A GENERAL OUTLINE OF THE STRUCTURE OF A SIMULATION MODEL FOR POLISH AGRICULTURE

Leon Podkaminer

February 1980
WP-80-26

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

PREFACE

One of the main purposes of the Food and Agriculture Program at IIASA is to build a series of interconnected national agricultural models covering sufficiently large parts of the globe's food consumption, production and exchange.

Poland, being a big agricultural producer and having a noticeable share of the international food and feed market, deserves some attention in this context. Another important factor favoring the choice of Poland as a subject of modeling effort is the fact that the current specific problems of the Polish economy may resemble the ones that sooner or later are likely to face many medium-size countries that have not yet attained the highest level of industrialization. Among these problems are the heterogeneity of agricultural technologies, observed economic phenomena and organizational patterns, mixed structure of land ownership (large-scale public ventures are typical as small private farms) impending intensification of rural-urban migration and a high level of foreign indebtedness.

ACKNOWLEDGEMENTS

Prof. Ferenc Rabar's and Dr. C. Csaki's kind cooperation is gratefully acknowledged.

A GENERAL OUTLINE OF THE STRUCTURE OF A SIMULATION MODEL FOR POLISH AGRICULTURE

Leon Podkaminer

INTRODUCTION: THE OBJECTIVES IN DEVELOPING THE MODEL

The model of Polish Agriculture (MPA) will be the first systems simulation model to describe the operation of the Polish agricultural sector. At the same time, it will be among the very first of the systems simulation models of a macroeconomic character for the Polish economy.

Although the MPA is expected to be linked to IIASA's system of the Food and Agricultural Program's models, its main objective will be to provide the methodological and practical experience necessary for further systems simulation studies of the Polish economy, and in particular of Polish agriculture. At the same time, the information to be introduced by the MPA--imperfect as it may seem--is hoped to substantially facilitate at least some of the governmental decision-making related to agriculture.

In the future, the simulation model of Polish agriculture is hoped to be a basis for the determination of the constraints of a normative model for the development of the agricultural sector in Poland. The constraints, though probably not very elegant from the point of view of mathematical theory, are expected to reflect the imperfections and irregularities of the actual economic processes.

Needless to say, the realistic model representation of the complex system of Polish agriculture, let alone any attempt at actual practical utilization of the model, seems to impose certain prerequisites regarding the participation of experts in specific fields related to Polish agriculture. The elaboration of the Model of Polish Agriculture is a joint undertaking of IIASA and the Polish institutions interested in the development of this model. Most of the work is being carried out by the Food and Agricultural Systems Modelling Laboratory of the Systems Research Institute of the Polish Academy of Sciences in collaboration with the Institute of Agricultural Economics. This collaboration is sponsored by the Polish Advisory Committee for IIASA's Food and Agriculture Program (FAP).

There is also noticeable interest in the MPA on the part of the prominent scientists representing the important institutions (connected with both the agriculture and the overall economic planning) so far not participating directly in this effort. This fact may be of great significance as far as the realization of the objectives of the work is concerned.

IIASA's contribution consists of providing theoretical and methodological assistance whenever especially difficult questions arise in the course of the development of MPA. The following text, which was the basis of the work conducted in Poland is just one example of this assistance.

THE GENERAL FORMAL FEATURES OF THE MPA

The general concept of MPA follows the pioneering methodology developed at IIASA's Food and Agriculture Program with respect to the modeling of the centrally planned economies. [1,2,3,4].

The specific content of the model structure will, however, differ in some respects from that of the Hungarian Agricultural Model (HAM). This fact will reflect the qualitative differences between the Polish and Hungarian economies. At the same time, the differences between the model structures may be seen as reflecting the differences between both the problems perceived as the most important in the two countries, and the measures that are being applied in order to scope with these problems.

A careful analysis of the details of both model structures would prove that some apparently differing solutions express virtually the same principles; and the very basic "philosophy" of the models, expressed in their dynamic and descriptive character, the completeness in the treatment of both the national economy and the food and agriculture sector, the explicit separation of the government decision-making and the requirement that the financial equilibrium be maintained, are exactly the same.

THE GENERAL STRUCTURE OF THE MPA

The MPA will be a system of submodels similar to those of HAM. The most concise visualization of the general structure of MPA is given in Figure 1.

