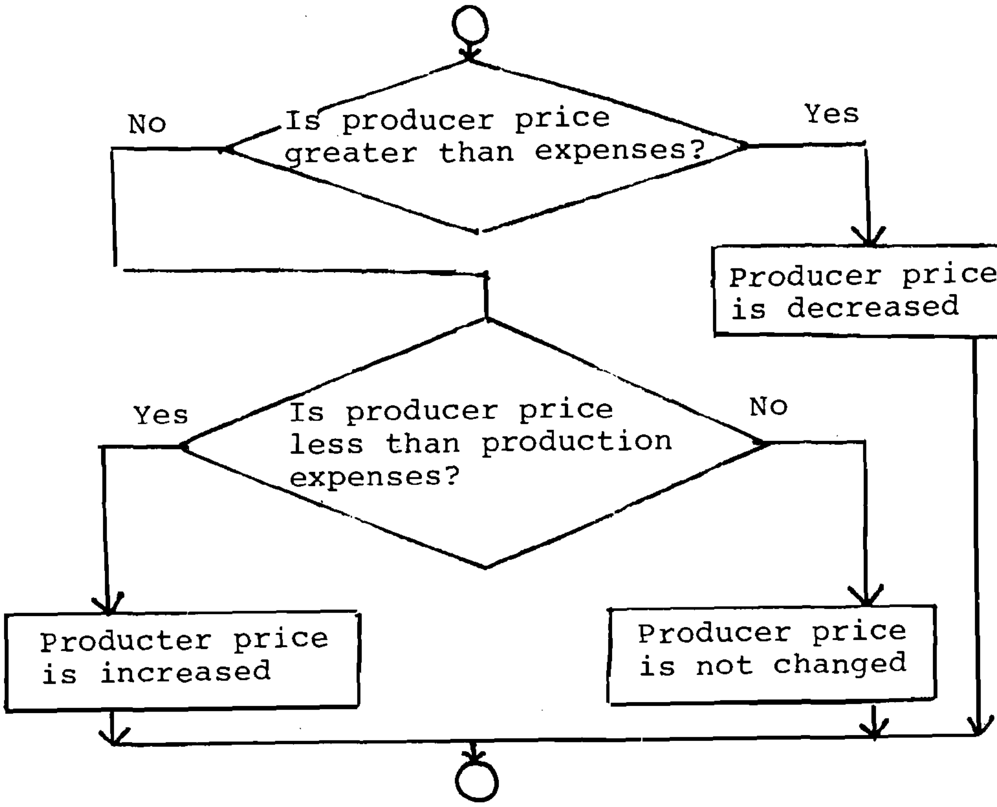

Figure 6. Adjustment of producer prices in food processing

COMMODITY COVERAGE AND DATA BASE OF HAM-2

Besides satisfying the common requirements for IIASA's food and agricultural models, HAM-2 has been constructed to be useful in investigating major developmental problems in Hungarian food and agriculture. Therefore in the disaggregation of food and agriculture the specific requests of the possible model users have also been considered. HAM-2 has actually a more detailed commodity coverage than other FAP models. Firstly agricultural raw materials and processed food commodities are handled separately according to the two main sectors of food production in the model. Table 2 contains the list of commodities considered in HAM-2. Hungarian agricultural production is covered by 21 commodities. Most of the agricultural commodities represent a group of products (e.g. food grains or fruits) under "other field crops" and "other animal husbandry" the rest of the production not represented individually are aggregated. The commodity "additional farm activities" represents the non-agricultural activities such as construction

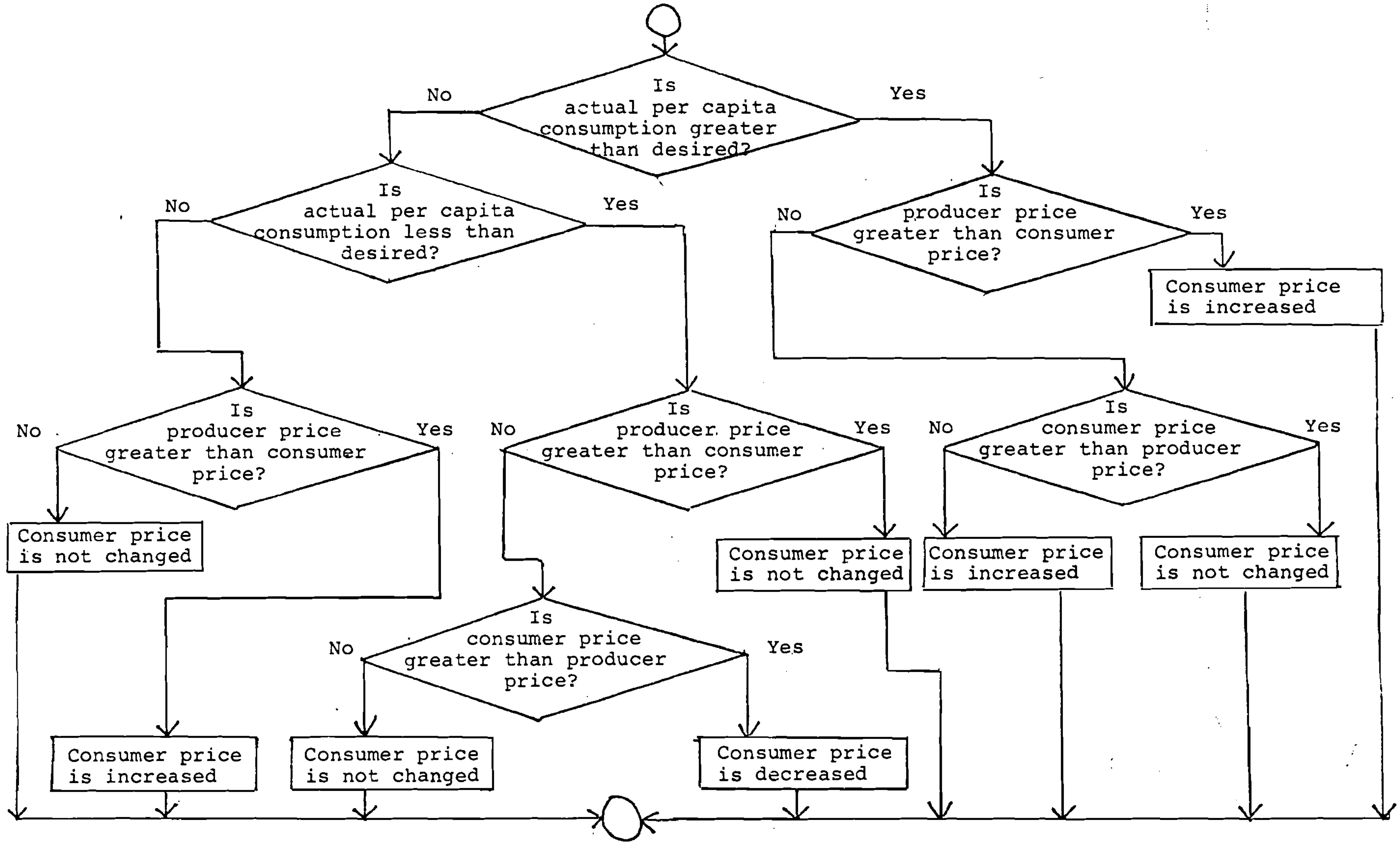

Figure 7. Revision of consumer prices

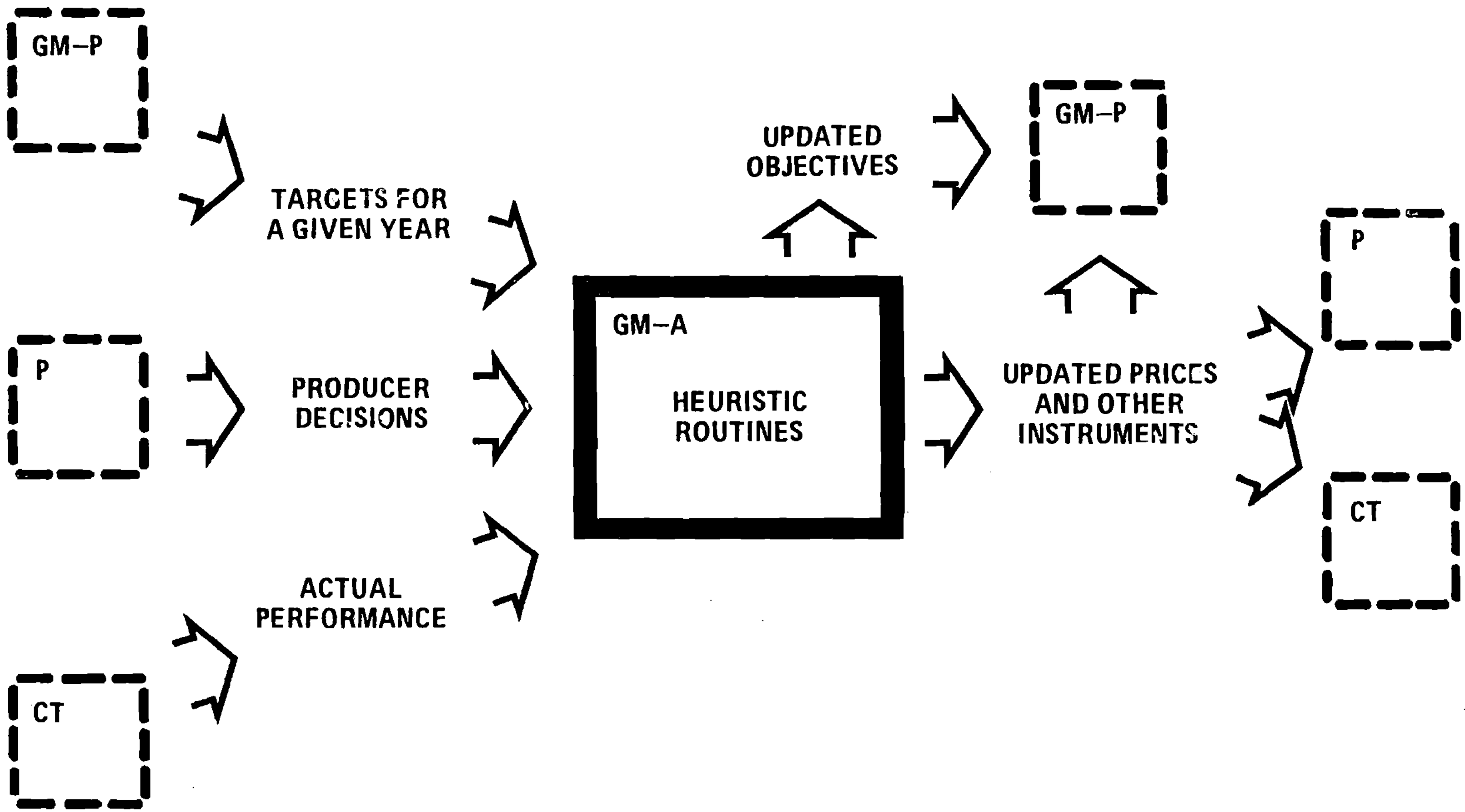

Figure 8. Role of government economic analysis block in HAM-2

Table 2. Commodity coverage of HAM-2.

AGRICULTURE

1. Food grains
2. Coarse grains except corn
3. Corn
4. Oil seeds
5. Sugarbeet
6. Green fodders
7. Potatoes
8. Vegetables
9. Other field crops
10. Fruits
11. Grapes
12. Beef cattle
13. Dairy cattle
14. Pigs
15. Sheep meat
16. Wool
17. Poultry meat
18. Eggs
19. Other animal husbandry
20. Alfalfa for drying
21. Additional farm activities

FOOD PROCESSING

22. Flour
23. Bran
24. Vegetable oils
25. Oil-cake
26. Beef
27. Pork
28. Lamb
29. Slaughtering wastes/offal
30. Processed meat (high moisture content)
31. Processed meat (low moisture content, smoked, canned)
32. Poultry meat (processed)
33. Processed eggs
34. Slaughtering wastes/offal (poultry)
35. Dairy products
36. Milk powder
37. Protein feeds
38. Feed mix
39. Sugar
40. Canned fruits
41. Canned vegetables
42. Wine
43. Other processed foods
44. Coffee
45. Tea, cocoa

REST OF THE ECONOMY

46. "n-th" commodity

and service done by the farms. These activities do not belong to agriculture in nature, but in the Hungarian situation they are so much interlinked with agriculture that their aggregation with the rest of the economy would complicate the modelling of agriculture to a large extent. (They are based on the labor force and resources of agriculture, income generated by these activities mostly invested in agriculture). The commodity coverage of household and private agriculture module (P-1) is somewhat narrower than that of the socialist agricultural module (P-2).

The 24 processed food commodities in HAM-2 express the present structure of the Hungarian food processing industry. In the selection of commodities the commodity classification of the Hungarian National Planning Bureau has been used as the major guideline. (Table 2 contains the list of processed commodities.) Out of the 24 commodities, 22 are related to raw materials domestically produced. Coffee, tea and cocoa are imported as raw materials and are further processed, mainly only packed.

The 46th commodity is related to the rest of the economy aggregating all the rest of the economy including production and services.

The data base of HAM-2 includes various sources. Primarily statistical data available from the Central Statistical Bureau and from the Ministry of Food and Agriculture have been utilized. As far as international prices are concerned, we relied upon FAO data tapes. The trends of biological and technological development, the overall targets for growth of the economy and other previous government decisions constraining agricultural development were supplied by experts from the National Planning Bureau and the Research Institute for Agricultural Economics. The main data base for parameters in production models was taken from the the annual statisical survey of the Research Institute for Agricultural Economics and the Center for Statistical and Economic Analysis at the Ministry of Food and Agriculture on inputs and expenses of various commodities. Estimates from the Farm Machinery Research Institute have also been considered. The algorithm for revising government policy instruments has been developed based on interviews with high level officials and information supplied by the Ministry of Finance.

VERIFICATION AND VALIDATION OF THE MODEL

Through simulation models various real-life situations can be studied. The model must suit the purpose of the specific study and also truly represent the fragment of reality in which we are interested. Therefore in developing HAM-2 great attention has been paid to the model's relation to reality and to the problem of the reliability of results generated by the model.

The problems of agriculture, full of random effects and biological correlations, can generally only be represented by complicated mathematical models and handled by elaborate computer programs. It is not a simple task therefore to estimate how accurately a large scale agricultural model such as HAM-2 reflects reality and how well the simulation system can be used with regard to the targets. Unfortunately there is hardly any method that can be of definite help in this field.

The methodology of controlling and pre-testing simulation models is still at a rudimentary stage. The philosophical interdependences and aspects of evaluating models can not be regarded as fully or clearly defined, and in international technical literature on simulation practice, a method of model evaluation commonly accepted has not been established yet. However, most books dealing more thoroughly with simulation emphasize the advantages of performing a two-way analysis before operating the model. The first stage is the verification of the model, that is the confrontation of the model with reality to check whether the model truly represents reality. The second stage is the validation of the model, that is the necessity to evaluate the model from the aspect of specific analysis, rather than from the point of reality, to study to what degree the model satisfies certain research or investigation objectives.

The model's relation to reality can be expressed by the relation of the characteristics of the studied system given by the computer on the basis of the model and the characteristics connected with the real system. Thus the proof of reliability is the total or partial conformity of certain values of the dependent variables with the results of the empirical studies concerning the phenomena symbolized by the former. On this basis one can decide whether the model properly represents the situation to be described. In principle the model's relation to reality can, therefore, be easily defined but to prove this in specific cases is more difficult. This is caused not only by the lack of suitable methods for this purpose but frequently also by the missing bases of comparison. There are hardly any empirical data about how a certain part of the modelled systems operate, and there are also cases where the system studied does not even exist in reality (when studying some plan interrelations, for instance), and thus there are no factual data available concerning its functioning either.

Verification is relatively simpler if the model describes an existing system, and the results of the model can be compared with factual data from real-life situations. The various methods of statistical analysis may play an important part in evaluating simulation methods. If model results are given in the form of time series, the following tests are suggested:

-- statistical tests, indifferent to distribution, to check whether actual and simulated time series tend in the same direction,
-- regression of simulated time series with the actual time series,
-- factor analysis of the two time series to check whether the levels of factors differ considerably.

When results are given in the form of averages, ratios, or probability distribution, the usual statistical methods of verifying the hypotheses are applied. All these tests cannot usually be done in the course of the simulation study. Thus the executors of the simulation have to choose those indicators through which they intend to verify the simulation model's relation to reality.

T.H. Naylor's so-called multiple-stage model verification process is perhaps the best known procedure in the technical literature on simulation. The essence of this three-phase method is as follows:

-- selection of assumptions, hypotheses of basic importance from the point of view of describing the system studied,
-- logically testing the basic assumptions,
-- empirical study of the model's behaviour.

Naylor's method comprises of an evaluation of a logical type. Such an evaluation is necessary because normally the basic hypotheses of the models cannot be checked in any other way. In the further phases of the checking process, Naylor starts from the assumption that the behaviour of the simulation model as a whole may be forecasted on the basis of some variables. If values are attributed to some of the variables, the expected results on the basis of the model, i.e., the features of the operation of the simulated system, can be obtained. These features can then be compared with the data for the operation of the real system. For comparison the above mentioned statistical methods may be applied.

If empirical data for the operation of the modelled system is lacking, an evaluation can be performed only on a subjective basis. Subjective judgement cannot be excluded even if we can carry out exact tests. The level and the exactness of the approach considered as the proof of the coverage of reality have undoubtedly a bearing on the problem too, but primarily results depend on the objectives of the study and to a large extent on the subjective judgement of the person in charge of checking. No absolute standards or levels can be set to estimate the model's relation to reality. Lacking such objective standards we must accept results of various confidence limits in the simulation practice. It is important to stress therefore that the realization of the simulation process overwhelmingly depends on a sense of scientific responsibility and conscience of the executors.

Depending on the nature of the problem, model verification and testing may either be covered in a simpler or more complicated way. In the case where the system exists in real-life and can be described by a linear-deterministic model, verification can generally rely on objective bases and statistical methods. But in the case of simulating more complicated biological and economic systems, logical testing of the main postulates of the model cannot be neglected either. The applicability of such models can be considered as proved only if both logical and exact tests show positive results.

Because HAM-2 describes a rather complex and complicated system, controls have been made several time in the process of developing the model.

As part of the model building the coverage of reality of the mathematical model has been studied first. Having constructed the model, the positive results of control evaluations enabled the procedure to the next stages, and ensured that possible errors in the early stage were avoided. If the model is regarded problematically at some point or points, it is necessary to return to the model construction, or eventually to the analysis of the system itself, repeating and checking upon the previously mentioned stages of model construction.

One has to be fully aware when evaluating the model's mathematical structure that mathematical models always mean certain abstractions from the particulars of reality and that objective conditions often make the precise, exact modelling of certain interdependences impossible from the very start. We considered as characteristic features of a satisfactory model the following:

- each component of the system studied is represented by a corresponding variable or variables,
- the parameters are reliable,
- concerning logic and mathematics, the interdependences are formulated exactly and correctly.
- the model is easily understandable and applicable,
- the structure of the model is determined by the the objectives of the study,
- the model can easily be adapted to new postulates and relatively easily developed.

In the case of HAM-2, the implementation of these requirements has been proved logically, empirically and by means of subjective judgement. Verification on a logical basis included the comparison of the field studied, the model's structure and the thorough, logical analysis of the interdependences of the model. Empirical investigations included simpler, manual calculations in order to show what values the dependent variables may take and how these values relate to the results of empirical observations concerning the phenomena symbolized by them. The evaluation of certain model parts was performed on a subjective basis. While it is generally not good for subjective judgement to play too great a part, in situations where there is no other choice, this is the only method and one has to rely on general experience and knowledge.

In relation to the structure of HAM-2, a so-called sensitivity analysis has also been done. The sensitivity analysis was connected to parameters, coefficients and other factors of the model whose values had been fixed in advance and thus did not change while the model is operated. From the components of the model mentioned, primarily selected were those which in some respect uncertain, less exact, or the reliability of which were doubtful.

In the course of the sensitivity analysis of HAM-2 we changed the values of the selected parameters considered unreliable, leaving the rest of the model untouched. In this way we were able to estimate to what degree and how this change influenced the operation of the model, and in which way the characteristics of the simulated system changed. The main point of the sensitivity analysis was to show whether the alteration of the uncertain parameters influenced the model's relation to reality, and if affirmative, to what extent. In general a model is in sensitive relation to one or more of its parameters, if their values considerably influence the picture drawn of the system studied by the model. Sensitivity means therefore that if we modify the values of unreliable parameters the model losses its ability to be suitable to simulate the system studied. To gain positive results from the sensitivity analysis, it is necessary to return to an earlier phase of the model building and, to reconsider the interrelations of the studied system as described by the model. At the same time, additional data has to be collected to carry on the survey further in order to define the parameters in question more exactly and thoroughly. A simulation will be really reliable only in the case where the results of sensitivity analysis are satisfactory. In the case of HAM-2, the sensitivity analysis was mainly related to parameters of the production block and parameters in the Government Economic Analysis submodel.

Besides analyzing the relationship between the model and reality, we tested whether HAM-2 was correct from the point of view of computer programming. Several computer runs of the model were made to answer these questions. These test runs aimed at revealing any errors and shortcomings in the computer program. In this work we applied the following methods:

-- the model was run simulating a shorter time (only one year) and the results were compared with those of manual calculations,
-- the more complicated independent routines were separately run and tested,
-- simple control situations were constructed to test the most frequently occuring situations.

The checking of the model, especially the sensitivity analysis and the program testing, involved a lot of calculations and time. We have learnt from HAM-2 that the verification and validation of the model play a very important part in the simulation process. We also learnt through experience that repeated checking during the course of simulation is very necessary since the probability of making errors multiplies itself. Errors can occur during the construction of the mathematical model, during computer programming, in data collection, in operating the model and in evaluating the information gained by the model.

The first control point comes after building the mathematical model. Having settled all questions related to computer processing, a complex testing of the whole simulation system should be made. These tests either confirm the answers to the problems of the model, or it is necessary to return to the model and eliminate the errors by carrying out certain alterations and repeating certain phases of the model building. On the whole, the utility of the information can be the final standard of the success of the simulation. There may be cases when certain problems with the model only appear after the simulation is finished. Nothing else can then be done but by the repeated study of the system to start model building again and try to find a solution that might produce really valuable information satisfying the objectives of the study. Figure 9 shows the role of testing in the course of developing HAM-2.

