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USE OF MATHEMATICAL MODELS IN AGRICULTURAL ECONOMICS ANALYSIS

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Dedicated to Prof. K. Srinivasa Rao on his 75^{th} ***Birth Anniversary***

Abstract: It has been clearly recognized that quantitative regularities play a vital role in economy. The adoption of mathematics in economics analysis brings a high level of precision to the analysis, assumptions are clearly stated, procedures are specified and the logical consistency of mathematically based models is easier to check than non-mathematical models. Therefore mathematical models represent the most appropriate methodological method of analysis. The model is based on the division of economic and technological processes in agriculture into four stages according to the agribusiness specificity. The mathematical description of four stages used in production functions is provided.

Keywords and Phrases: Model, quantitative regularities, logical consistency, agri-business.

1. Introduction

Theories when described in mathematical language gain not only notational simplicity, clarity and condensation but the more prominent virtue of mathematization is the manipulation of theories by taking advantage of well-established mathematical operations. The purpose behind such manipulations to obtain inferences that are unattainable without replacing verbal arguments by quantitative precision. It has been clearly recognized that quantitative regularities play a vital role in economics. It is hence possible that they can be well described on formalised mathematical parameters. Mathematical models are useful for description of economic processes for a number of reasons.

The first among these is 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.

2. Research Methodology

A model is commonly believed to be an object which replaces the original and shows the most important features and qualities of the original for investigation. More precisely, 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 other 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 knowledge method through objects alternates. The model is a unique method for knowledge which the researcher puts between himself and the objects being researched.

While 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 - labour
- H - feeding stuffs
- O - equipment
- I - investment
- P - price.

Finally, let us assume that:

- X - gross agricultural product
- 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 to 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 goat prescribed takes a 15 to 24 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.

3. Results

The researcher, in order to describe the gross output of goods processed in agriculture, thus proposes a production function of the following form:

$$X_t'' = a_0 e^{a_1 t} C_t^{\alpha_1} L_t^{\alpha_2} \tag{3.1}$$

where: X_t'' - intermediate product of goods processed in agricultural production (young animals and weight gain)
C_t'' denotes capital in the form of fixed and floating assets
L_t'' stands for labor expenditure for production of the intermediate product
t is time variable
a_0 is coefficient of neutral technical progress
a_1 denotes coefficient of autonomous growth
α_1, α_2 represent 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:

$$X_t' = a_0 + a_1(1-y)X_t'' + a_2 L_t' + a_3 H_t + a_4 O_t + a_5 t \tag{3.2}$$

where
X_t' denotes final product of agriculture
L_t' denotes labor expenditure for production of the final product
H_t' is cost of feeding stuffs
O_t' is cost of equipment
ω represents part of production losses associated with the deaths of young animals
t is time variable
t
$a_0, a_1, ..., a_5$ are 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:

$$X = \beta(1 - y')(1 - z)X' \times \frac{P_d}{P_r} \tag{3.3}$$

where
X - cost of the final product of agriculture purchased by processing enterprises allow for purchasing price and market prices
y- part of production losses in second stage, associated with plants and animals death
z - 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

$$Y_t = a_0 C_t^{\alpha_1} L_t^{\alpha_2} (X_t + \Delta X)^{\alpha_3} \tag{3.4}$$

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
$\alpha_1, \alpha_2, \alpha_3$ - 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.

4. Conclusion

We can conclude the discussion by saying that the aforesaid mathematical model of production and processing of agricultural products as a single economic system is immensely useful. It 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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