Obviously, the essential submodels shown in Figure 1 will consist of many more specific modules. Currently, it seems expedient to identify only the general functions of the submodels displayed below.

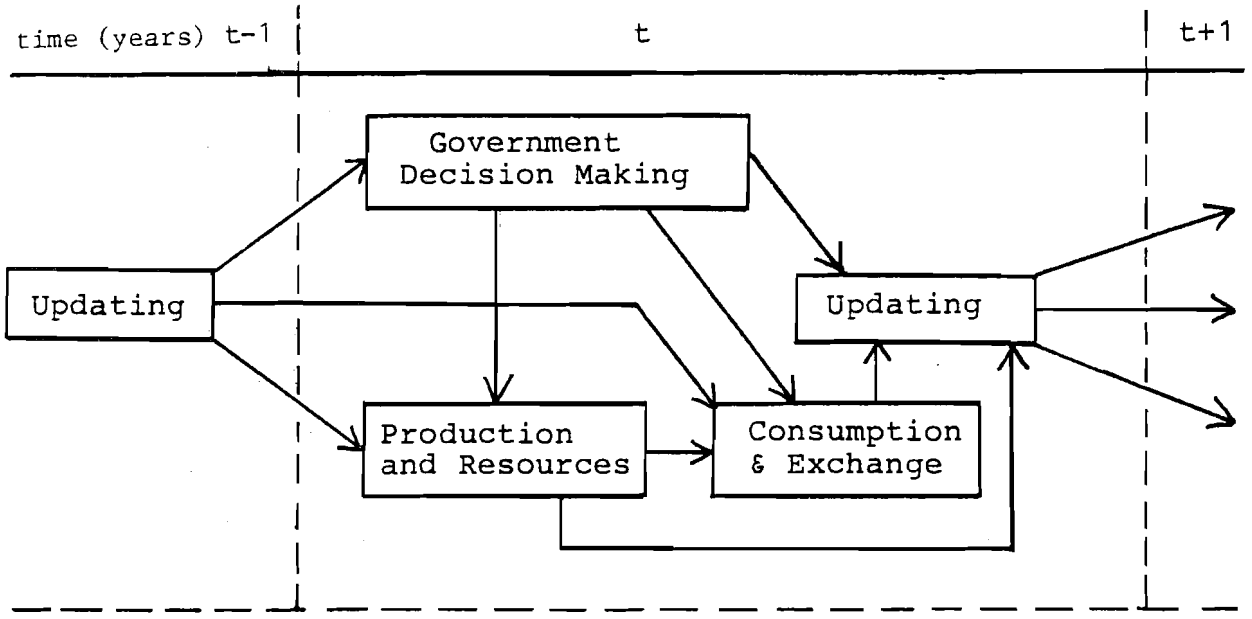

Figure 1. A schematic diagrammatic representation of the MPA.

Government Decision-Making

This submodule generates information on the government decisions affecting

-- the current production of the economy, investments, migrations;

-- the general preliminary plan on consumption and foreign exchange.

Production and Resources

This submodel generates information on

-- the current production of the economy;

-- the reallocation of resources and changes following both investments and decapitalization of resources. The information on the migration flows also belongs to the output of this submodel.

Consumption and Trade

This submodel generates information on the

-- market situation and the consumption by the population;

-- foreign exchange.

Updating

This submodule transforms all relevant information on the present operation of the economy into the data specifying the model of the economy for the next year.

THE GENERAL STRUCTURE OF THE "PRODUCTION AND RESOURCES" SUBMODEL

This submodel consists of three modules: "Agriculture", "Rest of Economy", and "Food Processing".

The "Agriculture" Module

Within this module, there are five submodels for

-- traditional private farming;

-- modern private farming;

-- part-time private farming;

-- state-owned farming;

-- cooperative farming.