EXPERIMENTS IN THE USE OF HAM-2

The computer program of HAM-2 has been developed in Hungary by the computer center of the Hungarian National Planning Bureau under the leadership of Laszlo Zeold. In the programming work the computer program of HAM-1 was used as a starting point. At present one program version exists allowing us to do runs on the Hungarian Planning Bureau's ICL-System 4/70 computer. The implementation of the model in IIASA's PDP 11/70 computer will take place later in the year.

At the end of the computation different types of output can be printed out. At present the output system of HAM-2 consists of two major elements:

a) Annual Results which serve the analysis of time periods containing very detailed results on each simulated year and on each module of the model including the updated model coefficients.

b) Summary of Results covers time series of the most important indicators making the global analysis of the various runs possible.

The Summary of Results is the most useful type of output, and in most cases the information needs on the individual runs can be satisfied based on it. Of course the more detailed analysis or debugging cannot be done without the Annual Results. The Summary of Results is structured according to 8 tables, namely:

1. Dynamics of Production Trade and Prices: planned and actual production, export and import of individual commodities in physical units and unit production costs, domestic producer, consumer and world market prices also according to commodities and simulated years.

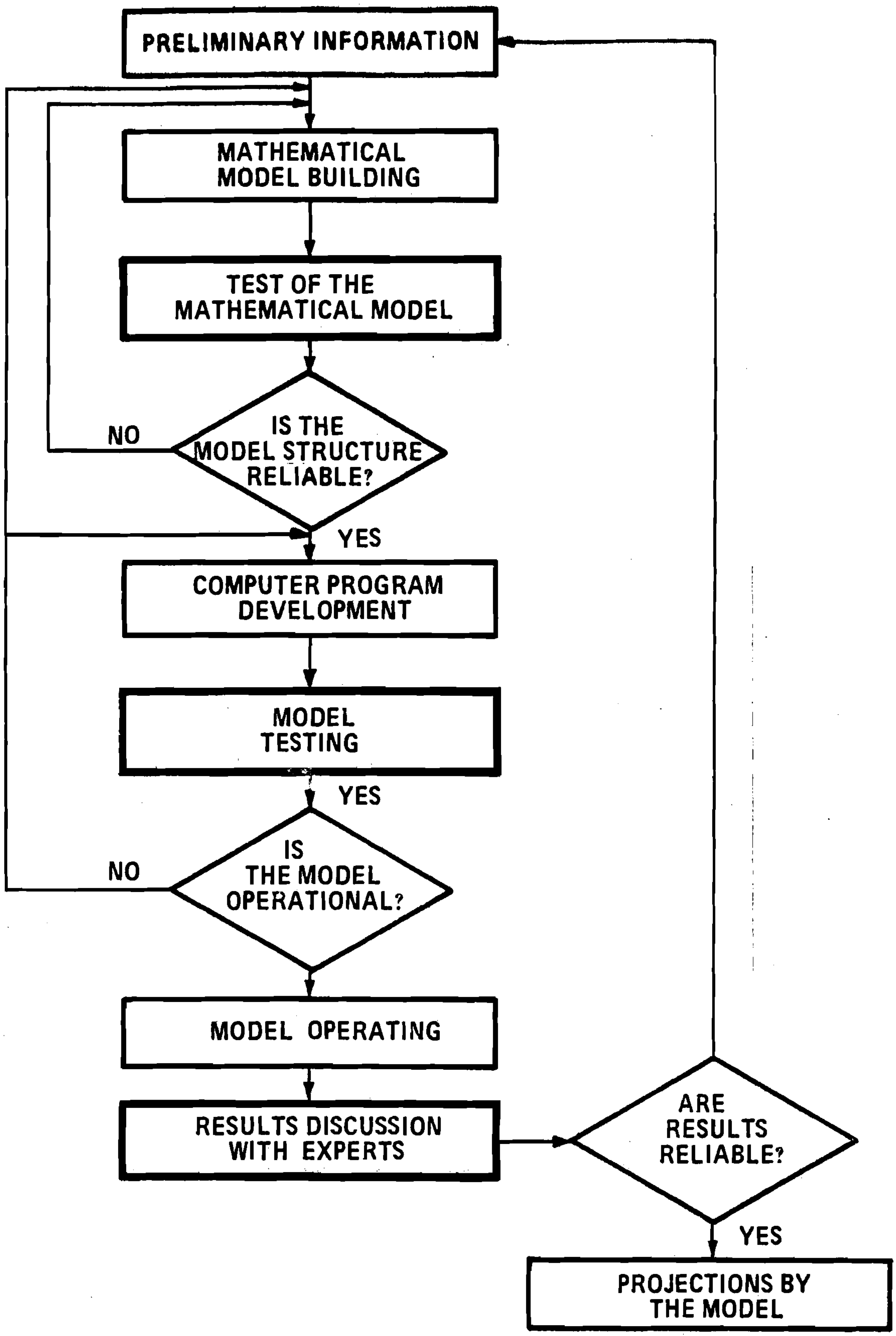

Figure 9. Structure of verification and validation in Developing HAM-2

2. General Indicators of Development: general indicators of production, foreign trade, investment, income development on current and fixed prices for the whole simulated period and indexes of the development in comparison with major plan targets.

3. Cropping Structure and Yields: share of individual crops in total plowland and their projected unit outputs in physical measurement.

4. Fixed assets: the development of fixed assests of agriculture and food processing by major sorts in physical units.

5. Financing of Investments: financial accounts for investment, for the producing sector and for the whole economy, according to simulated years.

6. Resources: summary of major production resources including labor and land.

7. Foreign Trade: balance of payments for food and agriculture and the whole economy, total exports and imports according to dollar and rubel markets in value.

8. Dynamics of Consumption: the desired and actual per capita consumption by commodities in physical units.

9. Policy Instruments: tax rate and centralized part of amortization, annual growth of unit wages.

Up to the present, numerous runs of HAM-2 have been done. These runs represent two types of investigations, namely:

-- testing the operation of the whole system, and investigation of the model's relation to reality,
-- investigation related to the elaboration of the five-year plan of Hungarian food and agriculture for the period 1981-85.

The larger number of runs belong to the first type of the abovementioned two points. Some of them served simply debugging purposes. In other cases the sensitivity of the crucial parameters have been investigated. Finally, several runs have been required to test our assumptions on various decision-making procedures. These runs led us to the so-called basic variant of HAM-2, which can be considered as the appropriate decription of the present Hungarian food and agriculture system, obviously on the aggregation level and accepting the assumptions of the model.

The use of HAM-2 for actual planning purposes has just recently begun and the work is far from finished. After testing the model first HAM-2 has been used to aid decision-making on further development of domestic agricultural price systems as well as pricing mechanism. HAM-2 has been run with:

- various assumptions on relative prices of major agricultural commodities,
- modifying the pricing mechanism built in the model according to the major alternatives considered as future possibilities by the National Planning Bureau.

Further steps are planned for the use of HAM-2:

- the strategies for further development of food export structure,
- the efficiency of increasing food export for oil,
- the major alternatives for investments in food and agriculture (agriculture versus food processing),
- the feasibility of major growth targets in food and agriculture,
- investigation of alternatives for technological development,

are to be investigated by this model.

HAM-2 will also be used to project the overall indicators of agricultural development and export-import possibilities within the framework of a research project of the Hungarian Academy of Sciences on the biological potential and ecological limits of Hungarian agriculture. Based on the results of this project, the Production Block of HAM-2 might also be further refined.

On the whole we feel that the results of various runs of HAM-2 are rather promising. They have supported the appropriateness of our approach and prove that the HAM model structure can really contribute to the further development of planning techniques and actual decision-making. The first runs have already led to conclusions which aid the decision-making on price policy. Figure 10 shows the basic trends of the develop-

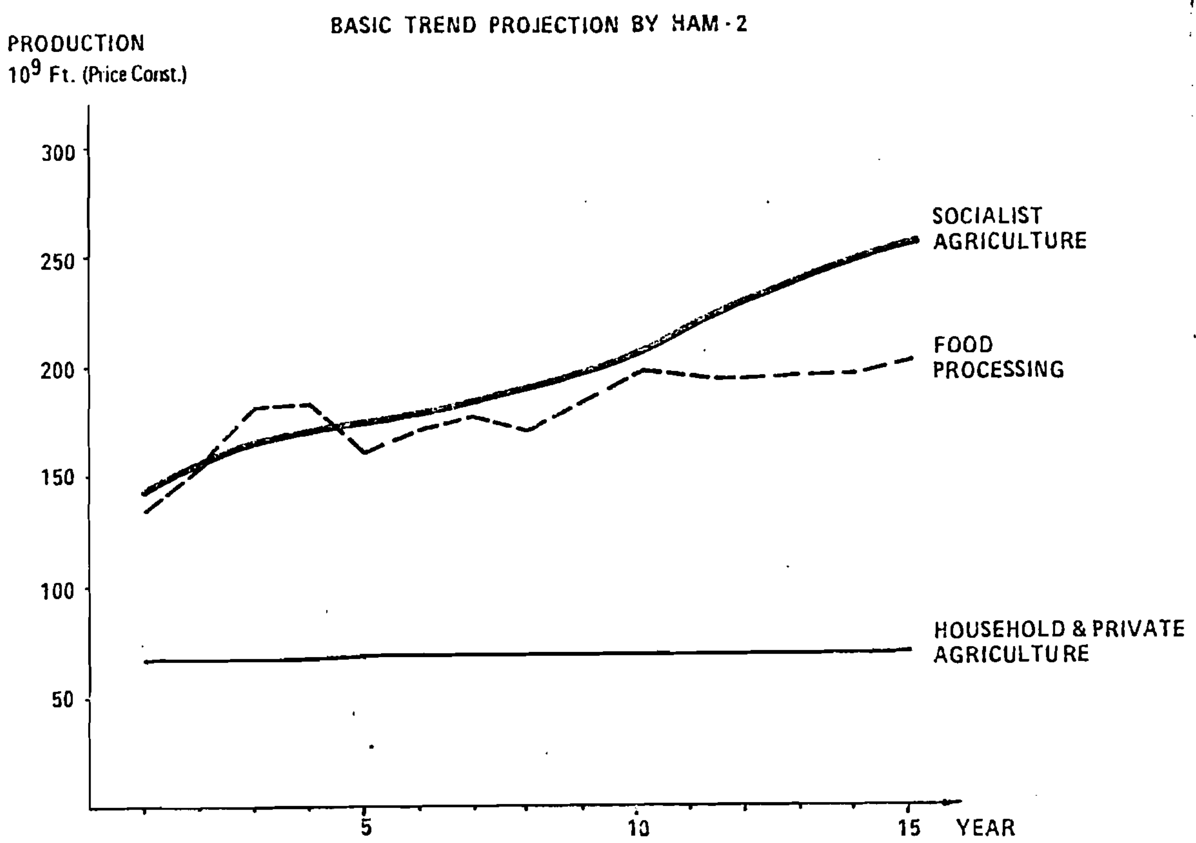

Figure 10. Basic trends in the development of Hungarian Food and Agriculture as projected by HAM-2

ment of Hungarian food and agriculture as forecasted by the basic version of HAM-2. In Figure 11 the changes in cropping structure are shown. These results represent the type of information supplied by HAM-2. Obviously the detailed discussion of results even those of one run, exceeds the limits of this paper.

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 1).

Superscripts:

h, s, p, n	producer sector (household and private agriculture, socialist sector of agriculture, food processing, rest of the economy)

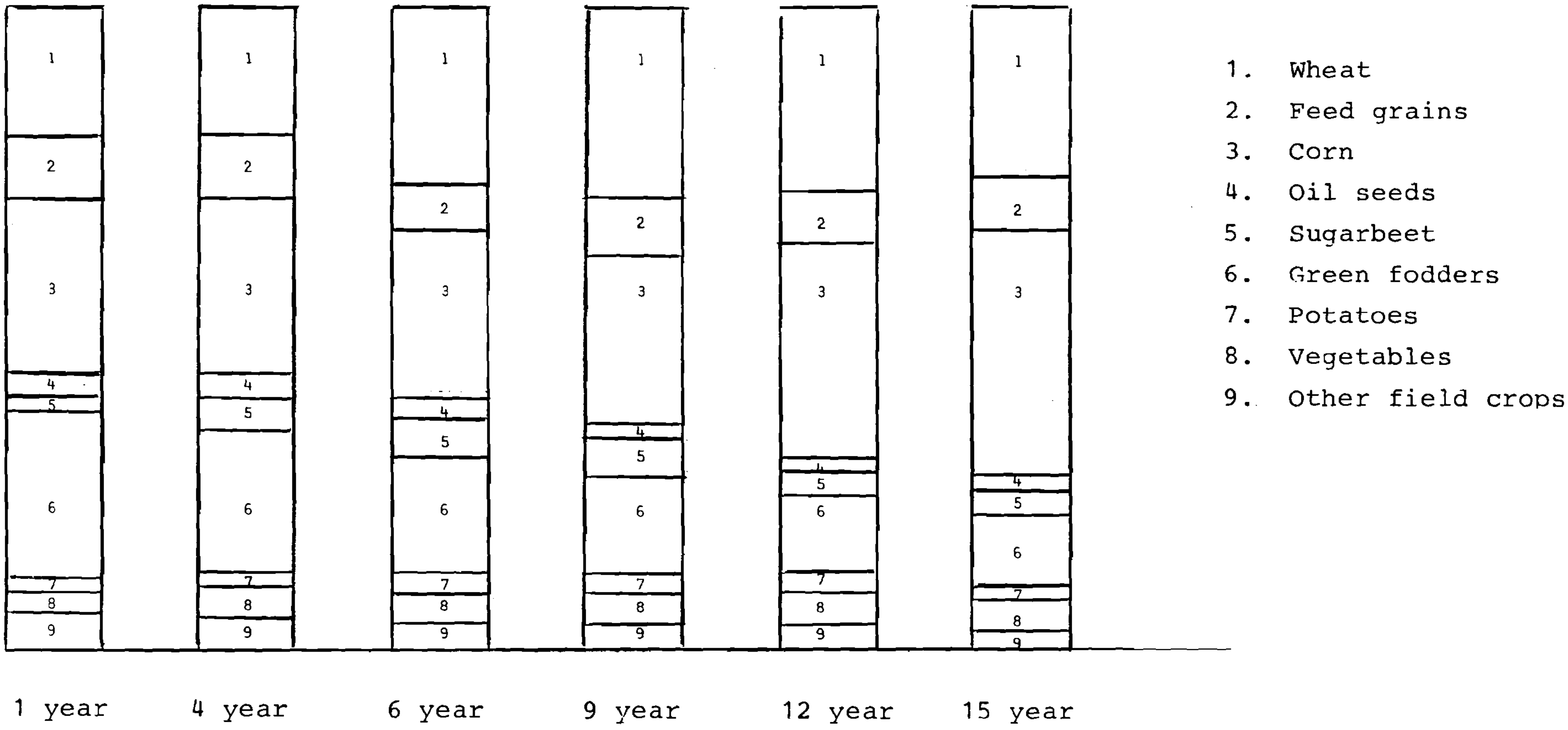

Figure 11. Development of cropping structure as projected by HAM-2

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

<u>Subscripts</u>:

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

<u>In parenthesis</u>:

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

<u>Symbols</u>:

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 2 shows, the Government Economic Management Submodel (GM) is devoted to the simulation of policy making and planning (GM-P), and, economic analysis and revising 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, required detailed analysis of the system.

In Hungary as in all CMEA countries, 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's 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 four modules; the calculation of major economic goals of government (GM-P-1), the fixing of food consumption targets (GM-P-2), the planning of food production, and foreign trade (GM-P-3), and setting of government investment targets (GM-P-4).

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, the desired growth of private consumption, and the required positive balance of payments related to agriculture and food processing are fixed based on the exogenous long-range objectives.

First the desired net national product is fixed and in addition the planned accumulation fund available for food and agriculture is also calculated as follows:

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

$$DGNP^{(t)} = (1+a)GNP^{(t-1)}$$

$$DGNPA^{(t)} = (1+b)GNPA^{(t-1)}$$

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

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

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

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

$$PDGINA^{(t)} = hPAFA^{(t)}$$

$$PGINS^{(t)} = PAFA^{(t)} - PDGINA^{(t)}$$

As far as the desired positive balance of payments from food and agriculture is concerned, the balance is determined on international dollar and rubel as well as on domestic producer prices. The desired balance of payment in dollar markets:

$$KA^{(t)} = (1+c^{(t)})KA^{(t-1)}$$

$$PYO^{(t)} = (1+c^{(t)})YO^{(t-1)}$$

Finally, based on the desired annual growth rate of private consumption, the target value of total consumption at producer prices is calculated as follows:

$$PCTOT^{(t)} = (1+i^{(t)})\ (CONP^{(t-1)} + GPE^{(t-1)} + CONS^{(t-1)}$$

Plan for Consumption (GM-P-2)

In the GM-P-2 Module a detailed plan for per capita consumption of commodities is elaborated. In connection with the above, starting from the desired growth of total consumption, (private and community* consumption) first of all we have to ensure that:

1. the planned consumption fund satisfies the minimum consumption growth requirements (adjustment of $f^{(t)}$) parameter:

$$PLF^{(t)} = f^{(t)}(PNNP^{(t)} + DESPN^{(t-1)} - PYO^{(t)} - YS^{(t-1)})$$

If the planned consumption fund is not sufficient:

$$PCTOT^{(t)} > PCF^{(t)}$$

$f^{(t)}$ is modified as follows:

$$f^{(t)} = \frac{PCTOT^{(t)}}{PNNP^{(t)} + DESPN^{(t-1)} - PYO^{(t)} - YS^{(t-1)}}$$

and

$$PLF^{(t)} = PCTOT^{(t)}$$

2. the endowments of population (personal income and fund for community consumption) are in accordance with the planned consumption fund (adjustment of $o^{(t)}$ and $ep^{g(t)}$). The income of population is planned as follows:

$$PTPE^{(t)} = [(1+o^{(t-1)})(WES^{(t-1)} + WEP^{(t-1)} + WEN^{(t-1)})$$
$$+ BS^{(t-1)} + BP^{(t-1)} + BN^{(t-1)}]\ (1-t^{in,po})$$
$$+ es^{g}GSP^{(t-1)} - ASP^{(t-1)} + (1-t^{in,h})INH^{(t-1)}$$

The planned community consumption from commodity i in physical units:

$$PTCG_i^{(t)} = (1 + ep^{g(t-1)})\ PTCG_i^{(t-1)}$$

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* Consumption of population financed from government budget (e.g. in hospitals, schools, etc.)

and the sum in value:

$$PGPE^{(t)} = \sum_i p^{pr(t)} PTCG_i^{(t)} \quad .$$

If the planned income of the population does not meet the planned value of the consumption fund, the undesired deviations are alleviated by adjusting the targets for increases in wages and community consumption. The adjustment of unit wages for a giving period takes place as follows:

If $$PCF^{(t)} > \left(\frac{PTPE^{(t)}}{pci^{(t)}} + PGPE^{(t)}\right)(1+\varepsilon_1)$$

then $$o^t = \min\,(o^{(t-1)} + \beta_3;\ ok")$$

$$ep^{g(t)} = \min\,(ep^{g(t)} + \beta_4;\ ek")$$

If $$PCF^{(t)} < \left(\frac{PTPE^{(t)}}{pci^{(t)}} + PGPE^{(t)}\right)(1-\varepsilon_1)$$

then $$o^t = \max\,(o^{(t-1)} - \beta_3;\ ok')$$

$$ep^{g(t)} = \max\,(ep^{g(t-1)} - \beta_4;\ ek')$$

otherwise $$o^t = o^{(t-1)}$$

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

Obviously the values of $PTPE^{(t)}$, $PTCG_i^{(t)}$ and $PGPE^{(t)}$ have to be recalculated by using the adjusted $o^{(t)}$ and $ep^{g(t)}$ coefficients and:

$$PJOV^{(t)} = \frac{PTPE^{(t)}}{pci^{(t)}} + PGPE^{(t)}$$

As the total endowments of the population are determined, the consumer's demand for various commodities are planned. For determining expected consumer's demand in a given year, the same method is used as for generating the final demand. We assume that the income of the population available after deducting savings and other commitments is spent in buying various commodities. Obviously in this case the planned sum of consumer's income is used in this case. The planned consumer demand towards a specific commodity is influenced by the consumer prices and the level of income. The planned demand for commodity in HAM-2 is described as follows:

$$PTC_i^{(t)^1} = \frac{\rho_i^{(t)} \quad PTPE^{(t)}}{p_i^{c(t)}}$$

$$\rho_i^{(t)^1} > 0 \text{ and } \sum \rho_i^{(t)^1} = 1$$

The $\rho_i^{(t)}$ parameters are determined by using C.E.V. Leser's non-linear demand model.

We assume that planned consumer expenditures on commodity i can be described as:

$$PTC_i^{(t)} \; p_i^{c(t)} = \frac{c_{1(i)}\left(\dfrac{p_i^{c(t)}}{PTPE^{(t)}}\right)^{c_{2(i)}} PTPE^{(t)}}{\sum\limits_j c_{i(j)}\left(\dfrac{p_j^{c(t)}}{PTPE^{(t)}}\right)^{c_{2(j)}}}$$

where $c_{1(i)}$, $c_{2(i)}$ are parameters related to commodity i and therefore:

$$PTC_i^{(t)} = \frac{c_{1(i)} p_i^{c(t)(c_{2(i)}-1)} PCPE^{(t)(1-c_{2(i)})}}{\sum\limits_j c_{1(j)} p_j^{c(t)(c_2 j)} PCPE^{(t)(-c_2 j)}}$$

Based on time series of $TC_i^{(t)}$, $p_i^{c(t)}$ and $TPE^{(t)}$, the c_1 and c_2 paramaeters have been estimated using the least square method.

$$\rho_i^{(t)} = \frac{c_{1(i)} \left(\frac{p_i^{c(t)}}{PCPE^{(t)}} \right)^{c_{2(i)}}}{\sum_j c_{1(j)} \left(\frac{p_j^{c(t)}}{PCPE^{(t)}} \right)^{c_{2(j)}}}$$

and $\rho_i^{(t)}$ is expressing the share of commodity i in planned consumer expenditures in period (t).

