Scientific Journal
Warsaw University of Life Sciences – SGGW

PROBLEMS OF WORLD AGRICULTURE

Volume 11 (XXVI)
Number 3

Warsaw University of Life Sciences Press
Warsaw 2011

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The agricultural production in mathematical models

Abstract. The theoretical questions of mathematical modeling of agricultural production processes are described. Production of agricultural goods and foodstuffs is modeled except for the production of forage and involvement of equipment and techniques, buildings, infrastructure etc. The model is based on a division of economic and technological processes in agriculture into four stages specific for agribusiness. A mathematical description of four stages in used production functions is provided.

Keywords: agriculture, agricultural production, mathematical model, production function.

Introduction

It is known there are quantitative regularities in economics, so it is possible to make a strictly formalized mathematical description of them. There are several reasons for the use of mathematical models for description of economic processes. The first comes from the impossibility of constructing physical economic models, i.e., small physical copies of real processes which are widely used, for example, in the technical sciences. The second reason consists in the fact that all components and subsystems of an economic system are rigidly interconnected with each other, so there are extremely limited possibilities of local economic experiments and it is impossible to make a 'pure' experiment.

Thus, at the disposal of researchers are their own past experience, the experience of others, direct experiments with the economy and mathematical modeling. Therefore, mathematical models represent the most appropriate methodological method of analysis.

Research methods

The term 'model' in most cases means an object which replaces the original and shows the most important features and qualities of the original for investigation. In the general form a model is a conditional image of the researched object, designed to simplify the investigation. A mathematical model in economics is a mathematical description of economic process or an object produced for research purposes and for managing the research. In another words it is a mathematical method of solving economic problems.

The process of model construction, examination and application is called modeling. In accordance with the definition of a model the main feature of modeling is an indirect

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knowledge method through objects alternates. The model is a unique method for knowledge which the researcher puts between himself and the objects being researched.

During constructing a model it is assumed that its direct investigation provides a new knowledge about the simulated object. Therefore, under the current conditions a mathematical model is the primary means of economic investigation.

Despite the fact that the approach used in the modeling greatly simplifies the real process, it allows to analyze the qualitative relationship linking the processes of government regulation and agricultural production and to give the corresponding quantitative estimates.

Let us introduce variables needed for constructing the model:

- C – capital
- L – labor
- H – feeding stuffs
- O – equipment
- I – investment
- P – price.

Finally, let us assume that:

- X – gross agricultural production
- Y – volume of production in manufacturing industries
- t – time
- β – part of agricultural products coming to produce processing industry.

Simulated are main, core production processes, i.e. direct agricultural production and food production without the production of feed, equipment, machinery, building and construction, infrastructure, etc. The model is based on the division of economic and technological processes in agriculture into four stages according the agribusiness specificity:

- goods processed in agriculture
- primary production in agriculture
- procurement of agricultural raw material by processing enterprises
- industrial processing of raw materials and food production.

The first two stages are stages of agricultural production. Sales of agricultural raw materials for their subsequent processing separately are allocated to the third stage. Production from industrial processing is the fourth stage. The overall structure of the model is shown in Figure 1.

The first stage ‘Goods processed in agriculture’ characterizes quite definite complex of economic, organizational and technological activities in agricultural production for obtaining and forming an intermediate product. This complex allows supplying the first production cycle and then an intermediate product is directed to and consumed in the primary production completely.

Separation of this stage is conditioned by the available features of agricultural production associated with the production cycle duration. So in the crop production, in fact, the cultivation process of one or another crop is not limited even growing season. In livestock production cycle could be even longer. For example, receipt of pig products takes a 10 to 14 months period and the complete first cycle of cattle breeding lasts for no less than two years. These features cause the appearance of goods in processing and the

formation of intermediate product.