The yearly performance of each of the subsectors of agriculture is being modeled in a way resembling the one C. Csaki used in his description of socialist agriculture. Obviously, there are some new aspects of the problem that have to be allowed for. These may be listed in the following way:

-- the government decisions, with respect to state-owned farming, may (and do) determine (among other things) the production targets for particular products. With respect to other subsectors, indirect methods are applied: changes in prices, taxation, subsidies, availability of the basic means of production;

-- the criteria for decision-making are by no means identical in various subsectors;

-- the subsectors have different sources of financing their operations;

-- the subsectors do not act independently. As they enter some cooperation agreements (transactions in land, feed, labor force, machinery, breeding material) the submodules must be interconnected. (The interconnection will be somewhat similar to that C. Csaki used for interconnecting HAM's modules for "Agricultural Production" and "Food Processing".)

The "Rest of Economy" Module

The structure of this module has not yet been finally determined. There seem to be two basic options:

-- an aggregated approach, with a single equation for the "n-th" product;

-- a disaggregated approach, with basic industries being described by separate production functions.*

"Food Processing" Module

This module is likely to be modeled directly in the same form as HAM.

THE GENERAL STRUCTURE OF THE "CONSUMPTION AND TRADE" SUBMODEL

Several assumptions govern the operation of the "Consumption and Trade" submodel. The most important ones are likely to be the following:

-- the distribution of goods produced in the given year is made through the home market with "pegged" prices. (The domestic consumer prices are assumed to be determined whilst establishing the overall economic plans of the government).

-- The World Market Prices are determined on the basis of adjustment of the home market to the world market. (If a country's share in the world transaction is insignificant, one could say that the World Market Prices are, in fact, taken as exogenous by the country). The determination of World Market Prices is one of the functions of the whole system of models developed at IIASA's FAP.

-- The size and structure of both foreign exchange and domestic consumption by the population will be determined by an algorithm representing the "automatic" operation of a socialist state controlling the market, and realizing its prescribed preferences. The algorithm will have to guarantee some desirable level of the domestic consumption with respect to the basic groups of goods.

Consumption (by population) is determined by a mathematical programming model representing the "automatic" operation of the market, realizing prescribed government preferences.

---

* This approach will be developed at a later date.

More specifically, the objective function of the model will be the maximization of the net earnings from foregin exchange. The constraints of the model will guarantee some desirable level of domestic consumption with respect to the basic groups of goods. It is worth noting that in order to specify the constraints, one would have to formulate the relationships between the consumers' demand for particular commodities and prices and incomes. This will be done in an auxiliary "demand" module formulated along the line of conventional demand theory. Because several groups of the population are, in fact, distinguished (while introducing different subsectors of the agriculture) and their incomes, savings and investments may be identified, it may seem logical to require that each producing group be considered as a separate consuming subpopulation. This approach implies the possibility of market disequilibria: at given prices and incomes, the effective demand for some goods may be greater than the supply.

THE GENERAL STRUCTURE OF THE "GOVERNMENT DECISION-MAKING" SUBMODEL

The general structure of the submodel tries to represent the actual structure of the overall State Economic Policymaking. Hence, several general principles have been accepted as indispensable in the submodel.

-- The national economy is a hierarchical structure: the interests of the whole economy have priority over the ones attributable to the particular sectors and subsectors;

-- the interests of a given element of the hierarchy make up a fairly complicated, ordered system of preferences;

-- within the whole structure a drive for rationality is seen. This takes the form of attempts at a simultaneous optimization of the different criteria that follow the presence of the system of preferences. (The term "simultaneous" should not be taken literally. Rather, it should be understood as relating to the term "efficient", as known from the theory of poly-optimization.)

The specific modules of the "Government Decision-Making" submodel will be constructed and interconnected in such a way as to represent the basic principles given above. To be more specific, the structure of preferences for all levels of planning will be specified. Then, the means of safeguarding the interests of the higher levels of the hierarchy in the performance of the lower ones will be described. Eventually, the way in which each level of decisionmaking (or planning) will be described by a poly-optimization programming model (most likely this will be a sort of a goal-programming model).*

Before giving a brief presentation of the components of the submodel, it is worth listing some of the "conflicting" preferences that must be allowed for:

-- the preference for urbanization and industrialization;

-- the preference for self-sufficiency;

-- the preference for a rise in the share of socialist farming within the agricultural sector;

-- the preference for equal incomes and consumption for all groups of the population;

-- the preference for market stability;

-- the preference for market equilibrium;

-- the preference for a "clean" account of foreign exchange.