Finally in the GM-P-2 Module the planned consumption fund and total consumption are compared and if:

$$PCF^{(t)} < \sum_i p_i^{pr(t)} PTC_i^{(t)} + PGPE^{(t)}$$

the value of $PTC_{46}^{(t)}$, planned per capita consumption from the rest of the economy is decreased until:

$$PCF^{(t)} = \sum_i p_i^{pr(t)} PTC_i^{(t)} + PGPE^{(t)}$$

Government Plan on Food and Agriculture (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 and imports. These are the basis for the analysis of the performance in a given year.

In the GM-P-3 module, commodity balances are given for each agricultural and processed food commodity listed in Table 2. 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:

$$PP_i^{(t)} - \left(\sum_{\underline{i}} \alpha_{\underline{i}i}^{(t)} PP_{\underline{i}}^{(t)} + \sum_f \alpha_{fi}^{(t)} PP_f^{(t)} + \alpha_{ni}^{(t)} PP_n^{(t)} + \sum_k \alpha_{ki}^{(t)} RI_k^{(t)} + PE_i^{(t)} + PS_i^{(t)} \right) + PI_i^{(t)} + S_i^{(t-1)}$$

$$= PTC_i^{(t)} + PTCG_i^{(t)} + PTCS_i^{(t)}$$

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

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

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 the case of resource k in agriculture the constraints are formulated as:

$$\sum_i \alpha_{ik}^{(t)} PP_i^{(t)} \le SKAPT_k^{(t)}$$

the resources of the household and private sector are also considered:

$$\sum_i \alpha_{ik}^{(t)} PP_i^{(t)} \le SKAPT_k^{(t)} + HKAPT_k^{(t)}$$

Production capacities in the household sector are determined based on actual production in the previous period:

$$HKAPT_k^{(t)} = \frac{HP_k^{(t-1)}}{\gamma^k}$$

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

$$\sum_i \alpha_{il}^{(t)} PP_i^{(t)} \leq LS_1^{(t)} + LS_2^{(t)} + LSH^{(t)} - \frac{HP_i^{(t-1)}}{APH_i} - \frac{HP_{i+1}^{(t-1)}}{APH_{i+1}}$$

where commodity i and i+1 are the plantations in the household and private sector. The production resources in food processing are modelled according to the major types of processing similarly to resources in agriculture:

$$\sum_f \alpha_{fk}^{(t)} PP_f^{(t)} \leq KAPT_k^{(t)}$$

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:

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

The required positive balance of payments of food and agriculture:

$$\sum_i p^{w(t-1)} \left(PE_i^{(t)} - PI_i^{(t)}\right) + \sum_f p_f^{w(t-1)} \left(PE_f^{(t)} - PI_f^{(t)}\right) \geq DBPA^{(t)}$$

Individual lower and upper limits may also be given on production of individual commodities to avoid extreme solutions due to linear programming algorithms. The resource utilization coefficients ($\alpha_{ik}^{(t)}$, $\alpha_{fk}^{(t)}$) are generated from the production block of the previous period in Module UD-3. Available labor force is determined based on exogenously given trend coefficients, and the actual labor used in food and agriculture in the previous period.

For module GM-P-3 alternative goal functions can be considered such as the maximization of the positive balance of payment from food and agriculture:

$$\max \mathrm{PBPA}^{(t)}$$

or the efficiency of agricultural foreign trade can also be maximized through the maximization of net foreign exchange returns on domestic production expenditures at domestic currency as follows:

$$\max \sum_i (\mathrm{dsp}_i^{w(t)} - \delta \mathrm{KT}_i^{(t-1)})(\mathrm{PE}_i^{(t)} - \mathrm{PI}_i^{(t)})$$

In the GM-P-3 module of HAM-2 commodities according to Table 3 are considered. Production sectors are not handled separately. The LP model actually consists of 75 variables and 63 constraints. Besides variables representing the production of various commodites, 29 variables are related to exports and 11 to imports of food and agricultural commodities. Out of the 63 constraints, 26 are connected with resources, 34 are commodity balances and 3 express overall economic requirements (e.g. lower bounds for gross national product of food and agriculture) for food and agriculture. The maximum efficiency of agricultural foreign trade has been considered as a major objective of central planners and is described by the objective function. The impacts of an alternative objective junction, namely the maximization of foreign exchange earnings from food and agriculture is also going to be investigated. Table 3 gives an overview of the structure of the linear programming model built in the GM-P-3 Module of HAM-2.

The Hungarian government operates mainly by indirect economic regulatory. Therefore the production plan targets generated by module GM-P-3 do not appear directly in the production.

Table 3. Structure of the linear programming model included in the GM-P-3 Module

	variables / constraints	production agriculture: plant prod. PPN_i^t	production agriculture: animal husb. PP_1^t	variable food processing ipar PPN_i^t	export variables PE_i^t	import variables PI_i^t	relation	right hand side
1.	Objective functions				cp_i^t	$-cp_i^t$		
2-14.	Resource constraints in agriculture	$\bar{a}_{ki}^{s/t/}$	$\bar{a}_{kl}^{s/t/}$				$\leq$	$LS_1^t+LS_2^t+LSH^t$ $SKAPT_k^t+HKAPT_k^t$ $PSLF^t+HLP^t$
15-26.	Resource constraints in food processing			$\bar{a}_{ki}^{p}$			$\leq$	$KAPT_k^t$
27-44.	Commodity balance in agriculture	1	$\bar{s}_{il}^{t}$	$-\frac{1}{jp_i}$	-1	+1	+	$PTC_i^t+PTCG_i^t+TCS_i^{t-1}$ $+PSE_i^t-PSI_i^t$
45-60	Commodity balance in food processing	1	$-a_{il}^{-s/t/}$	1	-1	+1	=	
62.	Gross production value	$p_i^{pr/t/}$	$\bar{s}_{il}^{t}p_i^{pr/t/}$	$p_i^{pr/t/}$			=	$DGNPA^t$
63.	Balance of foreign payment				$p_i^{w/t/}$	$-p_i^{w/t/}$	=	$DPBA^t$
61. 64-92.	Export constraints				1		$\leq$	PTK_i^t

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 now materials). Of course, one may construct a model in which government plan targets appear directly in the production block.

Investment Decisions of the Government Module GM-P-4

In Hungary two forms of investments are differentiated in food and agriculture. The development of irrigation systems, infrastructures and some large investments in food processing are financed directly by the government. (However in agriculture, most investment decisions are made at the enterprise level.) In the GM-P-4 module, the investment decisions of government are modelled by a heuristic algorithm. The following basic information is used in making these calculations:

-- the production facilities in food and agriculture in which the government might invest,
-- the planned amount of funds available for direct government investments
-- shadow prices of scarce production facilities are supplied by GM-P-3 Module.

The possible fields of investments are ranked based on shadow prices generated by GM-P-3 LP. The resource with the largest shadow price has priority in distributing available funds. For each production facility a so-called investment unit is defined based on economy of scale and previous practice. First one unit of investment is selected in the production facilities starting with those having the largest shadow prices. After planning one investment unit in the production facility with the lowest positive shadow price, the procedure starts again planning the second investment unit at resource with the highest priority, etc., until all the available funds are utilized.

In Figure 12, the algorithm built in HAM-2 for planning investments is outlined.

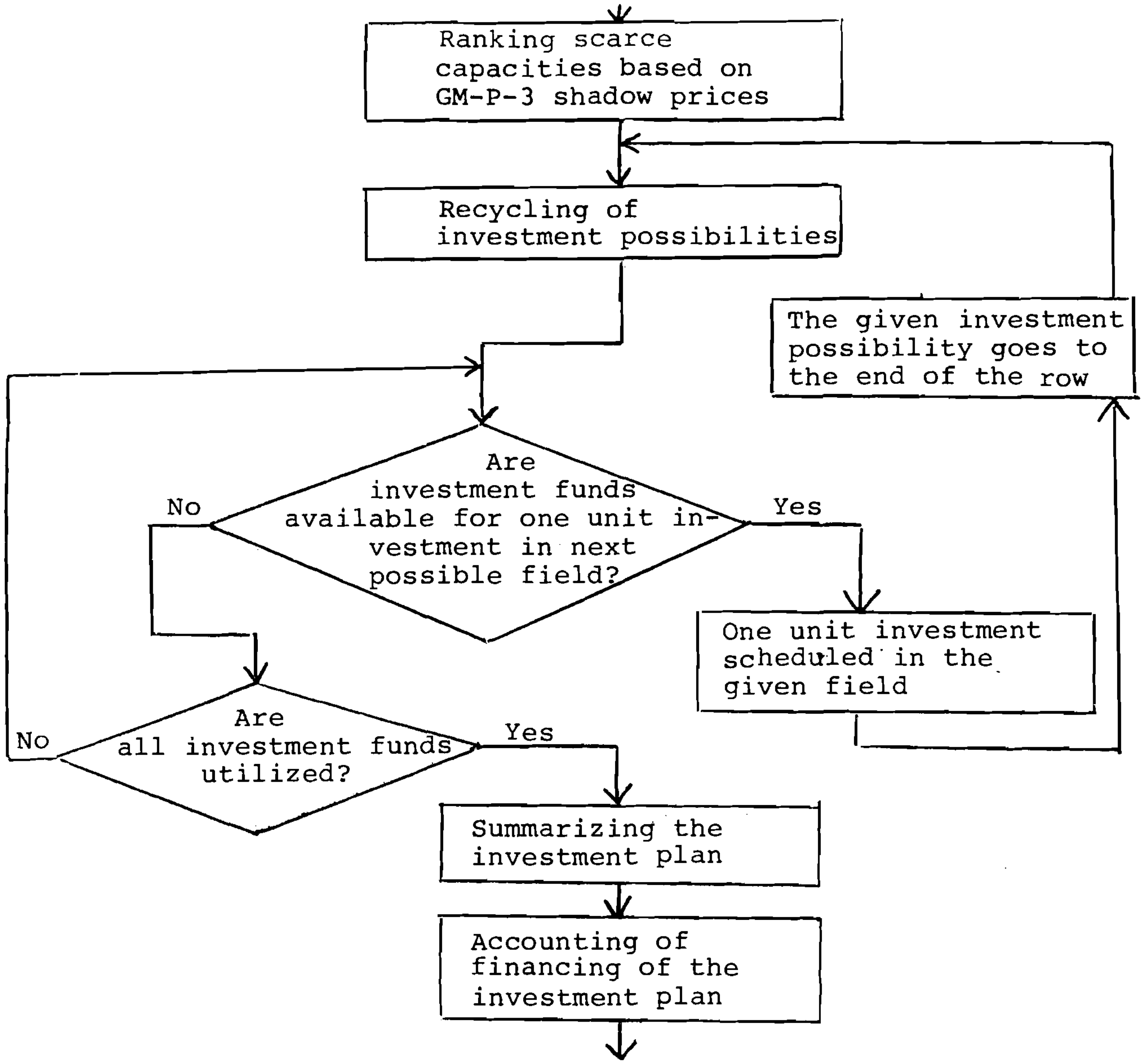

Figure 12. Procedure planning investments in HAM-2

Production Block (P)

The second major block of HAM-2 is devoted to the description of producers' decisions and production itself. The main role of this block is to generate supply in a given time unit. The production block of HAM-2 consists of six modules. Contrary to other FAP models, in HAM-2 three production sectors of food and agriculture are distinguished, these are household and private agriculture, socialist agriculture and food processing.

Household and Private Agriculture P-1 Module

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 animal husbandry in the household and private sector.

-- Some of the food products from the household and private farms are directly consumed by the owners of these farms.

The most important part of the P-1 module describes the decisions on the product mix. By <u>supply functions</u> the expected supply of crops and animal products are determined. To establish the most appropriate methodology for describing the behaviour of household and private agriculture, several alternatives were investigated, these were: linear programming, non-linear optimization, trend interpolation and supply functions. The supply functions seemed to fit our objectives and the available data base most appropriately.

The supply of crop products are first determined. We assume that the supply from commodity i is a function of available land, producer prices and yields. By supply functions, the actual share of various commodities in the total land available are determined as follows:

$$h\rho_i^{(t)} = \frac{c_{3(i)}\left(\frac{1}{p_i^{pr(t)} \ APH_i \ LSH^{(t)}}\right)^{c_{4(i)}}}{\sum_j c_{3(j)}\left(\frac{1}{p_j^{pr(t)} \ APH_j \ LSH^{(t)}}\right)^{c_{4(j)}}}$$

The actual supply can be described as:

$$HP_i^{(t)} = h\rho_i^{(t)} \ LSH^{(t)} \ APH_i^{(t)} \qquad i = 1,\ldots.11$$

The crop production is not constrained by labor availability. Household and private agriculture is based on work mostly done by cooperative farm members and workers in industry and elsewhere in addition to their main occupation and by women staying at home. The total amount of labor availability for this additional agricultural activity is modelled by a trend function reflecting a deminishing trend in time (see Module UD-1). We always assume that the rest of the labor force, after deducting the needs of crop production, is used for keeping animals in the household and the private sectors.

The total labor requirements of crop production:

$$TWHV^{(t)} = \sum_i HP_i^{(t)} \ WH_i$$

Labor force available for animal husbandry:

$$TWHA^{(t)} = TWH^{(t)} - TWHV^{(t)}$$

The supply of animal products is influenced by available labor, producer prices, and productivity of labor in producing various commodities. Similarly to crop production, the share of available labor for various commodities of animal husbandry are determined as follows:

$$h\rho_i^{(t)} = \frac{c_{3(i)} \left(\dfrac{WH_i^{(t)}}{p_i^{pr(t)} \quad TWHA^{(t)}} \right)^{c_{4(i)}}}{\sum_j c_{3(j)} \left(\dfrac{WH_i^{(t)}}{p_j^{pr(t)} \quad TWHA^{(t)}} \right)^{c_{4(j)}}}$$

and the actual supply:

$$HP_i^{(t)} = h\rho_i^{(t)} \frac{TWHA^{(t)}}{WH_i^{(t)}} \qquad i = 12,\ldots 19$$

The $c_{3(i)}$ and $c_{4(i)}$ parameters of supply functions have been estimated by using the least square method based on the time series of 1964-1976. Table 4 gives full information on crops and animal products considered in Module P-1 (11 crop and 8 animal products). The suitability of parameters of supply functions have been verified by statistical methods.

After determining the production, the intermediate input requirements of household and private agriculture are calculated as follows:

$$HD_j^{(t)} = \sum_i HP_i^{(t)} \mu_{ji}$$

These requirements are satisfied by the socialist sector of agriculture. In the case of inputs also produced by the household and private sector, the outgoing demand is obviously decreased by the internal production:

Table 4. Variables related to production and their symbols in production block of HAM-2

Branch product	Technology	Scale of branch	Total production by commodities	Output from sector	Household production
	value or	physical unit	m.t. hl, value,		
AGRICULTURE					
Feed Grain Production	SPT011 SPT012	SP01			
1. feed grain			SPN01	SPA01	HP01
Coarse Grain Production	SPT021	SP02			
2. coarse grain			SPN02	SPA02	
Corn Production	SPT031	SP03			
3. corn			SPN03	SPA03	HP03
Oil Crop Production	SPT041	SP04			
4. oil seeds			SPN04	SPA04	
Sugar Beet Production	SPT051 SPT052 SPT053	SP05			
5. sugar beet			SPN05	SPA05	
Green feed Production	SPT061 SPT062 SPT063 SPT064 SPT065	SP06			
6. green fodder			SPN06	SPA06	HP06
Potatoe Production	SPT071 SPT072 SPT073	SP07			

Branch product	Technology	Scale of branch	Total production by commodities	Output from sector	Household production
	value or	physical unit	m.t. hl, value,		
7. Potatoes			SPN07	SPA07	HP07
Vegetable Production	SPT081 SPT082	SP08			
8. vegetable			SPN08	SPA08	PH08
Other Field Crop Production	SPT091 SPT092	SP09			
9. other field crops			SPN09	SPA09	HP09
Fruit Production	SPT101 SPT102	SP10			
10. fruits			SPN10	SPA11	HP11
Grape Production	SPT111 SPT112	SP11			
11. grape			SPN11	SPA11	HP11
Cattle Production	SPT121 SPT122 SPT123 SPT124	SP12			
12. beef			SPN12	SPA12	HP12
13. milk			SPN13	SPA13	HP13
Pig Production	SPT141 SPT142	SP14			
14. pork			SPN14	SPA14	HP14
Sheep Production	SPT151 SPT152 SPT153	SP15			
15. lamb			SPN15	SPA15	HP15

Branch product	Technology	Scale of branch	Total production by commodities	Output from sector	Household production
	value or	physical unit	m.t. hl,	value,	
16. wool			SPN16	SPA16	HP16
Poultry Production	SPT171 SPT172 SPT173 SPT174	SP17			
17. poultry meat			SPN17	SPA17	HP17
18. eggs			SPN18	SPA18	HP18
Other Aminal Husbandry	SPT191 SPT192	SP19			
19. other animal products			SPN19	SPA19	HP19
Feed Dehydrating	SPT201	SP20			
20. alfalfa pellots				SPN20	SPA20
Additional Activities	SPT211	SP21			
21. service of additional activities			SPN21	SPA21	
FOOD PROCESSING					
Milling Industry		FP22			
22. flour			FPN22	FPA22	
23. bran			FPA23	FPA23	
Oil Seed Processing		FP24			
24. vegetable oil			FPN24	FPA24	
25. oil cake			FPN24	FPA25	

Branch product	Technology	Scale of branch	Total production by commodities	Output from sector	Household production
	value or	physical unit	m.t.	hl, value,	
Meat Industry		FP26			
26. beef			FPN26	FPA26	
27. pork			FPN27	FPA27	
28. lamb			FPN28	FPA28	
29. slaughtering wastes offals			FPN29	FPA29	
30. processed meat, high moisture content			FPN30	FPA30	
31. processed meat smoked,			FPN31	FPA31	
Poultry Industry		FP32			
32. processed poultry meat			FPN32	FPA32	
33. processed eggs			FPN32	FPA32	
34. sloughtering wastes (poultry)			FPN34	FPA34	
Dairy Industry		FP35			
35. dairy products			FPN35	FPA35	
36. milk powder			FPN36	FPA36	
Protein Feed Production		FP37			
37. protein feeds			FPN37	FPA37	
38. feed mix			FPN38	FPA38	
Sugar Industry		FP39			
39. sugar			FPN39	FPA39	
Canning Industry		FP40			

Branch product	Technology	Scale of branch	Total production by commodities	Output from sector	Household production
	value or	physical unit	m.t. hl, value,		
40. canned fruits			FPN40	FPA40	
41. canned vegetables			FPN41	FPA41	
Wine Industry		FP42			
42. wine			FPN42	FPA42	
Other food Processing		FP43			
43. other processed food			FPN43	FPA43	

$$(HBF_i^{(t)} - HP_i^{(t)}) > 0 \quad ; \qquad HD_i^{(t)} = HBF_i - HP_i^{(t)}$$

or if production exceeds internal needs:

$$(HBF_i^{(t)} - HP_i^{(t)}) \leq 0; \qquad HD_i^{(t)} = 0$$

Agricultural products produced by the household and private sector for their own consumption is determined based on exogenously given trends:

$$TCS_i^{(t)} = (1 + hci) + CS_i^{(t-1)}$$

The total value of farm products used for self consumption:

$$CONS^{(t)} = \sum_i p_i^{pr(t)} TCS_i^{(t)}$$

Finally the financial consequences of household and private agricultural production are calculated.
Gross production value:

$$HAP^{(t)} = \sum_i p_i^{pr(t)} HP_i^{(t)}$$

Expenses related to the use of production facilities of socialist agriculture:

$$HDES^{(t)} = \alpha_9 HD_1^{(t)} IKT_1^{(t)} + \alpha_{12} HD_2^{(t)} IKT_2^{(t)} + \alpha_{15} HD_3^{(t)} IKT_3^{(t)}$$

$$HWES^{(t)} = \alpha_{10} HD_1^{(t)} IKT_1^{(t)} + \alpha_{13} HD_2^{(t)} IKT_2^{(t)} + \alpha_{16} HD_3^{(t)} IKT_3^{(t)}$$

$$HMI^{(t)} = \alpha_{11} HD_1^{(t)} IKT_1^{(t)} + \alpha_{14} HD_2^{(t)} IKT_2^{(t)} + \alpha_{17} HD_3^{(t)} IKT_3^{(t)}$$

$$IKTO^{(t)} = HD_1^{(t)} IKT_1^{(t)} + HD_2^{(t)} IKT_2^{(t)} + HD_3^{(t)} IKT_3^{(t)}$$

expenses of material inputs:

$$MEHI^{(t)} = PMUTR\ HD_{10}^{(t)} + HD_{11}^{(t)}$$

$$MEH^{(t)} = IKTO^{(t)} + (HD_6^{(t)} + HBF_6^{(t)})p_6^{pr(t)} + p_3^{pr(t)}HBF_3^{(t)}$$

$$+ p_{38}^{pr(t)} HD_7^{(t)} + p_8^{pr(t)} HD_1^{(t)} + p_7^{pr(t)} HD_9^{(t)}$$

$$+ p_{11}^{pr(t)} HBF_{11}^{(t)} + p_2^{pr(t)} HD_4^{(t)} + p_3^{pr(t)} HD_5^{(t)} + MEHI^{(t}$$

income and taxes paid:

$$INH^{(t)} = HAP^{(t)} - MEH^{(t)} - CONS^{(t)}$$

$$TXH^{(t)} = INH^{(t)} (1 - t^{in,h})$$

Production Decisions in Socialist Agriculture: Module P-2

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 included a linear programming model to describe the behaviour of state and cooperative farms. The possibilities of a more sophisticated mathematical representation of this sector were investigated during experiments with HAM-1, but finally the LP approach was also kept in HAM-2.