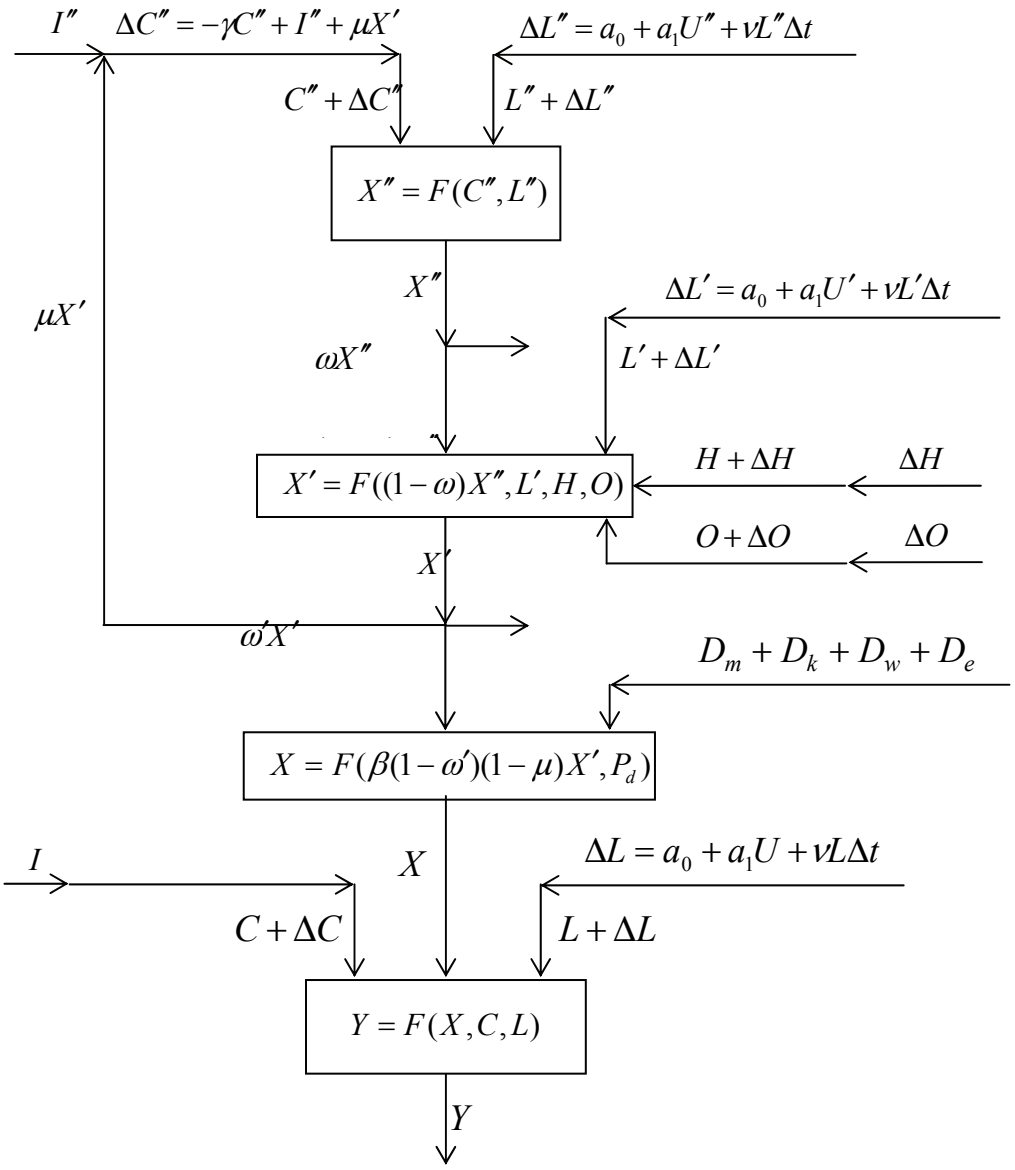

Fig. 1. Model of production and processing of agricultural products

Research results

For describing the gross output of goods processed in agriculture, the authors propose

a production function of the following form:

$$X''_t = a_0 e^{a_1 t} C_t^{\alpha_1} L_t^{\alpha_2} \qquad (1)$$

where:

X''_t – intermediate product of goods processed in agricultural production (young animals and weight gain)

C''_t – capital in the form of fixed and floating assets

L''_t – labor expenditure for production of the intermediate product

t – time variable

a_0 – coefficient of neutral technical progress

a_1 – coefficient of autonomous growth

α_1, α_2 – coefficients of intermediate product elasticity versus capital and labor.

In the second stage 'Primary production in agriculture' the intermediate product created in the first stage is consumed for production of the final product of agriculture. Consumption and changes of the intermediate product is influenced by a number of factors (or resources) such as labor, feed, fertilizer, irrigation and equipment.

Thereby, for description of production processes in the 'Primary production in agriculture' the following regression equation is used:

$$X'_t = a_0 + a_1(1-\omega)X''_t + a_2 L'_t + a_3 H_t + a_4 O_t + a_5 t \qquad (2)$$

where:

X'_t – final product of agriculture

L'_t – labor expenditure for production of the final product

H'_t – cost of feeding stuffs

O'_t – cost of equipment

ω – part of production losses associated with the deaths of young animals

t – time variable

$a_0, a_1, \ldots, a_5$ – parameters of the equation.

The third stage 'Procurement of agricultural raw material by processing enterprises' is the economic processes of agricultural raw material purchase and sale by processing enterprises. The part of the final product of agriculture $\beta(1-\omega')(1-\mu)X'$, purchased by processing enterprises as raw material, changes its value if there are declared guaranteed purchasing prices P. The residual between the guaranteed purchasing prices and market prices is recovered due to subsidies for agricultural products purchased by processing enterprises.

For the mathematical description of the third stage processes it is possible to use the following formula:

$$X = \beta(1-\omega')(1-\mu)X' \times \frac{P_d}{P_r} \qquad (3)$$

where:

X – cost of the final product of agriculture purchased by processing enterprises allow for purchasing price and market prices

ω' – part of production losses in second stage, associated with plants and animals death

μ – part of the final product that is used for reimbursement of production assets

liquidation and renewals in the first stage 'Goods processed in agriculture', i.e. for the seed, stock forming and the productive animals herd renewal

P_r – market price for agricultural products

P_d – purchasing price with allowance for government subsidies.

The fourth stage 'Processing of raw materials and food production' is the final stage of production and technological processes of agricultural production.

Production processes of this stage as well as in the first stage are described by the production function most accurately. The volume of production depends on the size and combination of resources, i.e. there is a direct dependence of the production result on resource inputs. Therefore, everything relating to production functions in the first stage is true for the production functions used in the fourth stage. On this assumption of the same conditions and rules, the following production function has been selected

$$Y_t = a_0 C_t^{\alpha_1} L_t^{\alpha_2} (X_t + \Delta X)^{\alpha_3} \qquad (4)$$

where

Y_t – output of processing industry (enterprises)

C_t – capital in the form of fixed and floating assets

L_t – labor expenditure for production of processing industry

ΔX – purchased of additional raw materials

t – time variable;

a_0 – coefficient of neutral technical progress

α_1, α_2, α_3 – coefficients of elasticity.

The production function (4) as opposed to the first stage function (1) for producing the output of processing industry (enterprises) uses three resources: capital C, labor L and raw materials X. The final product of agriculture X acts as a resource for the fourth production stage.

Conclusion

This mathematical model of production and processing of agricultural products as a single economic system will make it possible to consider changes in the agricultural and processing industry economics, to estimate the probable effects of new activities in the government economic policies, to explore the necessary degree of freedom for realizing them and to monitor the long-term negative and positive trends in production and processing of agricultural products.

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