In the sense of the traditional economic theory, the above preferences may, of course, be classified as non-economical ones. Nevertheless, as they are being practically taken into account, the model has to follow suit. It is worth noting that HAM adopts very similar assumptions, although the final order of preferences is obviously different from that likely to be put down in the MPA.

In the MPA there shall be some targets relating directly to the desired long-horizon state of the economy, whereas the current plans would try to approach this (state) as far as possible. (Certainly, both approaches seem to lead to very similar results).

---

*Other, more sophisticated approaches of the multiobjective optimization seem also applicable. (See A. Wierzbicki, "The Use of Reference Objectives in Multiobjective Optimization - Theoretical Implications and Practical Experience." IIASA, WP-79-66.)

A Brief Description of the Modules of the "Government Decision Making" Submodel

The Module for the Overall Economic Planning

This will be a mathematical programming module yielding an aggregated plan on production, consumption, investment and foreign exchange.

The Module for the Production Plan on Agriculture and Food Processing

This will be a mathematical programming model yielding information on the specific measures affecting the food and agriculture producing sectors. (The model solution will have to specify both the quotas, production targets, prices, taxes and subsidies.)

The Module for Planning of the Consumer Prices

This will be a mathematical programming model wherein a vector of the consumer prices is determined. (The constraints of the model will guarantee some maximum acceptable level of the excess demand for particular goods, and some maximum acceptable level of the compulsory savings. The objective function will be to minimize the value of the index of price increases.)

The General Structure of the "Updating" Submodel

The operation of the "Updating" submodel is concerned with the transition from year to year. Hence, the submodel consists of three modules describing the dynamics of the remaining submodels of the MPA.

The Module for Updating the "Government Decision Making"

This module is more or less similar to the "Economic Analysis of Government" in HAM. That is, the module rearranges the structure of current preferences, should the past performance have been unable to satisfy some minimum levels of some of the targets.

The Module for Updating the "Production and Resources"

This module updates the figures representing all the different assets: the labor force (hence migration) and land (hence rural transformation) will be described here.*

Technological and biological progress in the field of agricultural production will be allowed for. (There will be changing limits imposed upon the activities involving the advanced technologies.)

The Module for Updating the "Consumption and Trade"

This module updates the figures on consumers' endowments (savings). Also, there is a possibility in allowing the deferred consumption and demand here.

CONCLUDING REMARKS

The most general outline of the structure of the MPA presented above should be regarded as a first step towards the mature general structure of the model.

First of all, the specific modules of the model that are being meticulously analyzed have not yet reached their final, empirically relevant forms. Second, although the MPA follows the previous FAP works, the actual close collaboration on MPA and other FAP models may bring about further amendments in the MPA.**

---

*The intensification of the migration flows will be endogenously treated in the MPA. More specifically, the economic success of farming vis-a-vis the job opportunities in the industry will determine the amount of the migrants. Also, the updating of the plowland available will be endogenized.

**One may also legitimately expect a more or less modified econometric approach, as underlying for instance that demonstrated in Guenther Fischer and Klaus Frohberg's or Kirit Parikh's recent models to be applied to the Polish agriculture.

Third, one may expect some mathematical and computational problems even when considering the model outline in its present form. The problems, connected with solving

-- large-scale linear programming models;

-- large-scale parametric linear programming models;

-- medium-sized nonlinear programming models (related to the price planning optimization) of a specific, and pretty regular form;

-- medium-sized nonlinear programming models for the determination of the optimum overall economic plans in the presence of alternative objectives,

may effectively change part of the final version of the model's general structure.

REFERENCES

[1] Csaki, C., A. Jonas, and S. Meszaros. 1978. Modelling of Centrally Planned Food and Agricultural Systems: A Framework for a National Policy Model for the Hungarian Food and Agriculture Sector. IIASA, RM-78-11.

[2] Csaki, C. 1978. First Version of the Hungarian Agricultural Model (HAM-1). IIASA, RM-78-38.

[3] Csaki, C. 1979. Second Version of the Hungarian Agricultural Model (HAM-2). IIASA, WP-79-71.

[4] Parikh, K.S. 1977. A Framework for an Agricultural Policy Model for India. IIASA, RM-77-59.