The LP model is structured according to products. 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 and advanced so-called future technology. Table 5 gives an overview of the model. The irrigated production is not considered as a separate production variable. We assume that certain parts (more in the case of advanced technology) of the land which are used for a specific com-

Table 5. Structure of linear programming model for socialist agriculture.

	constraints/ variables	percent production SPT^{t}_{1j}	Animal husbandry SPT^{t}_{1j}	Other activities SPT^{t}_{1}	Relation	Right hand side
1.	objective function	$p_i^{pt(t)} j^{t}_{1j}$	$p_i^{pr(t)} si^{t}_{1j}$	1		max
2.	ploughland	1			$\leq$	LS^{t}_{1}
3.	pastures-meadows	1			$\leq$	LS^{t}_{2}
4-16.	other resource constriants	$a^{s(t)}_{k1j}$	$a^{s(t)}_{k1j}$	$a^{s(t)}_{k1}$	$\leq$	$SKAPT^{t}_{k}$ $PSLF^{t}$
17-20.	commodity balance	$j^{s(t)}{}_{1j} - a_i^{s(t)} 1_j$	$-a^{s(t)}_{i1j}$	$-a^{s(t)}_{i1}$	$\geq$	HD^{t}_{i}

moditie are irrigated. The inputs and expenses related to irrigation are considered as parts of total inputs and expenses. 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. The LP describing producer's decisions on the structure of production is the central element of Module P-2.

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

$$\sum_i \sum_j \alpha^{s(t)}_{ij1} \; SPT^{(t)}_{ij} \leq LS^{(t)}_1$$

Plantations:

$$\sum_j \alpha^{s(t)}_{ij3} \; SPT^{(t)}_{ij} = SKAPT^{(t)}_1$$

Meadows and pastures:

$$\sum_i \sum_j \alpha^{s(t)}_{ij2} \; SPT^{(t)}_{ij} = LS^{(t)}_2$$

Other physical resources (buildings, machinery) constraints:

$$\sum_{ij} \sum \alpha^{s(t)}_{ijk} \; SPT^{(t)}_{ij} \leq SKAPT^{(t)}_k - HD^{(t)}_k$$

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

$$\sum_i \sum_j \beta^{s(t)}_{ij} \; SPT^{(t)}_{ij} = SLF^{(t)}$$

*In the description of the P-2 LP Model in subscript i refers to commodity j to technology and k to production capacity.

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:

$$\sum_j \gamma_{ij}^{s(t)} \; SPT_{ij}^{(t)} = SPN_i^{(t)}$$

Individual lower and upper bounds are given on the size of the production variables to avoid an extreme solution and to ensure realistic behaviour of the model.

$$PTS_i^{'(t)} \leq SPN_i^{(t)} \leq PTS^{''(t)}$$

These lower and upper bounds are determined based on the analysis of past changes in the production structure of state and co-operative farms.

The introduction of "future" or advanced technologies is also 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:

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

$$SPT_{ij+1}^{(t)} \leq z_i^{(t)''} \; SPT_{ij}^{(t)} + SPT_{ij+1}^{(t)}$$

In the objective function of the model, the gross income (production value minus direct production expenses) of farming is maximized:

$$\max \sum \sum inc_{ij}^{(t)} \; SPT_{ij}^{(t)}$$

The $inc_{ij}^{(t)}$ coefficients are updated in each period before solving the LP model.

In HAM-2 the production activities of state and cooperative farms are represented by a relatively wide range of variables. The available resources and resource utilization are considered through 19 constraints. Product utilization is described by 21 equations. In the model a relatively wide range of resources and input factors are considered, and changes in production structure are constrained by upper and lower bounds partly updated annually, partly given exogenously.

Besides the LP model for determining the structure of production, Module P-2 consists of calculations

-- to determine total inputs needs of production,
-- to generate total disposable income of farming,
-- to get the average unit production costs of various commodities,

The input requirements, i.e., fertilizers, pesticides, and other industrial inputs and services, industrially processed protein and other feeds are calculated as:

$$IRA_k^{(t)} = \sum_i \sum_j \alpha_{ijk}^{(t)} SPT_{ij}^{(t)}$$

Next the disposable income is calculated:

Gross production value:

$$SAP^{(t)} = \sum_i p_i^{pr(t)} SPN_i^{(t)}$$

Amortization:

$$DES^{(t)} = \sum_k RS_k^{(t)} drs_k$$

Direct production expenses except industrial inputs and services:

land tax:

$$LTS^{(t)} = \sum_i \sum_j Xf_{ij} SPT_{ij}^{(t)}$$

inputs of agricultural origin:

$$MESS^{(t)} = \sum_i \sum_j Xa_{ij} SPT_{ij}^{(t)}$$

inputs of food processing origin:

$$MESP^{(t)} = \sum_i \sum_j Xb_{ij} SPT_{ij}^{(t)}$$

General management and overhead expenses:

$$SGMN^{(t)} = en\ SGMN^{(t-1)}$$

$$SGMA^{(t)} = ea\ SGMA^{(t-1)}$$

$$SGMM^{(t)} = em\ SGMM^{(t-1)}$$

$$SGM^{(t)} = SGMN^{(t)} + SGMA^{(t)} + SGMM^{(t)}$$

Expenses on industrial inputs and services:

$$MESI^{(t)} = \sum_k p_k^{pr(t)} IRA_k^{(t)} + SGMN^{(t)} + HMI^{(t)}$$

Labor expenses and taxes on wages:

$$ADMS^{(t)} = (1 + ed)\ ADMS^{(t-1)}$$

$$SLF^{(t)} = SLF^{(t)} + ADMS^{(t)} + \frac{HWES^{(t)}}{w^{s(t)}}$$

$$WES^{(t)} = SLF^{(t)}\ w^{s(t)}$$

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

Total production expenses:

$$TES^{(t)} = MESS^{(t)} + MESP^{(t)} + MESI^{(t)} + LES^{(t)} + DES^{(t)} + LTS^{(t)}$$

Disposable net income of socialist agriculture:

$$INCS^{(t)} = SAP^{(t)} - TES^{(t)} + IKTO^{(t)}$$

Most of the commodities are represented by two technological variables in this Module. In order to be able to compare production expenses with producer prices the average unit production costs of commodities are also calculated as follows: (In the description of the procedure, i refers to commodity, j to production capacity and j to technology).

$$XY_{ijk}^{(t)} = \frac{SPT_{ij}^{(t)} \; Xd_{ijk}^{(t)}}{SKAPIG^{(t)}} \quad (RS_k^{(t)} \; drs_k - HDESR_k^{(t)})$$

$$pxd_{ij}^{(t+1)} = \frac{\sum_k XY_{ijk}^{(t)}}{SPT_{ij}^{(t)}}$$

$$BARM1_i^{(t)} = \sum_k SPT_{ik}^{(t)} \; (MESS_{ik}^{(t)} + MESP_{ik}^{(t)} + MESI_{ik}^{(t)} + LTS_{ik}^{(t)}$$

$$+ pxd_{ik}^{(t)} + LESS_{ik}^{(t)})$$

$$OKT_i^{(t)} = \frac{BARMI_i^{(t)}}{SPN_i^{(t)}} + \frac{pi^{pr(t)} \; SGM^{(t)}}{SAP^{(t)}}$$

$i = 1,\ldots,11,\ 14,\ 19,\ldots,21$

Special rules are used to calculate the unit costs of product 12, 15 and 17 as follows:

$$XT^{(t)} = BARMI_e^{(t)} + \frac{p_e^{pr(t)} SPN_e^{(t)} + pe{+}1^{pr(t)} \; SPN_{e+1}^{(t)}}{SAP^{(t)}} \cdot SGM^{(t)}$$

$$YT^{(t)} = \frac{p_e^{pr(t)} \; SPN_e^{(t)}}{p_e^{pr(t)} \; SPN_e^{(t)} + p_{e+1}^{pr(t)} \; SPN_{e+1}^{(t)}}$$

$$OKT_e^{(t)} = \frac{YT^{(t)} \cdot XT^{(t)}}{SPN_e^{(t)}}$$

$$OKT_{e+1}^{(t)} = \frac{(1+YT^{(t)})\cdot XT^{(t)}}{SPN_{3+1}^{(t)}}$$

$e = 12, 15, 17$

Calculation of Final Outputs of Agriculture (P-4)

The available agricultural commodities are calculated from the producer's decision models (P-1, P-2) with consideration for the random effects of weather conditions on yields of 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 imputs 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 yields and the final output of agriculture are calculated in the P-3 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:

$$\gamma_i^{h(t)*} \quad , \quad \gamma_{ij}^{s(t)*}$$

are the actual yields in period (t); and

$$\theta_i^{h(t)} \quad , \quad \theta_{ij}^{s(t)*}$$

express the effects of weather on yield.

Based on $\gamma_i^{h(t)*}$ and $\gamma_{ij}^{s(t)*}$, the final outputs of agriculture ($SPN_i^{(t)}$, $BPA_i^{(t)}$ and $HP_2^{(t)}$) can be calculated.

Module P-3 actually represents only a theoretical possibility offered by the HAM model structure, and it is not included in HAM-2. Methods for considering weather conditions have not yet been developed within FAP. The routines applied, if necessary, to distribute raw products between processing and consumption are included in module P-4.

Food Processing--Module P-4

In the fourth module of the Production Block the production of food processing is scheduled. In the first version of HAM a linear programming model was used for this purpose. After analyzing the experiences with HAM-1 we decided to substitute the LP model by a simulation algorithm. Because the structure of food processing is almost completely determined by available resources and raw materials, where little space is left for optimization, the use of simulation procedure seemed to be appropriate. The basic principles of these algorithms are as follows:

- production facilities are considered according to major branches of Hungarian food processing industry, and given mostly according to processed commodities in our commodity list;
- alternative usage of production facilities are not considered.

In Module P-5 the production program of the food processing industry is calculated according to the major branches of the industry. This procedure is based on the following equations:

a. Milling industry

$$FELH_1 = \frac{1}{\gamma_1} (PTC_{22} + PTCG_{22} + \gamma_{28}\ FPN_{43}^{(t-1)})$$

$$FPN_{22} = PTC_{22} + PTCG_{22} + \gamma_{28}\ FPN_{43}^{(t-1)}$$

$$FPN_{23} = \gamma_2 \; FELH_1$$

$$KAPIG_1 = FELH_1$$

b. Vegetable oil processing

$$FELH_4^{(t)} = SPN_4^{(t)} - PE_4^{(t)}$$

$$FPN_{24}^{(t)} = \gamma_3 \; FELH_4^{(t)}$$

$$FPN_{25}^{(t)} = \gamma_4 \; FELH_4^{(t)}$$

$$KAPIG_2^{(t)} = FELH_4^{(t)}$$

c. Meat industry is modelled according to two levels of processing. First slaughtering and primary meat processing is described:

$$FELH_{12}^{(t)} = SPN_{12}^{(t)} + HP_{12}^{(t)} - PE_{12}^{(t)}$$

$$FPN_{26}^{(t)} = \gamma_5 \; FELH_{12}^{(t)}$$

$$FELH_{14}^{(t)} = SPN_{14}^{(t)} + HP_{14}^{(t)} - TCS_{14}^{(t)} - PE_{14}^{(t)}$$

$$FPN_{27}^{(t)} = \gamma_6 \; FELH_{14}^{(t)}$$

$$FELH_{15}^{(t)} = SPN_{15}^{(t)} + HP_{15}^{(t)} - PE_{15}^{(t)}$$

$$FPN_{28}^{(t)} = \gamma_7 \; FELH_{15}^{(t)}$$

$$KAPIG_3^{(t)} = FELH_{12}^{(t)} + FELH_{14}^{(t)} + FELH_{15}^{(t)}$$

$$FPN_{29}^{(t)} = \gamma_8 \; FELH_{12}^{(t)} + \gamma_9 \; FELH_{14}^{(t)} + \gamma_{10} \; FELH_{15}^{(t)}$$

then further processing of meat (production of sausages, salami, etc.) is handled:

$$FELH_{26}^{(t)} = \alpha_2 \; FPN_{26}^{(t)}$$

$$FELH_{27}^{(t)} = FPN_{27}^{(t)} - PTC_{27}^{(t)} - PE_{27}^{(t)} - PTCG_{27}^{(t)}$$

$$FPN_{30}^{(t)} = \gamma_{11} \; FELH_{26}^{(t)} + \gamma_{12}\alpha_3 \; FELH_{27}^{(t)}$$

$$FPN_{31}^{(t)} = \gamma_{13}(1 - \alpha_3)\ FELH_{27}^{(t)}$$

$$FELH_{17}^{(t)} = SPN_{17}^{(t)} + HP_{17}^{(t)} - TCS_{17}^{(t)} - PE_{17}^{(t)}$$

$$FPN_{32}^{(t)} = \gamma_{14}\ FELH_{17}^{(t)}$$

$$FELH_{18}^{(t)} = SPA_{12}^{(t)} + HP_{12}^{(t)} - TCS_{18}^{(t)}$$

$$FPN_{33}^{(t)} = \gamma_{15}\ FELH_{18}^{(t)}$$

$$FPN_{29}^{(t)} = \gamma_{16}\ FELH_{17}^{(t)} + FPN_{29}^{(t)}$$

$$KAPIG_{4}^{(t)} = FPN_{30}^{(t)} + FPN_{31}^{(t)}$$

The wastes in meat processing are determined as follows:

$$KAPIG_{5}^{(t)} = FPN_{29}^{(t)}$$

$$KAPIG_{16}^{(t)} = FELH_{17}^{(t)}$$

If

$$(KAPT_{5}^{(t)} < KAPIG_{5}^{(t)}$$

then

$$FPN_{34}^{(t)} = \gamma_{16} \cdot KAPT_{5}^{(t)}$$

$$FELH_{29}^{(t)} = \gamma_{16} \cdot KAPT_{5}^{(t)}$$

If

$$(KAPT_{5}^{(t)} \geq KAPIG_{5}^{(t)}$$

then

$$FPN_{34}^{(t)} = \gamma_{16} \cdot FPN_{29}^{(t)}$$

$$FELH_{29}^{(t)} = FPN_{29}^{(t)}$$

d. Dairy industry:

$$FELH_{13}^{(t)} = SPA_{13}^{(t)} + HP_{13}^{(t)} - TCS_{13}^{(t)}$$

$$FPN_{35}^{(t)} = \gamma_{17} \cdot FELH_{13}^{(t)}$$

$$FPN_{36}^{(t)} = \gamma_{18} \cdot FELH_{13}^{(t)}$$

$$KAPIG^{(t)} = FPN_{35}^{(t)}$$

$$KAPIG_{8}^{(t)} = FPN_{36}^{(t)}$$

e. Feed industry:

The modelling of this branch required a more complicated procedure. First the production of protein feeds is calculated:

$$Y_{1}^{(t)} = KEVTI^{(t)} + HD_{7}^{(t)} - STAKG^{(t)} - SKUK^{(t)} - HD_{14}^{(t)} - HD_{15}^{(t)}$$

$$FPN_{37}^{(t)} = FPN_{34}^{(t)} + FPN_{25}^{(t)} + FPN_{36}^{(t)} .$$

If

$$(FPN_{37}^{(t)} + S_{37}^{(t-1)} - Y_{1}^{(t)}) > \phi ,$$

then

$$FELH_{20}^{(t)} = \phi .$$

otherwise

If

$$(FPN_{37}^{(t)} + S_{37}^{(t-1)} + FPN_{20}^{(t)} + S_{20}^{(t-1)} - Y_{1}^{(t)} > 0 ,$$

then

$$FELH_{20}^{(t)} = Y_{1}^{(t)} - FPN_{37}^{(t)} - S_{37}^{(t-1)} .$$

If

$$(FPN_{37}^{(t)} + S_{37}^{(t-1)} + FPN_{20}^{(t)} + S_{20}^{t-1} - Y1) \geq \phi \quad ,$$

then

$$FELH_{20}^{(t)} = FPN_{20}^{(t)} + S_{20}^{(t-1)} \quad .$$

$$FELH_{34}^{(t)} = FPN_{34}^{(t)}$$

$$FELH_{25}^{(t)} = FPN_{25}^{(t)}$$

$$FELH_{36}^{(t)} = FPN_{36}^{(t)}$$

$$FPN_{37}^{(t)} = FPN_{37}^{(t)} + FELH_{20}^{(t)}$$

The production of feed-mix is described as follows:

If

$$(HD_{14}^{(t)} + STAKG^{(t)} > FPN_{23}^{(t)}$$

then

$$\begin{cases} FELH_{2}^{(t)} = HD_{14}^{(t)} + STAKG^{(t)} - FPN_{23}^{(t)} \\ FELH_{23}^{(t)} = FPN_{23}^{(t)} \end{cases}$$

If

$$(HD_{14}^{(t)} + STAKG^{(t)} \leq FPN_{23}^{(t)}$$

then

$$FELH_{2}^{(t)} = \phi$$

$$FELH_{23}^{(t)} = HD_{14}^{(t)} + STAKG^{(t)}$$

$$FELH_3^{(t)} = SKUK^{(t)} + HD_{15}^{(t)}$$

$$FPN_{38}^{(t)} = Y_1^{(t)} + FELH_2^{(t)} + FELH_3^{(t)} + FELH_{23}^{(t)}$$

$$FELH_{37}^{(t)} = Y_1^{(t)}$$

If

$$(Y_1^{(t)} - FPN_{37}^{(t)} - S_{37}^{(t-1)} > 0) \quad ,$$

then

$$X_1^{(t)} = Y_1^{(t)} - FPN_{37}^{(t)} - S_{37}^{(t-1)} \quad .$$

Otherwise

$$X_1^{(t)} = 0 \quad .$$

$$KEVTE^{(t)} = X_1^{(t)} \cdot \gamma_{20} + FELH_{34}^{(t)} \gamma_{19} + FELH_{25}^{(t)} \cdot \gamma_{20} + FELH_{36}^{(t)} \cdot \gamma_{21} \quad .$$

$$KAPIG_9^{(t)} = FPN_{38}^{(t)} \quad .$$

e. Sugar industry:

$$FELH_5^{(t)} = SPN_5^{(t)}$$

$$FPN_{39}^{(t)} = \gamma_{23} SPN_5^{(t)} + KAPT_{10}^{(t)}$$

$$FELH_3^{(t)} = FELH_3^{(t)} + \frac{1}{\gamma_{24}} KAPT_{10}^{(t)}$$

$$KAPIG_{11}^{(t)} = \gamma_{23} SPN_5^{(t)}$$

f. Canning industry:

$$FELH_{10}^{(t)} = SPN_{10}^{(t)} + HP_{10}^{(t)} - PTC_{10}^{(t)} - PTCG_{10}^{(t)} - TCS_{10}^{(t)}$$

$$FPN_{40}^{(t)} = \gamma_{25} FELH_{10}^{(t)} \quad .$$

$$FELH_{8}^{(t)} = SPN_{8}^{(t)} + HP_{8}^{(t)} - PTC_{8}^{(t)} - PTCG_{8}^{(t)} - TCS_{8}^{(t)}$$

$$FPN_{41}^{(t)} = \gamma_{26}\ FELH \quad .$$

$$KAPIG_{12}^{(t)} = FPN_{40}^{(t)} + FPN_{41}^{(t)} \quad .$$

g. Wine industry:

$$FELH_{11}^{(t)} = SPN_{11}^{(t)} + (1 - \alpha_4) HP_{11}^{(t)} - PTC_{11}^{(t)} - PE_{11}^{(t)} - PTCG_{11}^{(t)} \quad .$$

$$FPN_{42}^{(t)} = \gamma_{27} FELH_{11}^{(t)}$$

$$KAPIG_{13}^{(t)} = FPN_{42}^{(t)}$$

h. Other food processing:

$$FPN_{43}^{(t)} = (1 + \alpha_5) FPN_{43}^{(t-1)}$$

$$FELH_{22}^{(t)} = \gamma_{28}\ FPN_{43}^{(t)}$$

$$FELH_{33}^{(t)} = \gamma_{29}\ FPN_{43}^{(t)}$$

$$FELH_{39}^{(t)} = \gamma_{30}\ FPN_{43}^{(t)}$$

$$FELH_{42}^{(t)} = \gamma_{31}\ FPN_{43}^{(t)}$$

$$FELH_{9}^{(t)} = \gamma_{32}\ FPN_{43}^{(t)}$$

$$KAPIG_{14}^{(t)} = FPN_{43}^{(t)}$$

After the program of production, the unit production costs are calculated using commodity specific rules as follows:

$$wf^{(t)} = (1 + t^{wa}) \; w^{p(t)}$$

$$OKT_{22}^{(t)} = (p_1^{pr(t)} \; FELH_1^{(t)} + wf^{(t)} m_1 \; FELH_1^{(t)} + drp_1 \; RF_1^{(t)} +$$

$$+ AKT_1^{(t)} - p_{23}^{pr(t)} \; FPN_{23}^{(t)})/FPN_{22}^{(t)} \quad .$$

$$OKT_{23}^{(t)} = p_{23}^{pr(t)} \; .$$

$$OKT_{24}^{(t)} = (p_{24}^{pr(t)} \; FELH_4^{(t)} + drp_2 RF_2^{(t)} + wf^{(t)} m_2 \; FELH_4^{(t)}$$

$$+ AKT_2^{(t)} - p_{25}^{pr(t)} \; FPN_{25}^{(t)}/FPN_{24}^{(t)} \; .$$

$$OKT_{25}^{(t)} = p_{25}^{pr(t)} \; .$$

$$OKT_{26}^{(t)} = (p_{12}^{pr(t)} \; FELH_{12}^{(t)} + wf^{(t)} m_3 \; FELH_{12}^{(t)} + \frac{FELH_{12}^{(t)}}{KAPIG_3^{(t)}} \; (drp_3 RF_3^{(t)}$$

$$+ AKT_3^{(t)}/FPN_{26}^{(t)} \; .$$

$$OKT_{27}^{(t)} = ((p_{14}^{pr(t)} + wf^{(t)} m_3) \; FELH_{14}^{(t)}$$

$$+ \frac{FELH_{14}^{(t)}}{KAPIG_3^{(t)}} \; (drp_3 RF_3^{(t)} + AKT_3^{(t)}))/FPN_{27}^{(t)} \; .$$

$$OKT_{28}^{(t)} = ((p_{15}^{pr(t)} + wf^{(t)} m_3) \; FELH_{15}^{(t)} + \frac{FELH_{15}^{(t)}}{KAPIG_3^{(t)}} \; (drp_3 RF_3^{(t)}$$

$$+ AKT_3^{(t)}))/FPN_{28}^{(t)} \; .$$

$$OKT_{30}^{(t)} = (p_{26}^{pr(t)} \; FELH_{26}^{(t)} + p_{27}^{pr(t)} \; \alpha_3 \; FELH_{27}^{(t)} + wf^{(t)} m_4 \; FPN_{30}^{(t)}$$

$$+ \frac{FPN_{30}^{(t)}}{KAPIG_4^{(t)}} \; (drp_4 \; RF_4^{(t)} + AKT_4^{(t)}))/FPN_{30}^{(t)}$$

$$OKT_{31}^{(t)} = (p_{27}^{pr(t)} \ (1 - \alpha_3) \ FELH_{27}^{(t)} + wf^{(t)} m_4 \ FPN_{31}^{(t)} + \frac{FPN_{31}^{(t)}}{KAPIG_4^{(t)}} \ (drp_4 RF_4^{(t)} + AKT_4^{(t)}))/FPN_{31}^{(t)} \ .$$

$$OKT_{32}^{(t)} = (p_{17}^{pr(t)} \ FELH^{(t)} + wf^{(t)} m_6 \ FELH_{17}^{(t)} + drp_6 RF_6^{(t)} + + \frac{p_{32}^{pr(t)} \ FPN_{32}^{(t)}}{p_{32}^{pr(t)} \ FPN_{32}^{(t)} + p_{33}^{pr(t)} \ FPN_{33}^{(t)}} \ AKT_6^{(t)})/FPN_{32}^{(t)} \ .$$

$$OKT_{33}^{(t)} = (p_{18}^{pr(t)} \ FELH_{18}^{(t)} + \frac{p_{33}^{pr(t)} \ FPN_{33}^{(t)}}{p_{32}^{pr(t)} \ FPN_{32}^{(t)} + p_{33}^{pr(t)} \ FPN_{33}^{(t)}} \ AKT_6^{(t)}) /FPN_{33}^{(t)} \ .$$

$$OKT_{34}^{(t)} = (wf^{(t)} m_5 \ FELH_{29}^{(t)} + drp_5 RF_5^{(t)} + AKT_5^{(t)})/FPN_{34}^{(t)}$$

$$X_1^{(t)} = \frac{p_{35}^{pr(t)} \ FPN_{35}^{(t)}}{p_{35}^{pr(t)} \ FPN_{35}^{(t)} + p_{36}^{pr(t)} \ FPN_{36}^{(t)}}$$

$$OKT_{35}^{(t)} = (p_{13}^{pr(t)} \ FELH_{13}^{(t)} \ X \ 1 + wf^{(t)} m_7 \ FPN_{35}^{(t)} + + drp_7 RF_7^{(t)} + AKT_7^{(t)})/FPN_{35}^{(t)} \ .$$

$$OKT_{36}^{(t)} = (p_{13}^{pr(t)} \ FELH_{13}^{(t)} \ (1-X_1^{(t)}) + wf^{(t)} m_8 \ FPN_{36}^{(t)} + drp_8 \ RF_8^{(t)} + AKT_8^{(t)})/FPN_{36}^{(t)} \ .$$

$$OKT_{37}^{(t)} = (p_{34}^{pr(t)} \ FPN_{34}^{(t)} + p_{25}^{pr(t)} \ FPN_{25}^{(t)} + p_{36}^{pr(t)} \ FPN_{36}^{(t)} + p_{20}^{pr(t)} \ FELH_{20}^{(t)})/FPN_{37}^{(t)} \ .$$

$$OKT_{38}^{(t)} = (FELH_{37}^{(t)} \ p_{32}^{pr(t)} + p_{23}^{pr(t)} \ FELH_{23}^{(t)} + p_2^{pr(t)} \ FELH_2^{(t)} + p_3^{pr(t)} \ (FELH_3^{(t)} - \frac{1}{\gamma_{24}} \ KAPT_{10}^{(t)}) + wf^{(t)} m_9 \ FPN_{38}^{(t)} + drp_9 \ RF_9^{(t)} + AKT_9^{(t)})/FPN_{38}^{(t)} \ .$$

$$OKT_{39}^{(t)} = (p_5^{pr(t)} \; SPN_5^{(t)} + p_3^{pr(t)} \; \frac{1}{\gamma_{24}} \; KAPT_{10}^{(t)} +$$

$$+ wf^{(t)})m_{10} \; KAPT_{10}^{(t)} + m_{11} \; KAPIG_{11}^{(t)}) +$$

$$+ drp_{10} RF_{10}^{(t)} + drp_{11} \; RF_{11}^{(t)} + AKT_{10}^{(t)}$$

$$+ AKT_{11}^{(t)})/FPN_{39}^{(t)} \; .$$

$$OKT_{40}^{(t)} = (p_{10}^{pr(t)} \; FELH_{10}^{(t)} + wf^{(t)} m_{12} \; FPN_{40}^{(t)} +$$

$$+ \frac{FPN_{40}^{(t)}}{KAPG_{12}^{(t)}} \; (drp_{12} \; RF_{12}^{(t)} + AKT_{12}^{(t)}))/FPN_{40}^{(t)}$$

$$OKT_{41}^{(t)} = (p_8^{pr(t)} \; FELH_8^{(t)} + wf^{(t)} m_{12} \; FPN_{41}^{(t)} + \frac{FPN_{41}^{(t)}}{KAPKG_{12}^{(t)}} (drp_{12} \; RF_{12}^{(t)} +$$

$$+ AKT_{12}^{(t)}))/FPN_{41}^{(t)} \; .$$

$$OKT_{42}^{(t)} = (p_{11}^{pr(t)} \; FELH_{11}^{(t)} + wf^{(t)} m_{13} \; FPN_{42}^{(t)} + drp_{13} \; RF_{13}^{(t)} +$$

$$+ AKT_{13}^{(t)})/FPN_{42}^{(t)} \; .$$

$$OKT_{43}^{(t)} = (p_{22}^{pr(t)} \; FELH_{22}^{(t)} + p_{33}^{pr(t)} \; FELH_{33}^{(t)} + p_{39}^{pr(t)} \; FELH_{39}^{(t)} +$$

$$+ p_{42}^{pr(t)} \; FELH_{42}^{(t)} + p_9^{pr(t)} \; FELH_g^{(t)} +$$

$$+ drp_{14} \; RF_{14}^{(t)} + AKT_{14}^{(t)})/FPN_{43}^{(t)} \; .$$

Finally, the financial consequences of the given food processing activities are calculated.

a. Labour requirement and expenses:

$$PLF^{(t)} = m_2 \; FELH_1^{(t)} + m_2 \; FELH_4^{(t)} + m_3(FELH_{12}^{(t)} + FELH_{14}^{(t)} + FELH_{15}^{(t)})$$

$$+ m_4 \; (FPN_{30}^{(t)} + FPN_{31}^{(t)} + m_5 \; FELH_{29}^{(t)} + m_6 \; FELH_{17}^{(t)}$$

$$+ m_7 \; FPN_{35}^{(t)} + m_8 \; FPN_{36}^{(t)} + m_9 \; FPN_{38}^{(t)} + m_{10} \; KAPT_{10}^{(t)}$$

$$+ m_{11}\ KAPIG_{11}^{(t)} + m_{12}\ (FPN_{40}^{(t)} + FPN_{41}^{(t)}) + m_{13}\ FPN_{42}^{(t)}$$

$$+ m_{14}\ FPN_{43}^{(t)} \quad .$$

$$_{w}p^{(t)} = {}_{w}p^{(t-1)}(1 + o^{(t)}) \quad .$$

$$WEP^{(t)} = {}_{w}p^{(t)}\ PLF^{(t)}$$

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

b. Other expenses:

$$DEP^{(t)} = \sum_{i=1}^{14} drp_i\ RF_i^{(t)}$$

$$MEPS^{(t)} = \sum_{i=1}^{21} p_i^{pr(t)}\ FELH_i^{(t)}$$

$$MEPP^{(t)} = \sum_{i=22}^{43} p_i^{pr(t)}\ FELH_i^{(t)}$$

$$MEPI^{(t)} = \sum_{k=1}^{14} AKT_i^{(t)}$$

$$MEP^{(t)} = MEPS^{(t)} + MEPP^{(t)} + MEPI^{(t)}$$

c. Gross production value:

$$PAP^{(t)} = \sum_{i=22}^{43} p_i^{pr(t)}\ FPN_i^{(t)}$$

d. Net income of food processing:

$$INCP^{(t)} = PAP^{(t)} - \sum_{i=22}^{43} FPN_i^{(t)} \cdot OKT_i^{(t)} \quad .$$

Rest of the Economy

The non-food production part of the economy is modelled in an aggreggated way. In HAM-2, the so-called nth commodity (commodity 46 in our commodity classification) represents the rest of the economy including industrial production and all types of services. The scale of the nth sector is determined by the available labor and assets as follows:

$$P_n^{(t)} = \alpha_6 \left(NLF^{(t)}\right)^{\alpha_7} \left(RN^{(t)}\right)^{\alpha_8}$$

The available labor force is calculated as the rest of the total working population:

$$LAF^{(t)} = SLF^{(t)} + PLF^{(t)}$$

$$NLF^{(t)} = wp^{(t)} - LAF^{(t)}$$

In connection with the scale of activites in the rest of the economy, the related production expenses are also calculated:

$$WEN^{(t)} = w^{n(t)} \; NLF^{(t)}$$

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

$$DEN^{(t)} = drn \; RN^{(t)}$$

$$MEN^{(t)} = p_n^{pr(t)} \alpha_{nn}^{n(t)} \; P_n^{n(t)}$$

Investment Decisions of Producing Enterprises

Firms: The investment programs of agricultural and food processing firms are determined here. Similar principles are applied in the case of government investments, but the replacement of equipment which has depreciated is also considered. The simulation algorithm of Module P-6 includes the following procedures:

1. First the replacement of aged production facilities are carried out. Replacement is scheduled if the utilization of the given resource exceeds the desired level and funds for replacement are available.

In agriculture:

If $\frac{SKAPIG_k}{SKAPT^{(t)}}$ > ups, and the value of the depreciated equipment is equal to $dds_k\ RS_k^{(t)}$:

$$POT_k^{(t)} = dds_k\ RS_k^{(t)} .$$

Investment is scheduled if $INS^{(t)} \geq POT_k^{(t)}$. Obviously, available funds are adjusted after scheduling each type of replacement:

$$INS^{(t)} = INS^{(t)} - POT_K^{(t)} .$$

(The outline of the procedure can be seen in Figure 12).

In food processing:

If $\frac{KAPIG_k^{(t)}}{KAPT_k^{(t)}}$ > upp, and the value of the depreciated equipment is equal to $ddp_k > RF_k^{(t)}$:

$$POT_{k+12}^{(t)} = ddp_k \cdot RF_k^{(t)} .$$

Investment is scheduled if $INP^{(t)} \geq POT_{(k+12)}^{(t)}$. Available funds are updated in a similar way to those of agriculture as follows:

$$INP^{(t)} = INP^{(t)} - POT_{(k+12)}^{(t)} .$$

2. The new investments in agriculture are scheduled on the basis of shadow prices generated by the producer's decision LP model in Module P2. Therefore, only the fully utilized resources are considered as candidates for new investments. The resources with greater shadow prices have priority when the investment funds are distributed. In a similar way to government investment, for each investment option the scale of the investment is fixed as a preliminary measure and at first only one unit is scheduled. The allocation of investment funds

continues in this way, one additional investment unit being scheduled each time until the whole of the available funds are utilized. (An overview of the calculations is given in Figure 12).

3. The new investments in food processing are scheduled on the basis of the rate of resource utilization. New investments might be planned if:

$$\frac{KAPIG_k^{(t)}}{KAPT_k^{(t)}} \geq uip$$

then:

$$SPRI_{(k+12)}^{(t)} = \frac{KAPIG_k^{(t)}}{KAPT_k^{(t)}}$$

The resource with the larger $SPRI_{(k+12)}^{(t)}$ coefficient has priority. Similarly to agricultural investments the investments in food processing are planned by investment units starting from the resource with the highest priority, scheduling one unit each time until all the available funds are utilized.

As far as financial funds are concerned, the firm's investments are based on the enterprise's own resources and government subsidies. Because of fixed domestic producer prices, it is possible to calculate the enterprise's own investment funds before solving CT Block. The amount of government subsidies generated in the GM-P Block is subject to further adjustment in the CT Block as a means by which to reach balance of trade equilibrium. Investments planned according to target values for government subsidies should, therefore, also be further modified. To avoid this additional step, Module P-6 has actually been solved as a part of Block CT in HAM-2 when the final amounts of government subsidies are available and the final investment program can be calculated immediately.

Consumption and Trade Block

The Consumption and Trade Block plays a very important role in the operation of the whole system. The private and Government consumption as well as the countries' reactions to changing world market conditions are modelled by three modules.

Committed Demand (CT-1)

The first step in Module CT-1 is, on the basis of former model elements, to calculate the so-called committed expenditures which cannot be further modified during the simulation of one specific year. A simple calculation is required to determine:

-- the gross production value, income and income utilization of the producing sectors (socialist agriculture, food processing, rest of the economy) including the total intermediate demands of production;
-- the earnings and committed expenditure including household farming of the population;
-- the Government's income from the population and producing firms and the committed expenditure of the government.

The major elements of committed demands may be broken down as follows:

Income and income utilization of socialist agriculture:

$$INCS^{(t)} = SAP^{(t)} - (LES^{(t)} + MES^{(t)} + DES^{(t)} + LTS^{(t)}) + IKTO^{(t)}$$

If $INCS^{(t)} < \phi$,

then

$$DEF^{(t)} = -INCS^{(t)}$$

$$INCS^{(t)} = \phi$$

Taxes paid by socialist agriculture:

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

Bonus paid by socialist agriculture to employee:

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

Investment funds of socialist agriculture

$$IFES^{(t)} = (1 - (t^{in,s(t)} + v^{s}))\,INCS^{(t)} + (1 - dc^{s(t)})\,DES^{(t)} + IFES^{(t-1)}$$

<u>Income and income utilization of food processing industry:</u>

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

If $INCP^{(t)} < \phi$,

then

$$DEP^{(t)} = DEF^{(t)} - INCP^{(t)}$$

$$INCP^{(t)} = \phi$$

Taxes paid by food processing firms:

$$TXP^{(t)} = t^{in,p(t)} + t^{wa}\ WEP^{(t)}$$

Bonus paid by food processing firms to employee:

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

Investment fund of food processing firms:

$$IFEP^{(t)} = (1 - (t^{in,p(t)} + v^{p}))\,INCP^{(t)} + (1 - dc^{p(t)})\,DEP^{(t)} + IFEP^{(t-1)}$$

<u>Income and income utilization of the rest of the economy:</u>

$$INCN^{(t)} = p_{n}^{pr(t)}\ p_{n}^{n(t)} - (MEN^{(t)} + LEN^{(t)} + DEN^{(t)})$$

If $INCN^{(t)} < \phi$,

then

$$DEP^{(t)} = DEF^{(t)} - INCN^{(t)}$$

$$INCN^{(t)} = \phi$$

Taxes paid by the rest of the economy:

$$TXN^{(t)} = t^{in,n(t)} \; INCN^{(t)} + t^{wa} \; WEN^{(t)}$$

Bonus paid by the rest of economy to employee

$$BN^{(t)} = \nu^{n} \; INCN^{(t)}$$

Investment fund:

$$IFEAN^{(t)} = (1 - (t^{in,n(t)} + v^{n}))INCN^{(t)} + \\ + (1 - dc^{n(t)}) \; DEN^{(t)} + IFEAN^{(t-1)}$$

<u>Income and income utilization of population:</u>

$$INCPO^{(t)} = WES^{(t)} + WEP^{(t)} + WEN^{(t)} + BS^{(t)} + BP^{(t)} + BN^{(t)}$$

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

Endowment of private consumers available for buying goods:

$$TPE^{(t)} = INCPO^{(t)} - TXPO^{(t)} - ASP^{(t)} + (1 - t^{in,h})INH^{(t)} \\ + GSP^{(t)}$$

$$CPE^{(t)} = \frac{1}{t_p^{(t)}} \; TPE^{(t)}$$

Savings function of population:

$$ASP^{(t)} = aspi \cdot INCPO^{(t)}$$

Population social benefits (e.g. pension) from government:

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

Government's income from taxes and centralized amortization funds:

$$GT^{(t)} = TXS^{(t)} + TXP^{(t)} + TXN^{(t)} + TXPO^{(t)} + TXH^{(t)}$$

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

Finally, the gross and net national product for a given year can be calculated as follows:

$$GNPA^{(t)} = SAP^{(t)} + PAP^{(t)} + HAP^{(t)}$$

$$GNP^{(t)} = GNPA^{(t)} + p_{n}^{pr(t)} \ p_{n}^{(t)}$$

$$DESPN^{(t)} = DES^{(t)} + DEP^{(t)} + DEN^{(t)}$$

$$AGF^{(t)} = MES^{(t)} + MEP^{(t)} + MEN^{(t)} + MEH^{(t)} - 1KTO^{(t)}$$

$$NNP^{(t)} = GNP^{(t)} - AGF^{(t)} - DESPN^{(t)}$$

Growth rate of net national product:

$$ef^{(t)} = \frac{NNP^{(t)}}{NNP^{(t-1)}}$$

Modelling of Consumer's Demands (Module CT-2)

Module CT-2 is an important part of this model block and the whole model as well, describing the private consumption. The role of Module CT-2 is to determine the per capita consumer demands assuming that the endowment of consumers after deduction of savings is spent on buying various commodities.

The consumer demands toward a specific commodity are influenced by the prices and the level of endowment. In HAM-1 the demand for commodity i is described as follows:

$$CP_i^{(t)} = \frac{\rho_i^{(t)} \; CPE^{(t)}}{p_i^{c(t)}}$$

$$\rho_i^{(t)} > 0 \text{ and } \sum_i \rho_i^{(t)} = 1$$

where:

$CP_i^{(t)}$ = per capita demand for commodity i in period (t);

$CPE^{(t)}$ = per capita endowment of consumers in period (t);

$p_i^{c(t)}$ = consumer price of commodity i in period (t).

The $\rho_i^{(t)}$ parameters are determined in the model for each simulated year by using C.E.V. Leser's nonlinear demand model. Actually, the same demand system is used here as those in Module GM-P-2. Here, instead of plan targets on consumers income the final endowment of population is considered.

Exchange Module (Module CT-3)

Module CT-3 is a crucial part of the whole model, where the final level of private and government consumption as well as stocks satisfying balance of trade equilibrium conditions are determined. It is very important to underline that the reaction mechanism of domestic demands to new world market conditions (prices) is described here.

After some unsuccessful attempts with linear programming, based on Michiel Kayzer's suggestion, a relatively simple method has been developed to solve module CT-3.

In this module the so-called non-committed demands are determined which can be the subjects of further adjustment. The non-committed demand for a specific commodity consists of various elements; therefore, let q_{ih} express the h-th type of demand for commodity i. To reach a solution first we define a target level of the h-th demand of commodity i ($q_{ih}^{(t)}$) and introduce a vector (λ) which indicates the extent to which the targets are realized. Obviously the realization levels are constrained between two bounds:

$$\lambda^* \leq \lambda \leq \lambda^{**}$$

Let us assume that

y = vector of supply after the deduction of committed expenditures;

$p_i^{w(t)}$ = world market price of commodity i;

k = preliminary fixed balance of foreign trade.

The solution of moduel CT-3 is equal to the determination of such values of vector λ which satisfy:

$$p^w Q\lambda = p^w y + k$$

and

$$\lambda^* \leq \lambda \leq \lambda^{**}$$

and

Q is a matrix of non-committed demands.

During the solution procedure a strict preference ordering of various types of demands is followed. In case of changes in the world market prices a new λ vector has to be calculated. If no solution can be obtained, the λ^* and λ^{**} vectors have to be adjusted so that a solution can be reached. The calculating of vector λ is easily programmed. It is worthwhile to consider 1 as an initial value of λ_i. It is obvious that in case the target is realized, $\lambda_i \equiv 1$ and always $\lambda_i^* < 1$, $\lambda_i^{**} > 1$.

The module CT-3 of HAM-2 is based on this method. The supply after the deduction of demands related to committed expenditures which cannot be subjects of any further adjustments is given by former model modules. Using the symbol of the general model outline, the y vector related to HAM-2 is formulated as shown by Table 6.

The elements of Q matrix in HAM-2 can be seen on Table 7. The target values of noncommitted demands are determined as follows:

- -- As far as stocks are considered, so called optimal stocks are taken as target values. There optimal stocks are fixed exogenously.
- -- As the target value of direct government investments in food and agriculture the value of $PDGINA^{(t)}$ (planned direct government investments in food and agriculture) as determined in Module GM-P-1 is used. The target value of $GINN^{(t)}$ is calculated based on the value of $PAFN^{(t)}$ (planned capital accumulation of the rest of the economy) determined in Module GM-P-1 and $IFEAN^{(t)}$ (firm's investment fund in the rest of the economy).
- -- Targets on government subsidies to investments in agriculture and in food processings ($PGINSA^{(t)}$ $PGINSP^{(t)}$) are determined in GM-P-4 module as a part of determining government's investment
- -- The targets on consumption $PtG_i^{(t)}$ are fixed in the GM-P-2 module based on commodity specific trends.
- -- As targets are private consumption, the values of $TC_i^{(t)}$ related to consumer price for the given year and endowements calculated in module CT-1 determined by the non-linear demand system built in HAM-2 are used.

λ^* and λ^{**} express the extent of allowed deviation from target levels. For the various elements of α different λ^* and λ^{**} values are given, expressing the government objectives and policies in demand adjustment. Using the algorighm mentioned above, vector λ is determined and the final values of variables included in matrix Q can be calculated. Based on the elements of Q matrix the export-import vector is calculated:

$$EI_i^{(t)} = \sum_j q^{ij(t)} - y_i^{(t)}$$

If $EI_i^{(t)} \leq 0$ then $I_i^{(t)} = -EI_i^{(t)}$ and $E_i^{(t)} = 0$

If $EI_i^{(t)} \geq 0$ then $E_i^{(t)} = EI_i^{(t)}$ and $I_i^{(t)} = 0$

If $EI_i^{(t)} = 0$ then $E_i^{(t)} = 0$ and $I_i^{(t)} = 0$

Table 6. Supply vector (Y) in HAM-2*.

Stocks	Production	Household Production	Used in Processing	Inputs in Household Sector		Self Consumption		Supply vector Y
$+ S_1^{(t-1)}$	$+ SPA_{01}$	$+ HP_{01}$	$- FELH_{01}$	$- HD_8$				= 1
$+ S_2^{(t-1)}$	$+ SPA_{02}$		$- FELH_{02}$	$- HD_4$				= 2
$+ S_3^{(t-1)}$	$+ SPA_{03}$	$+ HP_{03}$	$- FELH_{03}$	$- HD_5$	$- HBF_3$			= 3
$+ S_4^{(t-1)}$	$+ SPA_{04}$		$- FELH_{04}$					= 4
	$+ SPA_{05}$		$- FELH_{05}$					= 5
	$+ SPA_{06}$	$+ HP_{06}$		$- HD_6$	$- HBF_6$			= 6
$+ S_7^{(t-1)}$	$+ SPA_{07}$	$+ HP_{07}$		$- HD_9$		$- TCS_7$		= 7
$+ S_8^{(t-1)}$	$+ SPA_{08}$	$+ HP_{08}$	$- FELH_{08}$			$- TCS_8$		= 8
$+ S_9^{(t-1)}$	$+ SPA_{09}$	$+ HP_{09}$	$- FELH_{09}$				- INFEL	= 9
$+ S_{10}^{(t-1)}$	$+ SPA_{10}$	$+ HP_{10}$	$- FELH_{10}$			$- TCS_{10}$		= 10
	$+ SPA_{11}$	$+ HP_{11}$	$- FELH_{11}$		$- HBF_{11}$	$- TCS_{11}$		= 11
	$+ SPA_{12}$	$+ HP_{12}$	$- FELH_{12}$					= 12
	$+ SPA_{13}$	$+ HP_{13}$	$- FELH_{13}$			$- TCS_{13}$		= 13
	$+ SPA_{14}$	$+ HP_{14}$	$- FELH_{14}$			$- TCS_{14}$		= 14
	$+ SPA_{15}$	$+ HP_{15}$	$- FELH_{15}$					= 15
	$+ SPA_{16}$	$+ HP_{16}$					- GYFEL	= 16
	$+ SPA_{17}$	$+ HP_{17}$	$- FELH_{17}$			$- TCS_{17}$		= 17
	$+ SPA_{18}$	$+ HP_{18}$	$- FELH_{18}$			$- TCS_{18}$		= 18
	$+ SPA_{19}$	$+ HP_{19}$				$- TCS_{19}$		= 19
$+ S_{20}^{(t-1)}$	$+ SPA_{20}$		$- FELH_{20}$					= 20
	$+ SPA_{21}$						- MTFEL	= 21
$+ S_{22}^{(t-1)}$	$+ FPA_{22}$							= 22
$+ S_{23}^{(t-1)}$	$+ FPA_{23}$							= 23
$+ S_{24}^{(t-1)}$	$+ FPA_{24}$							= 24

Table 6. Supply vector (Y) in HAM-2*.

Stocks	Production	Household Production	Used in Processing	Inputs in Household Sector	Self Consumption	Supply vector Y
	+ FPA_{25}					= 25
+ $S_{26}^{(t-1)}$	+ FPA_{26}					= 26
+ $S_{27}^{(t-1)}$	+ FPA_{27}					= 27
+ $S_{28}^{(t-1)}$	+ FPA_{28}					= 28
	+ FPA_{29}					= 29
+ $S_{30}^{(t-1)}$	+ FPA_{30}					= 30
+ $S_{31}^{(t-1)}$	+ FPA_{31}					= 31
+ $S_{32}^{(t-1)}$	+ FPA_{32}					= 32
+ $S_{33}^{(t-1)}$	+ FPA_{33}					= 33
	+ FPA_{34}					= 34
+ $S_{35}^{(t-1)}$	+ FPA_{35}					= 35
+ $S_{36}^{(t-1)}$	+ FPA_{36}					= 36
+ $S_{37}^{(t-1)}$	+ FPA_{37}					= 37
+ $S_{38}^{(t-1)}$	+ FPA_{38}		− KEVTI	− HD_7		= 38
+ $S_{39}^{(t-1)}$	+ FPA_{39}					= 39
+ $S_{40}^{(t-1)}$	+ FPA_{40}					= 40
+ $S_{41}^{(t-1)}$	+ FPA_{41}					= 41
+ $S_{42}^{(t-1)}$	+ FPA_{42}	+ HP_{42}			− TCS_{42}	= 42
+ $S_{43}^{(t-1)}$	+ FPA_{43}					= 43
+ $S_{44}^{(t-1)}$						= 44
+ $S_{45}^{(t-1)}$						= 45
+ $S_{46}^{(t-1)}$	+ P_n	$\alpha^n_{nn} p^{(t)}_n$	− $\frac{MESI}{p_n^{pr}}$	− $\frac{MEPI}{p_n^{pr}}$ − $\frac{MEHI}{p_n^{pr}}$	− $\frac{INS}{p_n^{pr}}$ − $\frac{INP}{p_n^{pr}}$ − $\frac{INN}{p_n^{pr}}$	= 46

*Symbols can be identified based on Table 4 and Appendix
Except stocks, all other variables in Table 7 are related to period (t).

Table 7. Non committed demands (Q) in HAM-2.

	Stocks			Investments				Community Consumption			Private Consumption		
	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	λ_7	λ_8	λ_9	λ_{10}	λ_{11}	λ_{12}	λ_{13}
1		S1											
2		S2											
3		S3											
4			S4										
5													
6													
7			S7							PTCG7			TC7
8			S8							PTCG8			TC8
9			S9										
10			S10							PTCG10			TC10
11										PTCG11			TC11
12													
13													
14													
15													
16													
17													
18													
19										PTCG19			TC19
20			S20										
21													
22			S22							PTCG22			TC22
23			S23										
24			S24							PTCG24			TC24
25													
26			S26							PTCG26			TC26
27			S27							PTCG27			TC27
28			S28										
29													
30			S30							PTCG30			TC30
31			S31							PTCG31			TC31
32			S32							PTCG32			TC32
33			S33							PTCG33			TC33
34													
35			S35							PTCG35			TC35
36			S36										
37			S37										
38			S38										
39		S39								PTCG39			TC39
40			S40							PTCG40			TC40
41			S41							PTCG41			TC41
42		S42							PTCG42			TC42	
43			S43							PTCG43			TC43
44		S44							PTCG44			TC44	
45		S45							PTCG45			TC45	
46	S46			PDGINA	GINN	PGINSA	PGINSP	PTCG46			TC46		

The final values of government investment subsidies $PGINSA^{(t)}$ and $PGINSP^{(t)}$ are also calculated. Based on the later information the investment program of the given year is finalized. Actually as it has already been mentioned, module P-6 is solved only at this moment having full and final knowledge on available investment funds.

Financial Account of a Given Year (Module CT-4)

As the state satisfying the balance of payment equilibrium condition has been reached in Module CT-3, in Module CT-4, the government budget and domestic financial consequences of the given product utilization structure are calculated.

exports, imports and consumer prices are calculated as follows:

$$TREP^{(t)} = \Sigma_i \ (dsp_i^{(t)} - p_i^{pr(t)}) \ E_i^{(t)}$$

$$TRIP^{(t)} = \Sigma_i \ (p_i^{pr(t)} - dsp_i^{w(t)}) \ I_i^{(t)}$$

$$TRCP^{(t)} = \Sigma_i \ (p_i^{c(t)} - p_i^{pr(t)}) \ TC_i^{(t)}$$

If $TREP^{(t)} < 0$ then $GES^{(t)} = -TREP^{(t)}$
and $TREP^{(t)} = 0$
$GES^{(t)} = 0$

$TRIP^{(t)} \leq 0$ then $GIS^{(t)} = -TRIP^{(t)}$

$TRCP^{(t)} < 0$ then $GCS^{(t)} = -TRCP^{(t)}$

The total tariff receipts of government:

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

The total amount of price subsidies of government:

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

Financial consequences of changes in stocks:

$$SDS^{(t)} = \sum_i \ p_i^{pr(t)} \ (S_i^{(t)} - S_i^{(t-1)})$$

$$SDP^{(t)} = \sum_f \ p_f^{pr(t)} \ (S_f^{(t)} - S_f^{(t-1)})$$

$$SDN^{(t)} = p_n^{(pr(t)} \ S_n^{(t)} - S_n^{(t-1)}$$

Total amount of investments in a given year:

$$TIN^{(t)} = SDS^{(t)} + SDP^{(t)} + SDN^{(t)} + TINS^{(t)} + TINP^{(t)} + PDGINA^{(t)} + PAFN^{(t)}$$

Income of government:

$$GI^{(t)} = GT^{(t)} + GD^{(t)} + GTRP^{(t)}$$

Expenditures of government:

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

Balance of government budget:

$$GISX^{(t)} = GI^{(t)} \quad GE^{(t)}$$

Balance of payment related to food and agriculture:

$$PBA^{(t)} = \Sigma_{i,} \quad p_i^{w(t)} \; EI_i^{(t)}$$

Analysis of Results, Revising Policy Instruments

After the final results are obtained for a given year based on an analysis of the performance of the whole system, some of the basic policy variables and instruments in the model are revised in Block GM-A (Economic Analysis of Government). By this part of the model, attempts have been made to describe one of the most complex elements of centrally planned food and agriculture systems. This is one of the first approaches thats ever been developed for modelling agricultural policy sphere in a centrally planned country. Actually in HAM-2, not the whole policy making sphere is endogenized. Based on interviews with high level officials and analysis of the present day practice, the basic policy structure and principles used in revising overall objectives and policy instruments have been outlined. These structures and principles are considered as given in the model and only their implementation is really modelled. The change of structure or in principles can be handled only by modifying the strucutre of the model.

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

First the overall performance of the system is analyzed in order to revise instruments controlling the growth of the whole economy as well as of those of its main branches. We assume that the major government objective to reach a desired growth of the economy basically are realised by changing the rate of investments in national income and shares of the major sectors in total investments.

In HAM-2 we assume that the desired path of growth,(lower and upper bounds within the actual growth, is considered as satisfactory) is given exogenously. The procedure described in module GM-A-1 starts with the calculation of the actual growth rates for the given period as follows;

--Growth of food and agriculture:

$$bf_1^{(t)} = \frac{\sum_{i=1}^{21} p_i^{(pr(t-1)} SPN_i^{(t)} + \sum_{f=22}^{43} p_i^{pr(t-1)} FPN_i^{(t)} + \sum_{i=1}^{19} p_i^{pr(t-1)} HP_i^{(t)} + p_{42}^{pr(t-1)} HP_{42}^{(t)}}{GNPA^{(t-1)}} - 1$$

--Growth of the rest of the econony:

$$bf_2^{(t)} = \frac{p_n^{pr(t-1)} \; p_n^{(t)}}{p_n^{pr(t-1)} \; p_n^{(t-1)}} - 1$$

--Share of sectors in total output

$$r_1^{(t-1)} = \frac{GNPA^{(t-1)}}{GNP^{(t-1)}}$$

$$r_1^{(t-1)} = 1 - r_1^{(t-1)}$$

--Growth of the whole economy:

$$af^{(t)} = r_1^{(t-1)} \cdot bf_1^{(t)} + r_2^{(t-1)} bf_2^{(t)}$$

The revision of instruments influencing overall growth depends upon the relation of actual growth situations to desired ones. We have to distinguish among situations when the overall growth is within the desired boundaries, when actual growth is less or higher than desired. In case the overall growth remains within the preliminary fixed lower and upper bounds, the growth of the economy is considered satisfactory and instruments are not revised. Otherwise adjustment takes place considering also the actual development of food and agriculture and the rest of the economy as well as their relation. On the whole, the GM-A-1 module consists of six basic cases of adjustments Figure 13 gives an overview of these cases).

CASE 1:

Overall growth is higher than desired, the development of the rest of the economy is also faster than desired. In this case, our objective is to decrease the growth of the rest of the economy, maintaining or increasing the rate of development in food and agriculture.

1/a. If actual investments exceeded plan targets, the income tax rates ($t^{in,n(t)}$) and centralized part of depreciation ($dc^{n(t)}$) are increased. If the development in agriculture is slower than desired the share of food and agriculture in total investments ($g^{(t)}$) is also increased.

1/b. If actual investments meet targets or remain below the target level, share of consumption national income ($f^{(t)}$) is increased. In case of unsatisfactory growth of food and agriculture, investments in this sector ($g^{(t)}$) are also increased.

CASE 2:

Overall growth is higher then desired with a similar situation in food and agriculture. Meanwhile the rate of development in the rest of the economy is satisfactory or less than desired. Similar to Case 1, the overall growth of the economy has to be decreased, maintaining or increasing the rate of growth in the rest of the economy.

2/a. If actual investments exceeds plan targets in food and agriculture, related income tax rates ($t^{in,s(t)}$, $t^{in,p(t)}$) and rate of centralized depreciation ($dc^{s(t)}$, $dc^{p(t)}$) are increased. In case of unsatisfactory development of the rest of the economy, investments in food and agriculture ($g^{(t)}$) are decreased.

2/b. If actual investments meet targets or are below the target level, the share of consumption in national income ($f^{(t)}$) is increased. In case of unsatisfactory growth of the rest of the economy , the share of food and agriculture in total investments ($g^{(t)}$ is decreased.

CASE 3

Overall growth is higher than the desired ones and both food and agriculture and the rest of the economy develope faster than desired, therefore, growth in both major sectors have to be limited.

3/a. If actual investments exceed targets in both major sectors, income tax rates ($t^{in,s(t)}$, $t^{in,p(t)}$ $t^{in,n(t)}$) and centralized parts of depreciation ($dc^{s(t)}$, $dc^{p(t)}$, $dc^{n(t)}$) are increased.

3/b. If actual investments are below the target level's share of consumption ($f^{(t)}$) in national income is increased.

CASE 4

The overall growth is below the desired level, the rest of the economy develops slowly also, while the rate of growth in food and agriculture is satisfactory or higher than desired. In this situation, the growth of the rest of the economy is stimulated in increasing investments.

4/a. If actual investments exceed targets, the share of investments in national income is increased ($f^{(t)}$ is decreased) and the share of the rest of the economy, in total investments, is also increased ($g^{(t)}$ is decreased).

4/b. If actual investments in the rest of the economy does not reach the target level income tax rate ($t^{in,n(t)}$) and the centralized part of the depreciation ($dc^{n(t)}$) in the n-th sector is decreased, the share of food and agriculture in total investments ($g^{(t)}$) might also be decreased.

CASE 5

The rate of overall growth is less than desired, similar to those of food and agriculture, meanwhile the growth in the rest of the economy is satisfactory or faster. In this situation, obviously, investments in food and agriculture are encouraged on the account of consumption and the rest of the economy.

5/a. If actual investments exceed target levels overall, consumption fund is decreased ($f^{(t)}$), and the share of food and agriculture in investments ($g^{(t)}$) is increased.

5/b. If the actual investments are below target level's income, tax rates ($t^{in,s(t)}$, $t^{in,p(t)}$) and centralized depreciation ($dc^{s(t)}$, $dc^{p(t)}$) are decreased. The share of food and agriculture in investments ($g^{(t)}$) is increased.

CASE 6

Besides slow overall growth, the rate of development both in the rest of the economy and in food and agriculture is below the desired level. In this situation, investment possibilities are enlarged for both sectors.

6/a. If actual investments are above target level's, the total investment fund is increased on the account of consumption ($f^{(t)}$ is decreased).

6/b. If actual investments do not reach target level's besides increasing the total investments fund, investment possibilities on firm level (increase tax rates $-t^{in,n(t)}$, $t^{in,s(t)}$, $t^{in,p(t)}$ and centralized depreciation $dc^{n(t)}$, $dc^{s(t)}$, $dc^{p(t)}$ are decreased) might also be increased.

The diagram presented on Figure 13 outlines the simulation procedure applied in Module GM-A-1: Symbols used are explained in Appendix No. 1.

Revision of Prices (Module GM-A-2 and GM-A-3)

Domestic prices in Hungary are not directly related to international prices, but certain impacts of world market prices upon producer and consumer prices can not be avoided. To develop

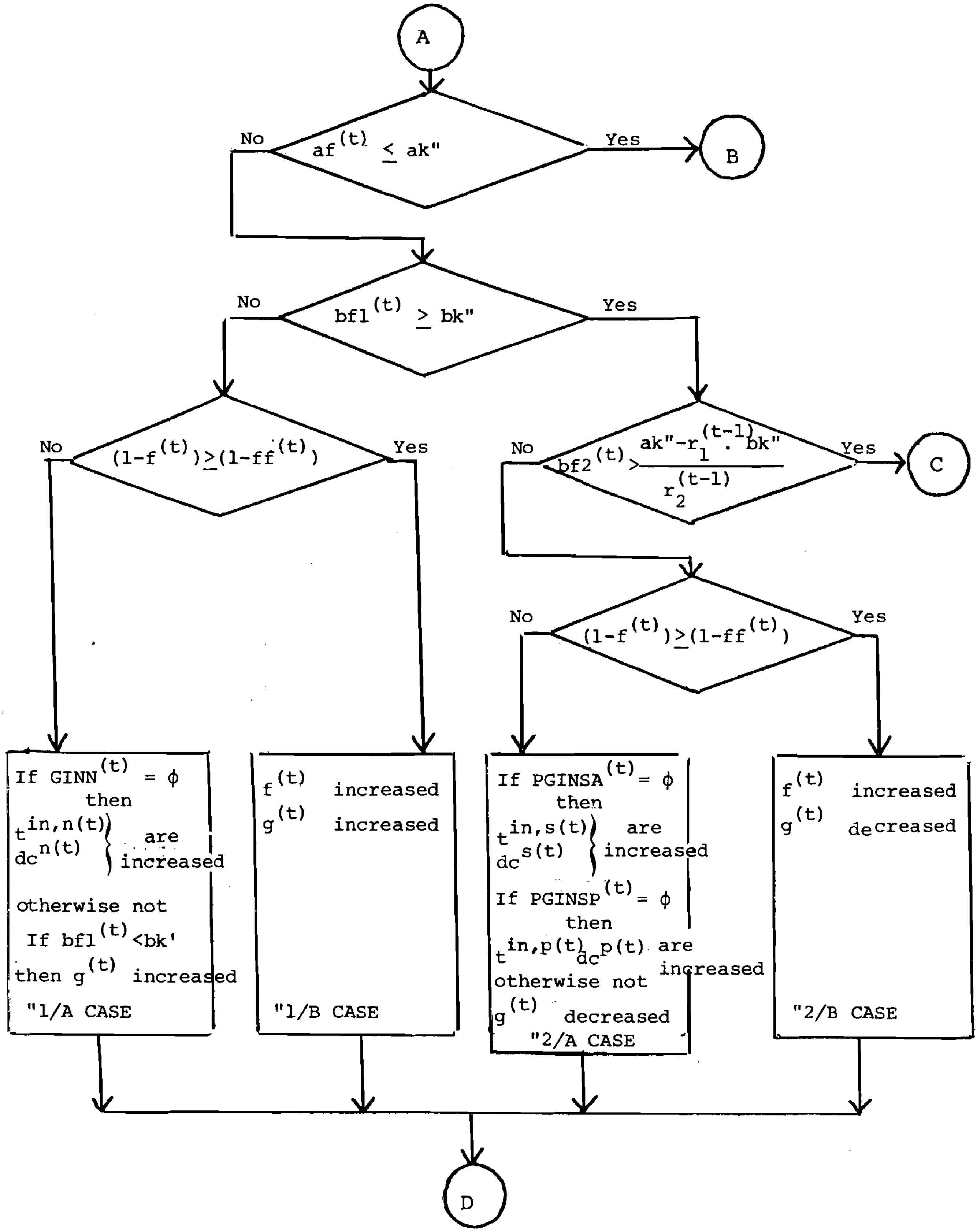

Figure 13. Revision of Basic Policy Veriables

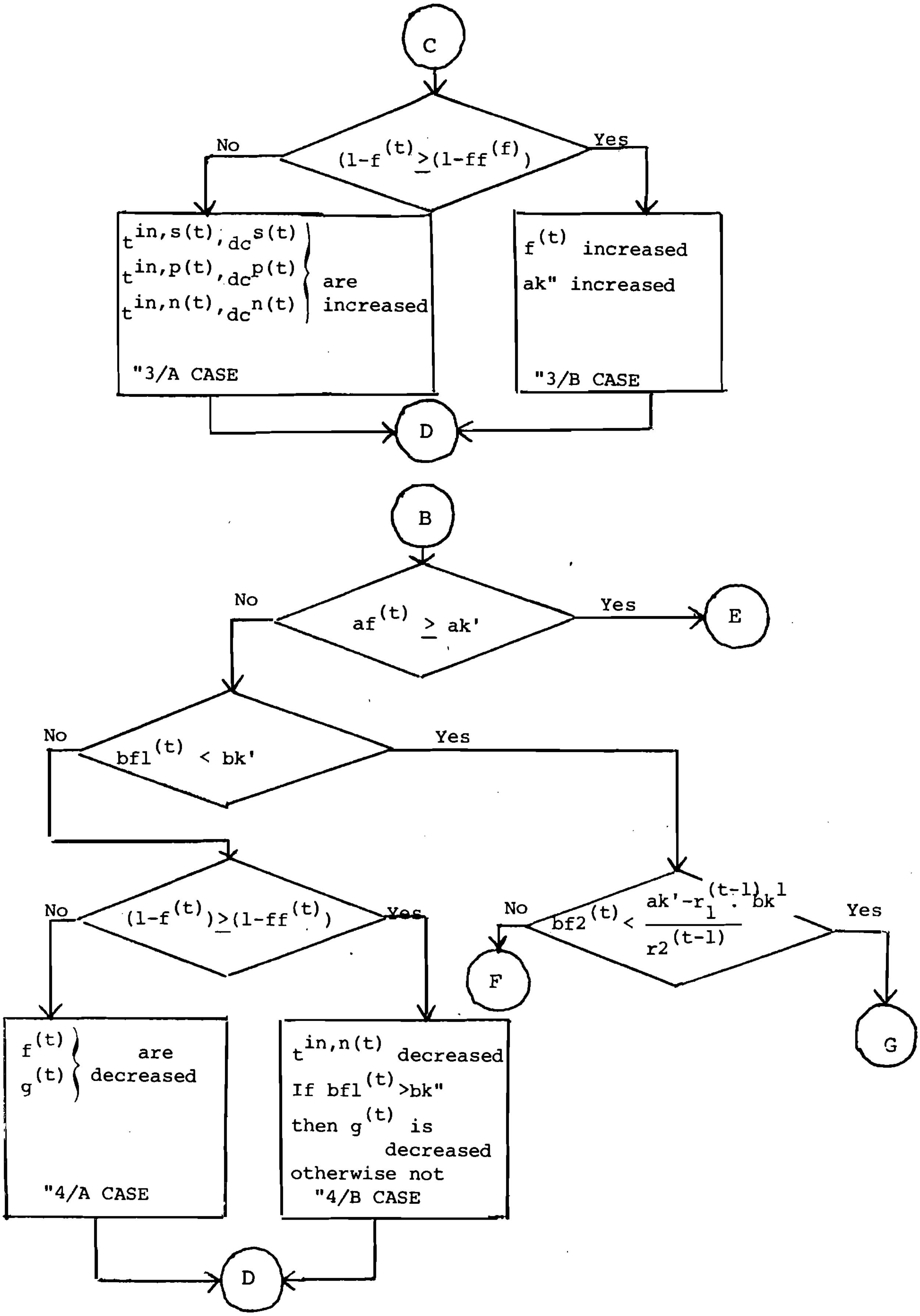

Figure 13 continued

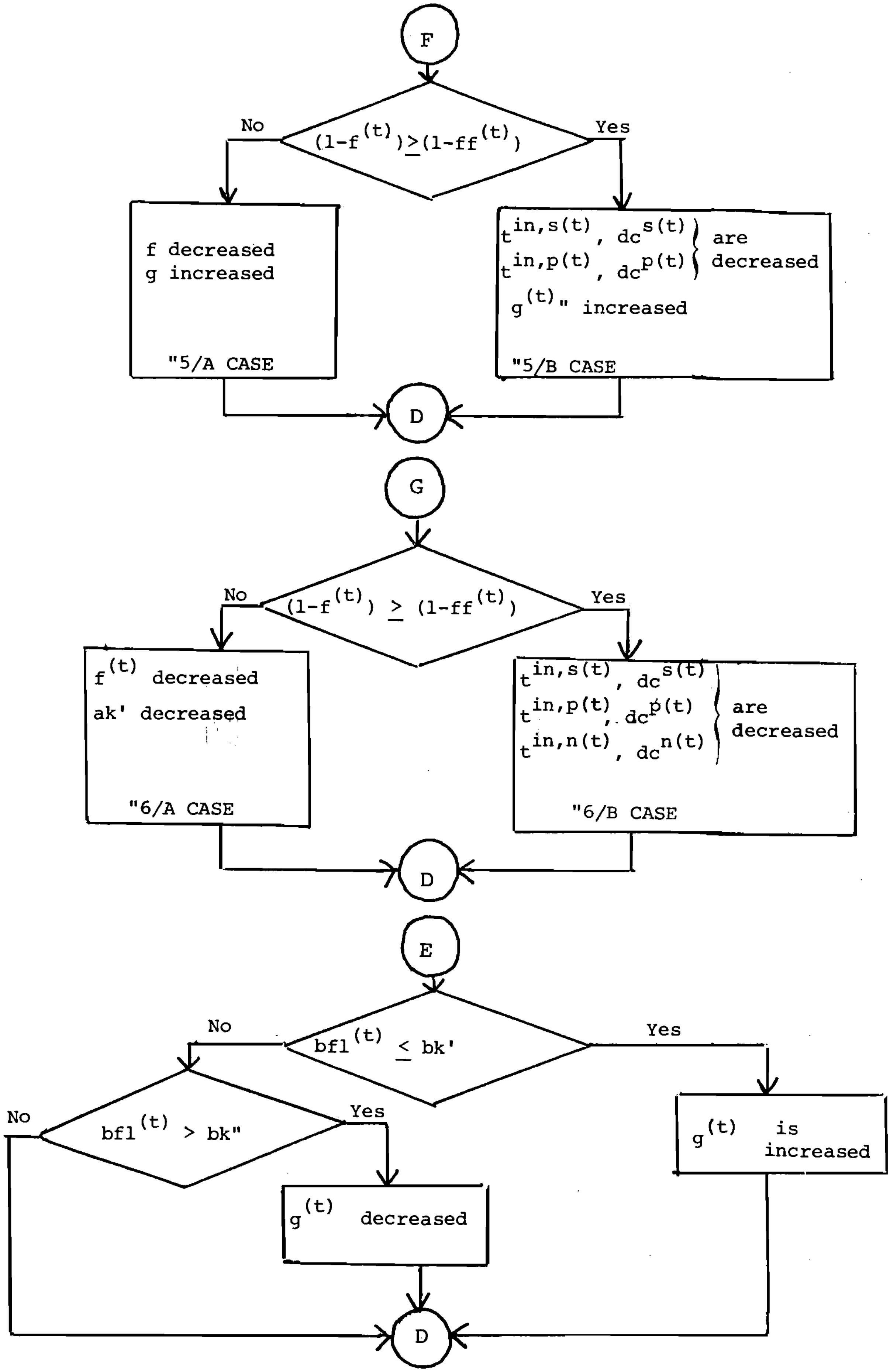

Figure 13 continued

Module GM-A-2 and 3, the rather complex system of pricing exists in Hungary at present has been studied. The pricing procedure included in HAM-2, we believe, explains the basic principles and logic of the Hungarian pricing system. But we are aware of the fact that actual pricing is very much commodity specific, influenced by the concret economic situation, and the application of major principles are very often lagged.

The revision of producer prices in HAM-2 is based on the comparison of plan targets settled in module GM-P-3, with actual production results for the given year. Price revision depends upon the extent of duration. The production expenses are also considered in price modification. (The simplified process of producer price revision is shown by Figure 14). Actually, production targets in GM-P-3 module are determined based on world market prices in the objective function, while actual production follows the domestic producer prices. World market prices have impact upon domestic producer prices through this indirect way.

In revising consumer prices, (GM-A-3), the so called desired strucutre of food consumption is used as a starting point. We assume that by changing consumer prices, government aims at meeting actual structure with the desired one. The desired structure of consumption is generated by using exogenously given trends. Consumer price might be modified if actual consumption of a given commodity deviates substantially from the desired level of consumption. In modifying consumer prices, the producer prices are also considered in order to keep the difference between consumer and producer prices of a given commodity within a certain limit. The process of revising consumer prices is outlined by Figure 15.

Updating Parameters (U.D.)

The last blocks of HAM-2, 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:

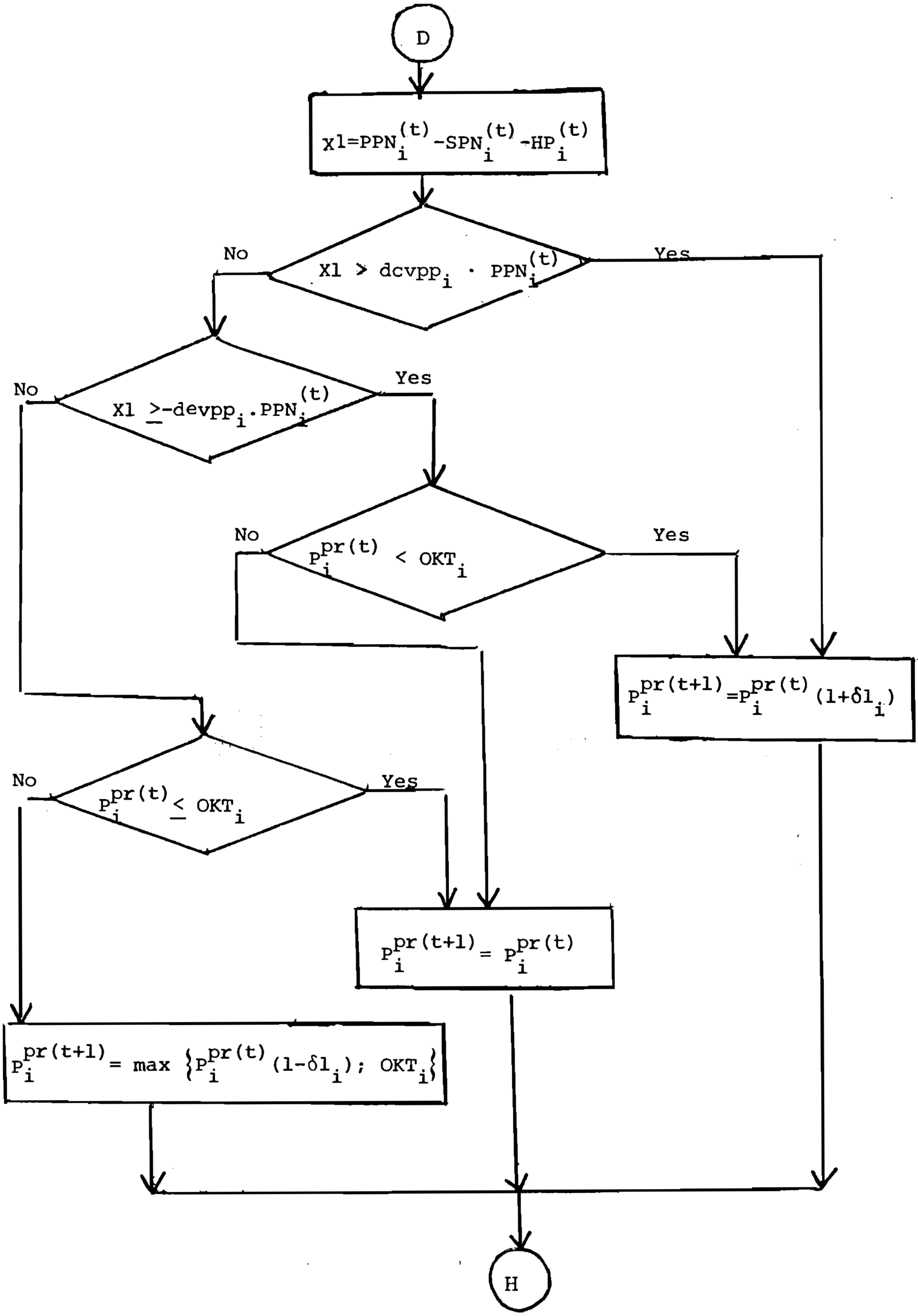

Figure 14. Process of producer's price revision

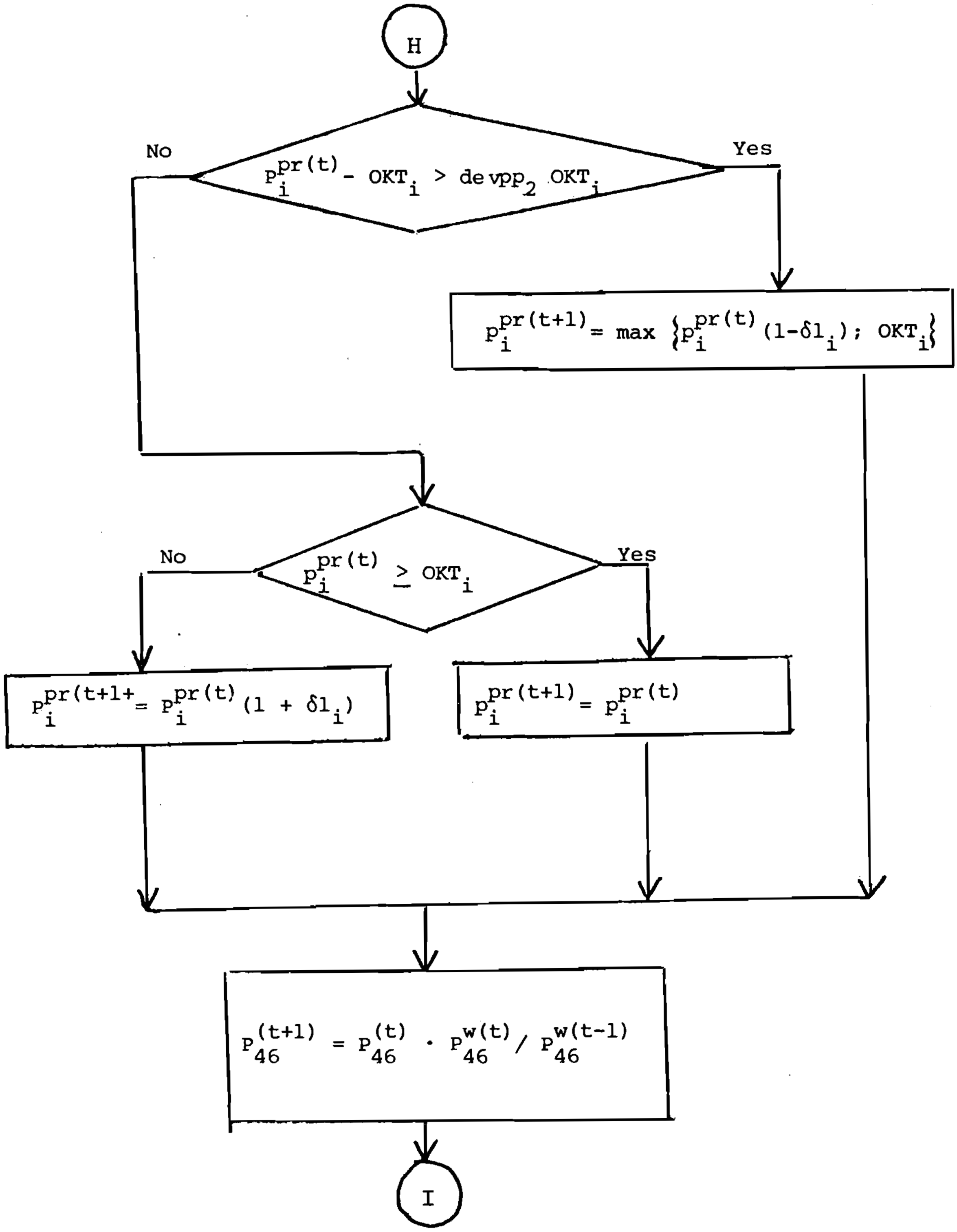

Figure 14 continued

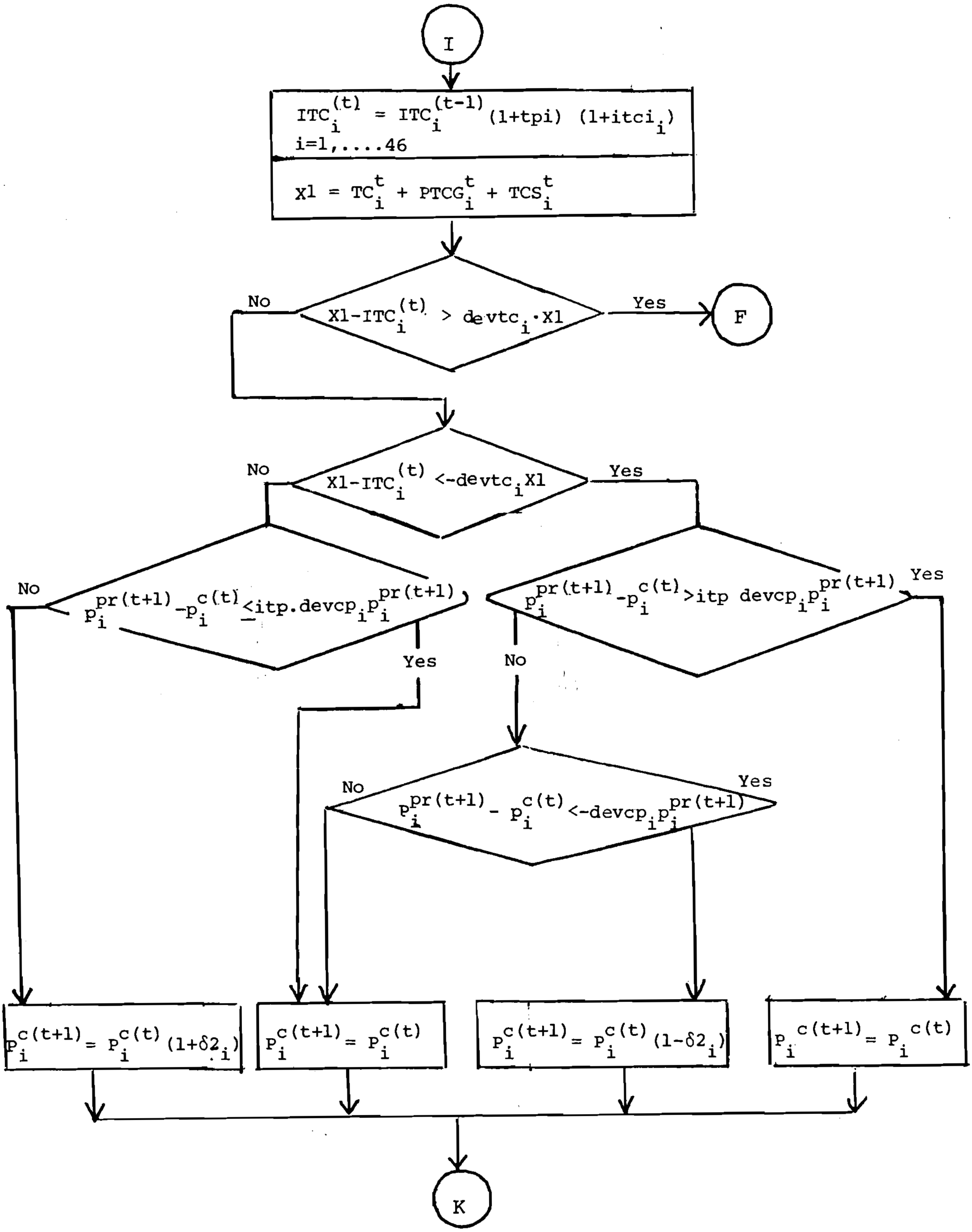

Figure 15. Revision of Consumer Prices

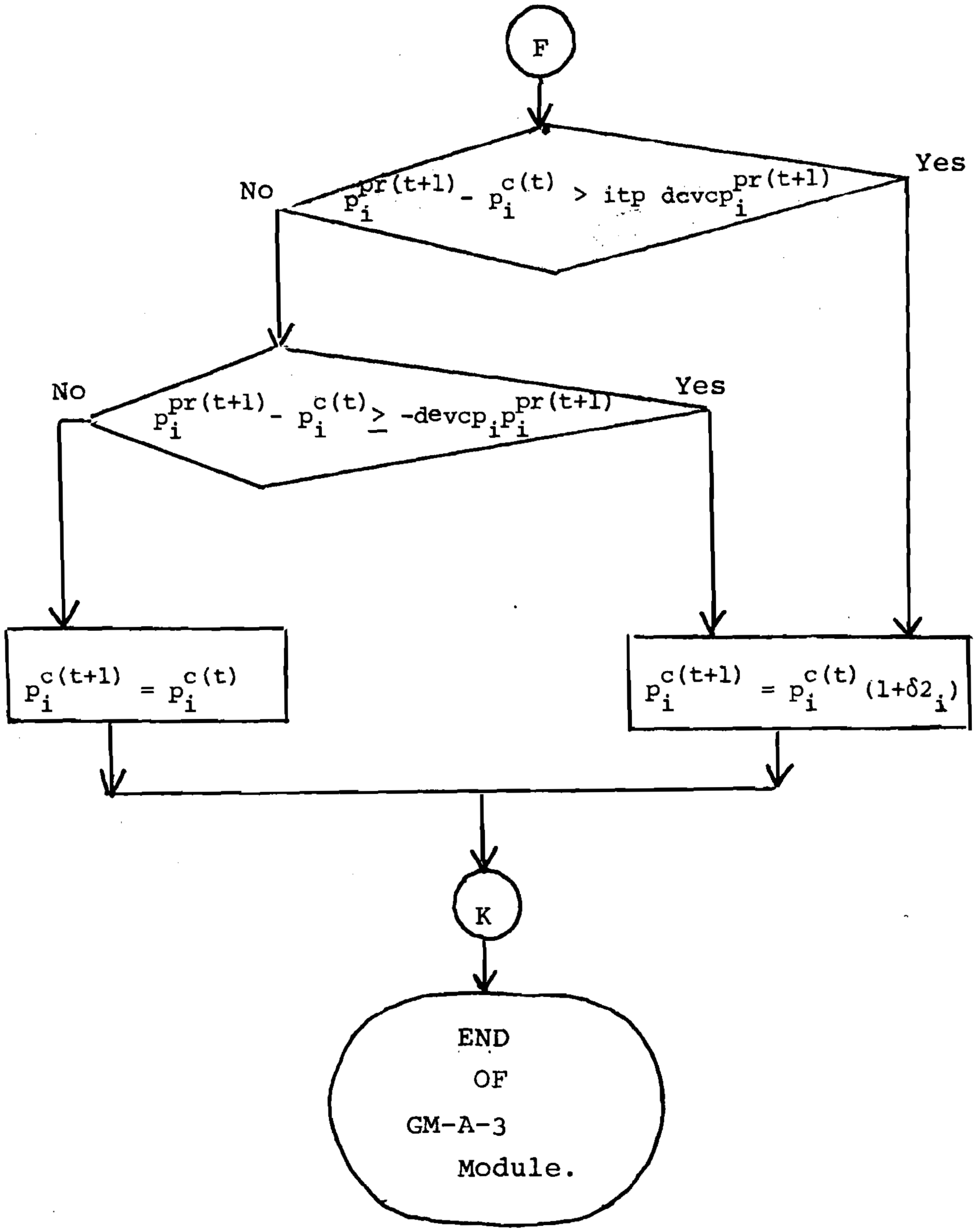

Figure 15 continued

-- calculation of demographic changes (UD-1)
-- updating of available land and physical resources (UD-2)
-- calculation of new parameters for GM-P-3 module (UD-3)
-- updatings of parameters for the Production Block (UD-4)

Demographic changes (UD-1)

HAM-2 does not include a demographic submodule. The available labor force, and changes in population are calculated from demographic prognosis 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 the agricultural labor force is considered. The available labor force in household and private sector is forcasted based on past trends.

The updating of the available labor force takes place actually based on the following three equations:

$$wp^{(t+1)} = wp^{(t)} (1 + wpi)$$

$$tp^{(t+1)} = tp^{(t)} (1 + tpi)$$

$$tWH^{(t+1)} = TWH^{(t)} (1 + wi)$$

Land and Physical Resources (UD-2)

The available land for agricultural purposes is modelled according to the socialist agriculture and household and private sector. Regular decrease of plow ands and meadows because of industrialization and urbanization is considered:

$$LS^{1(t+1)} = LS^{1(t)} (1 + lsi1)$$

$$LSR^{(t+1)} = LS^{2(t)} (1 + lsi2)$$

$$LSH^{(t+1)} = LSH^{(t)} (1 + lh)$$

The increase in physical resources is based on the investments of producing sectors as well as the government. Aged production facilities are obviously sorted out.

Fixed assets in the rest of the economy:

$$RN^{(t+1)} = RN^{(t)} - ddn\ RN^{(t)} + PAFN^{(t)}$$

Production facilities in agriculture

$$RS_i^{(t+1)} = RS_i^{(t)} (1 - dds_i) + POT_i^{(t)} + INV_i^{(t-ati(i))}$$

$$SKAPT_i^{(t+1)} = SKAPT_i^{(t)} (1 - dds_i) + (POT_i^{(t)} + INV_i^{(t-ati(i))}) / pks_i$$

$i = i,...,12$

Production facilities in food processing:

$$X1 = POT_{i+12}^{(t)} + INV_i^{(t-ati(i+12))}$$

$$RF_i^{(t+1)} - RF_i^{(t)} (1 - ddp_i) + X1$$

$$KAPT_i^{(t+1)} = KAPT_i^{(t)} (1 - ddp_i) + X1 / pkp_i$$

$i = 1,...,14$

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

Food and agriculture is described at an aggregated way by the GM-P-3 model. Technical coefficients of variables representing the production of different food and agricultural commodities are calculated based on the Production Block of the previous period as a weighted average of the various production options. The available resource and production facility capacities are taken from the UD-2 Module.

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

In agriculture the yields and output coefficients are calculated from functions estimated based on time series expressing the biological development in plant production and animal husbandry. These functions are given according to technologies. The inputs are determined from the projected yields and outputs. The fertilizer use is calculated from fertilizer response functions.

The 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 parameters related to investment decisions are updated based on time trends.

Appendix No. 1

LIST OF SYMBOLES

A		where it is determined
a	desired growth rate of GMP at constant price	Exogenous
$ADMS^{(t)}$	number of administrative staff in agriculture	P-3
$af^{(t)}$	actual growth rate of GNP at constant price	GMA-1
$AGF^{(t)}$	total material expenses in million Ft.	CT-1
ak', ak"	lower and upper bounds of desired growth of GNP	Exogenous
ak1	minimum value of ak'	Exogenous
ak2	maximum value of ak"	Exogenous
AKT_k	overhead expenses related to kth productions facility of food processing in million Ft.	UD-3
APH_i	unit output of the commiodity in household and private sector	Exogenous
ASP^t	new saving of populations in million ft.	CT-1
ati_k	time requirement of kth investment /k=1,...,26/	Exogenous

B		
b	desired growth rate of GNP in food and agriculture at constant price	Exogenous
$bf1^t$	actual growth rate of GNP in food and agriculture	GMA-1
bf2t	growth rate of gross production in rest of the economy at constant price	GMA-1
bk',bk"	lower and upper bound of desired growth rate of GNP in food and agriculture	Exogenous
BN^t	bonus paid by the rest of the economy in million ft.	CT-1
BP^t	bonus paid by food processing in million ft.	CT-1
BS^t	bonus paid by socialist agriculture in million ft.	CT-1

C

c^t	Planned decrease of allowed deficit of price balance of payment	Exogenous
$c1_{1-46}$, $c2_{1-46}$	parameters of demand system	Exogenous
$c3_{1-19}$, $c4_{1-19}$	perameters in supply function of household and private sector	Exogenous
CON^t	total value of goods bought by the population at constant price	CT-5
$CONP^t$	total value of goods bought by the population at producer price	CT-5
$CONS^t$	self consumption from products of household and privat forms at producer price	P-1
CPE^t	per capita endowment of consumers	CT-1

D

$dc^{n(t)}$	centralized part of amortization in the rest of the economy	GMA-1
$dc^{p(t)}$	centralized part of amortization in food processing	GMA-1
$dc^{s(t)}$	centralized part of amortization in socialist agriculture	GMA-1
ddn	rate of sorting out assets in rest of the economy	Exogenous
ddp_{1-14}	rate of sorting out assets in food processing	Exogenous
dds_{1-12}	rate of sorting out assets in socialist agriculture	Exogenous
DEF^t	total loss in producing sectors	CT-1
DEN^t	total amortization in rest of the economy	PT-7
DEP^t	total amortization in food processing	P-5

DES^t	total amortization in socialist agriculture	P-3
$DESPN^t$	total amortization in rest of the economy	CT-1
$devcp_i$	allowed deviation of consumer price from scale of producer price in percent of producer price	Exogenous
devla	steps in changing λ parameters	Exogenous
$devpp_i$	scale of allowed deviation of actual production from target in percent of target	Exogenous
$devpp_i$	scale of allowed duration of producer price from production expenses in percent of expenses	Exogenous
$devtc_i$	scale of allowed deviation from desired per capita consumption of commodity i in percent of actual figure	Exogenous
$DGNP^t$	planned value of GNP	GMP-12
$DGNPA^t$	planned value of GNP from food and agriculture	GMP-12
$DPBA^t$	planned balance of payment from food and agriculture in million ft.	GMP-12
drn	rate of amortization in rest of the economy	Exogenous
drp_{1-14}	rate of amortization of production facilities in food processing	Exogenous
drs_{1-12}	rate of amortization of production facilities in socalist agriculture	Exogenous
ds	dollar/Hungarian Forint exchange rate	

E

e	desired growth rate of net national product	Exogenous
$ef^{(t)}$	actual growth rate of net national product at current price	CT-1
$ep^{g(t)}$	planned growth rate of community consumption	Exogenous
es^g	growth rate of government social expenditures	Exogenous
e_a, e_m, e_n	coefficients used to forcast general management and overhead expenses	Exogenous

E_i^t	export of commodity i	CT-3
EI_i^t	balance of export-import of commodity i	CT-3

F

f^t	desired share of consumption in national income	GM-A-1
$FELH_i^t$	quantity of commodity i used for processing	P-5
ff^t	actual share of consumption in national income	CT-5
FP_i^t	scale of branch i in food processing	CT-5
FPA_i^t	net production of commodity i in food processing	P-5
FPN_i^t	production of i th commodity in food processing	P-5

G

g^t	planned share of food and agriculture in total investments	GM-A-1
GCS^t	government subsidy to consumer prices	CT-5
GD^t	centralized authorization	CT-1
GE^t	total government expenditures	CT-5
GES^t	total export subsidies	CT-5
gf^t	actual share of food and agriculture in total investments	CT-5
GI^t	total income of government	CT-5
$GINA^t$	direct government investments in food and agriculture	CT-5
$GINN^t$	direct government investments in the rest of the economy	CT-3
$GINS^t$	government subsity to investments in food and agriculture	CT-3
GIS^t	government import subsidies	CT-5

$GISX^t$	balance of government budget	CT-5
GNP^t	gross national product	CT-1
$GNPA^t$	gross national product in food and agriculture	CT-1
GP^t	government price subsidies	CT-5
GPE^t	community consumption at producer prices	CT-3
GSP^t	government social expenditures	CT-1
GT^t	total tax returns of government	CT-1
$GTRP^t$	tariff recipts of government	CT-5
$GYFEL^t$	wool processed in the rest of the economy	P-3

H

h	desired share of investments in socialist agriculture in investments of the whole food and agriculture	Exogenous
HAP^t	gross production value of household and private agriculture	P-1
HBF_3	intermediate consumption of corn in household and private agriculture	P-1
HBF_6	intermediate consumption of green feeds in household and private agriculture	P-1
HBF_{11}	intermediate consumption of grape in household and private agriculture	P-1
hci	growth rate of self consumption of commodities produced by household and private agriculture	Exogenous
HD_k^t	demand of household and private agriculture for kth production facility of socialist agriculture	P-1
$HDES^t$	amortization of resources of socialist agriculture used in household and private sector	P-1
HMI^t	industrial inputs related to production facilities of the rest of the economy used in household and private sector	P-1

HP_i^t	production of commodity i in household and private sector	P-1
hpri	projected growth of production in household and private sector	Exogenous
$HWES^t$	labor expenses related to production facilities of socialist agriculture used in household and private sector	P-1

I

i^t	desired growth rate of total consumption	3.1
I_i^t	import of the commodity i	CT-3
$IFEAN^t$	investment fund of enterprises in the rest of the economy	CT-1
$IFEP^t$	investment fund of firms in food processing	CT-1
$IFES^t$	investment fund of farms in socialist agriculture	CT-1
IKT1	unit costs of tractor type I usage	Exogenous
IKT2	unit costs of tractor type II usage	Exogenous
IKT3	unit cost of additional equipment use	Exogenous
$IKTO^t$	total expenses of resources of socialist agriculture used in household and private agriculture	P-1
IRA1	expenses of fertilizer usage in socialist agriculture	P-3
IRA2	total expenses on pesticides in socialist agriculture	P-3
IRA3	value of products and services of the rest of the economy used in socialist agriculture	P-3
$INCN^t$	net income realised in the rest of the economy	CT-1
$INCP^t$	net income realised in food processing	CT-1
$INCPO^t$	net income of population	CT-1
$INCS^t$	net income realised in socialist agriculture	CT-1

$INFEL^{t}$	products of other plant production used in the rest of the economy	CT-1
INH^{t}	income of population from household and private agriculture	P-1
INN^{t}	investments financed by firms own resources in the rest of the economy	P-7
INP^{t}	investments financed by firms own resources in food processing	P-5
INS^{t}	investments financed by farm's own resources in socialist agriculture	P-3
INV_{k}^{t}	amount of enterprise level investments in kth production facility	GMP-4
$INVI_{k}$	vector including the codes of investment possibilities for a given year	GMP-4
$INVU_{k}$	scale of investment in production facility k	Exogenous
ITC_{i}^{t}	desired per capita consumption of commodity i	GMA-2
$itci_{i}$	rate of change of desired per capita consumption of commodity i	Exogenous

K

KA^{t}	allowed deficit of balance of payment	GM-P-1-2
$KAP_{k}^{(t)}$	availability of production facilitie k in socialist agriculture	P-3
$KAPIG_{k}^{t}$	needs for production facility k in food processing	P-5
$KAPT_{k}$	availability of k-th production facility in food processing	5.1.
$KEVAB^{t}$	protein requirement of socialist agriculture	P-5
$KEVFE^{t}$	protein feed requirement of socialist agriculture	P-3
$KEVTI^{t}$	feed mix requirement of socialist agriculture	P-3

L

la_i	change of i th element of vector λ	Exogenous
LAF^t	labor force of agriculture and food processing	P-7
LEN^t	wages and related tax in rest of the economy	P-7
LEP^t	wages and related tax in food processing	P-5
LES^t	wages and related tax in socialist agriculture	P-3
lh	annual rate of change of land resource in household and private agriculture	Exogenous
$LS1^{(t)}$	plow land of socialist agriculture	SETUP
$LS2^{(t)}$	pastures and meadows in socialist agriculture	SETUP
LSH^t	land availability for household and private agriculture	SETUP
lsi1	annual rate of change of plowland belonging to socialist agriculture	Exogenous
lsi2	rate of change of available pastures and meadows	Exogenous
LTS^t	land tax paid by socialist agriculture	P-3

M

m_k	unit labor input coefficient related to k th production facility	Exogenous
MEH^t	expenses of household and private agriculture related to usage of production facility	P-1
$MEHI^t$	fertilizer and pesticides expenses in household and private agriculture	P-1
MEN^t	intermediate inputs of "n"th commodity in the rest of the economy	P-7
MEP^t	total material expenses in food processing	P-5
$MEPI^t$	value of "nth" commodity used in food processing	P-5

$MEPP^t$	intermediate inputs of food processing	P-5
$MEPS^t$	value of agriculture raw materials and in food processing	P-5
MES^t	total material expenses in socialist agriculture	P-3
$MESI^t$	value of n-th commodity used in socialist agriculture	P-3
$MESP^t$	value of feed mix used in socialist agriculture	P-3
$MESS^t$	value of agricultural matèrials used in socialist agriculture	P-3

N

NLF^t	labor force of the rest of the economy	P-7
NNP^t	net national product	CT-1

O

o^t	rate of change in wage	GMP1-2
OKT_i^t	production expenses of ith commodity	P-3, P-5

P

$p_i^{c(t)}$	consumer price of ith commodity	GM-A-3
$p_i^{pr(t)}$	producer price of ith commodity	GM-A-2
$p_i^{w(t)}$	international price of ith commodity	Exogenous
P_n^t	gross production in the rest of the economy	P-7
PAF^t	planned investment fund for the whole national economy	GM-P1-2
$PAFA^t$	planned investment fund in agriculture and food processing	GM-P1-2
$PAFN^t$	planned investment fund in the rest of the economy	GM-P1-2, CT-3
PAP^t	gross production value of food processing	P-5
PBA^t	balance of foreign trade related to food and agriculture	CT-5

pci	consumer price index	GMA-1-2
PCF^t	planned consumption fund	GMP1-2
$PCPE^t$	planned value of per capita consumption	GMP1-2
$PCTCT^t$	planned consumption at producers price	GMP1-2
$PDGINA^t$	planned direct government investments in socialist agriculture	GMP1-2
PE_i^t	planned export of commodity i	GMP-3
$PGINS^t$	planned investments of firms in food and agriculture	GMP1-2
$PGINSA^t$	planned government subsidy to agricultural investments	GMP-4,CT-3
$PGINSP^t$	planned government subsidy to investments in food processing.	GMP-4,CT-3
$PGPE^t$	planned value of community consumption	GMP-1-2
PI_i^t	planned import of commodity i	GMP-3
$PJOV^t$	planned value of income of population used for buying goods	GMP1-2
pkp_k	unit price of kth production facility of food processing	UD-3
pks_k	unit price of kth production facility in socialist agriculture	UD-3
PLF^t	labor force in food processing	P-5
PMUTR	unit price of fertilizer	UD-3
$PNNP^t$	planned net national product	GMP1-2
POT_k^t	value of replacement from production facility k.	P-6
PP_i^t	planned scale of production	GMP-3
PPN_i^t	planned production of commodity i	GMP-3
PTC_i^t	planned amount of commodity i bought by population	GMP-3
$PTCG_i^t$	planned community consumption of commodity	GMP-1-2,CT-3
$PTPE^t$	planned endowement of population	GMP-1-2

PYO^t	planned balance of export and import	GMP-1-2
Q		
Q	matrix of non-committed demands	CT-3
R		
$r1^t$	share of food and agriculture in gross national product	GMA-1
$r2^t$	share of rest of the economy in gross national product	GMA-1
RF_k^t	value of capital stock in food processing	UD-2
RN^t	capital stock in rest of the economy	UD-2
RS_k^t	capital stock in agriculture	UD-2
S		
S_i^t	stock of commodity i	CT-5
SAG^t	cummulated savings of population	CT-5
SAP^t	gross production value of socalist agriculture	P-3
SDN^t	value of increase of stocks in the rest of the economy	CT-5
SDP^t	value of increase of stocks in food processing	CT-5
SDS^t	value of increase of stocks in socialist agriculture	CT-5
$SEXP^t$	export at producer price	CT-5
SGM^t	overhead expenses in socialist agriculture	P-3
$SGMA^t$	other fixed assets requirements of management activities in socialist agriculture	P-3
$SGMM^t$	labor expenses within overhead expenses	P-3
$SGMN^t$	usage of nth commodity as a part of overhead expenses	P-3

$SIMP^t$	import at producer price	CT-5
$SKAPIG_k^t$	needs for kth production facility in socialist agriculture	P-3
$SKAPT_k^t$	capicity of kth production facility in socialist agriculture	UD-2
SLF^t	labour force of socialist agriculture	P-3
SP_i^t	scale of production brunch i in socialist agriculture	P-3
SPA_i^t	output of commodity i from socialist agriculture	P-3
SPN_i^t	total production of commodity in socialist agriculture	P-3
$SPRI_k^t$	shadow price of production facility k	GMP-3,P-3
$SPT_{i,j}^t$	scale of production of commodity i by using technology j.	P-3

T

$t^{in,h(t)}$	income tax rate in household farms	GM-A-1
$t^{in,n(t)}$	income tax rate in rest of the economy	GM-A-1
$t^{in,p(t)}$	income tax rate in food processing	GM-A-1
$t^{in,po(t)}$	income tax rate of population	GM-A-1
$t^{in,s(t)}$	income tax rate of socialist agriculture	GM-A-1
$t^{wa(t)}$	wage tax rate	GM-A-1
TC_i^t	total consumption of commodity i from personal income of population	CT-2
TCS_i^t	consumption of commodity i in household farms	P-1
TES^t	total production expenses of socialist agriculture	P-3
TIN^t	total accumulation	CT-5
$TINP^t$	investments in food processing	CT-5
$TINS^t$	investments in agriculture	CT-5

tp^t	total population	UD-1
TPE^t	income of population used for consumption	CT-1
tpi	annual growth rate of total population	
$TRCP^t$	government receipts on consumer prices	CT-5
$TREP^t$	government receipts on exports	CT-5
$TRIP^t$	government receipts on import	CT-5
TXH^t	income tax paid by household farms	P-1
TXN^t	tax paid by the rest of the economy	P-7
TXP^t	tax paid by food processing	CT-1
$TXPO^t$	tax paid by population	CT-1
TXS^t	tax paid by socialist agriculture	CT-1
TWH^t	total hours of work used in farming household	UD-1
$TWHA^t$	hour of work used in household sector animal husbandry	P-1
$TWHV^t$	hour of work used in household plant production	P-1

U

uip	level of utilization of production facilities in food processing, above new investment is desired	Exogenous
upp	level of utilization of resources in food processing above replacement of aged facilities is desired	Exogenous
ups	level of utilization of production facilities in socialist agriculture above replacement of aged facilities is desired	Exogenous

V

v^n	share of rewards in net income of rest of the economy	Exogenous
v^p	share of rewards in net income of food processing	Exogenous

v^s	share of rewards in net income of socialist agriculture	Exogenous

W

$w^{n(t)}$	per capita wages in rest of the economy	P-7
$w^{p(t)}$	per capita wages in food processing	P-5
$w^{s(t)}$	per capita wages in socialist agriculture	P-3
WEN^t	total wages in rest of the economy	P-7
WEP^t	total wages in food processing	P-5
WES^t	total wages in socialist agriculture	P-3
WH_i	labor input coefficient of commodity in household and private agriculture	Exogenous
wi	annual growth rate of labor inputs in household sector	Exogenous
wp^t	total working population	SETUP
wpi	annual rate of usage of working population	Exogenous

Y

y	vector of supply after deducting intermediate inputs and committed demands	CT-3
YO^t	balance of foreign trade	CT-5

α_1	rate of sloughtering of pigs produced by household and private sector	Exogenous
α_2	conversion rate between beef and processed beef	Exogenous
α_3	conversion rate between pork and processed pork	Exogenous
α_4	rate of own processing of grapes produced by the household and private sector	Exogenous
α_5	annual growth rate of producing other processed food	Exogenous
α_6, $\alpha 7$, α_8	parameters of production function of rest of the economy	Exogenous
α_9	share of amortization in expenses of tractor type I use	Exogenous
α_{10}	share of wages in expenses of tractor type I use	Exogenous
α_{11}	share of industrial inputs in expense of tractor type I use	Exogenous
α_{12}	share of amortization in expenses of tractor type II use	Exogenous
α_{13}	share of wages in expenses of tractor type II use	Exogenous
α_{14}	share of industrial inputs in expenses of tractor type II use	Exogenous
α_{15}	share of amortization in expenses of additional equipment use	Exogenous
α_{16}	share of wages in expenses of additional equipment use	Exogenous
α_{17}	share of industrial inputs in expenses of additional equipment use	Exogenous
α_{18}	share of rest of the economy in utilization of other crops	Exogenous
$\alpha_{n,n}^{n(t)}$	rate of intermediate inputs in total output of the rest of the economy	Exogenous

α_{ik}	unit production capacity k requirement of agricultural commodity i	UD-3
α_{il}	land input coefficient	UD-3
α_{fk}	unit input coefficient in food processing	UD-3
β_1	rate of change of consumption trend	Exogenous
β_2	rate of change of share of food and agriculture in total investments	Exogenous
β_3	rate of change of growth rate of unit wages	Exogenous
β_4	rate of change of growth rate of community consumption	Exogenous
β_5	rate of change of growth rate of consumption	Exogenous
β_6	change of income tax rate of rest of the economy	Exogenous
β_7	change of income tax rate of socialist agriculture	Exogenous
β_8	change of income tax rate of food processing	Exogenous
β_9	change of rate of centralized part of depreciation from rest of economy	Exogenous
β_{10}	change rate of centralized part of depreciation from socialist agriculture	Exogenous
β_{11}	change of rate of centralized part of depreciation from food processing	Exogenous
β_{12}	change of desired upper and lower bound of planned growth rate of GNP	Exogenous
λ_{1-32}	conversion rates in food processing	Exogenous
$\delta 1_i$	change of producer price in percent of previous price	Exogenous
$\delta 2_i$	change of consumer price in percent of previous price	Exogenous
$\varepsilon 1$	allowed deviation between planned and actual buying power	Exogenous
$\varepsilon 2$	allowed deviation from planned growth rate of consumption	Exogenous

$\mu_{j,i}$	resource requirement coefficient in household and private agriculture	Exogenous
$\rho_i^{(t)}$	share of commodity i in planned consumer expenditurs	GMP-2
$\rho_i^{(t))}$	share of commodity i in consumer expenditure	CT-2
$h\rho_i^{(t)}$	share of commodity in production capacities of household and private sector	P-1