The Stimulation Model for the Criterial Decision-Making at the Agricultural Enterprise

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Abstract. According to the general theory of systems, agricultural enterprises are from the category of closed systems in interaction with the external environment and they are close to the category of open systems. The decision maker (DM) needs to have information about the current state of the external environment with statistical analysis of the level achieved and forecasts for the future. Therefore, the task of improving the methods substantiating managerial decisions, using the criterion approach with simulation modeling of agricultural enterprises, is relevant. In the course of building the required model, three subtasks were solved: a conceptual model was built, which was transformed into a machine model, calculations were carried out, and the results were interpreted. Simulation modeling of the agricultural enterprise using a computer should study the performance of the agricultural enterprise before it is designed, at the stage of its setting up and in the course of its operation.

Keywords: livestock agricultural enterprise, management, simulation model.

1 Introduction

The basis for the stability of the economic, social, political situation in society and the world depends on the efficiency of the agro-industrial complex [1, 2]. Agriculture is divided into two main sectors in different countries of the world: crop and livestock. Thus, the livestock industry in the Russian Federation provides 45% of gross output, accumulates 75% of basic production assets and 70% of labor resources in agriculture. This industry is valuable because it produces products that are one of the most essential biologically valuable in the diet of the Russian people.

The changed conditions for the setting up and operation of the agricultural enterprise put the management of production activities, and the resolution of a number of strategic issues in the first place [3, 4]. In the economy of the Russian Federation, there has been a weakening and a change in the content of vertical components and a violation of horizontal information flows. According to the general theory of systems, agricultural enterprises are from the category of closed systems in interaction with the external environment and are close to the category of open systems. The decision maker (DM) faced the problems of forming the nomenclature and the volume of output, assessing the existing and expected future market needs for it. To do this, he needs to have information about the current state of the environment with a statistical analysis of the level achieved and forecasts for the future. Under these conditions, the statistical component [5, 6] becomes the central element in ensuring effective management in the context of the transition to the innovative economy.

On the other hand, such decisions should be based on statistically verified data on the achieved state of the agricultural enterprise, the dynamics of its changes, as well as opportunities and development directions, taking into account the specifics of the region to improve cost management while ensuring effective planning of future activities [7]. Therefore, the task of improving the methods of substantiating managerial decisions, using the criterion approach [8] with simulation modeling of agricultural enterprises, is relevant.

2 Problem Statement

Computer simulation [9] is widely used in the study and management of complex economic systems [10, 11]. This is explained by the fact that the dimension of problems being solved and non-formalized complex systems do not allow using strict optimization methods [12]. However, this modeling method is rarely used in decision-making tasks and it is almost never used to substantiate management decisions at agricultural enterprises.

3 Research Questions

It is necessary to develop a simulation method for the operation of a livestock enterprise, which will provide a rationale for management decisions by decision makers in the face of uncertainties and risks. The authors take into account the features of the simulation model at all stages of its life cycle.

4 Purpose of the Study

The study represents and describes a simulation model for managing a livestock agricultural enterprise, including subsystems for feed preparation and feeding, water supply, animal care, transportation, reception and processing of livestock products. It can be used at all stages of the life cycle: 1) at the design stage, to study the performance of a future agricultural enterprise; 2) at the stage of setting up the agricultural enterprise; 3) in the course of its operation to obtain information that complements the results of the enterprise, as well as to obtain forecasts for its further development.

5 Research Methods

Simulation modeling of the operation of the agricultural enterprise using a computer is advisable in the following cases:

a) To study the performance of the agricultural enterprise before it is designed, in order to determine the sensitivity of its features to changes in the structure, algorithms and parameters of the simulation object and the external environment;

b) At the stage of setting up the agricultural enterprise. For the analysis and synthesis of various variants of the enterprise. Choosing the variant from alternatives that would satisfy the given criterion of the performance efficiency;

c) In the process of the operation. To get information that supplements the results of the enterprise, and to obtain forecasts for the development of agricultural enterprises in time.

6 Findings

6.1 The expected specific value of the selection

In accordance with the systems approach, it is proposed to use the mathematical function of the subject {EV} as a basis for constructing a conception model of the decision maker [13] of the agricultural enterprise that relates the expected specific value in any situation of choice with the properties of possible actions, their possible results and existing environmental variables:

$$EV = \sum_i \sum_j P_i E_{ij} V_j = H[\{C_i\}, \{O_j\}, S_k].$$

When deriving the expected specific value of the choice (EV), notions of the subject $\{A\}$, possible ways of actions $\{C\}$, possible results $\{O\}$, the environment $\{S\}$, the possible choice by this subject $\{Pi\}$, the efficiency of each possible way of actions for each possible outcome $\{Eij\}$ and specific values of each result for a given subject $\{Vj\}$.

The blocks of the model are selected, the structure and properties that they should have are outlined.

6.2 The description of the external and internal environments of agricultural enterprises

To describe the production processes at agricultural enterprises we select a cybernetic approach [9], which describes the external and internal environment:

$$S_o = (A_{01},A_{02},\ldots,A_{0n},\Gamma_{01},\Gamma_{02},\ldots,\Gamma_{0p}),\ S_i = (A_1,A_2,\ldots,A_n,\Gamma_1,\Gamma_2,\ldots,\Gamma_p), \quad (1)$$

where A_{0i}, A_i – are elements of external and internal environments, respectively; Γ_{0i} , Γ_i – the relationship between the elements of respective environments.

6.3 The existing types of modeling of agricultural enterprises

The existing types of modeling of large systems that can be used in the analysis, synthesis and operation of agricultural enterprises are identified.

Criteria are formulated for the type of modeling in order to use it to substantiate management decisions at agricultural enterprises.

To reproduce the operation of the agricultural enterprise, simulation modeling is chosen as the one that most fully satisfies the requirements. Some advantages of simulation: the operation of the agricultural enterprise can be studied in any conditions; the results of field tests of the agricultural enterprise or its subsystems can be included for further research; stimulation has a well-known flexibility that is varying the structure, algorithms and parameters of a simulated enterprise; and it is practically the only implemented method that can study the operation of the enterprise at the stage of its design.

Mathematical, software, information, technical support of simulation modeling has been determined. A computer is chosen as a technical means of implementing the simulation model at the agricultural enterprise.

6.4 The structural diagram of the simulation model

The development of a conceptual model of the agricultural enterprise, including the construction of conceptual models of the internal and external environments, a structural diagram of a model of a livestock farm, as well as the selection of indicators for the efficiency of the system operation are given.

The main variables of the internal environment of the organization include: goals – A_1, structure – A_2, tasks – A_3, technology – A_4, and people – A_5. In order to apply this approach to the agricultural enterprise, it is obviously necessary to add another variable A_6 – land and / or animals. These variables cannot be considered independently of each other. Significant changes to any of them will lead to a certain extent impact on all other variables.

Agricultural enterprises most often have a two-stage fan-shaped management structure [5], shown in Figure 1, where M_1, M_2, ..., M_N are producers of agricultural products.

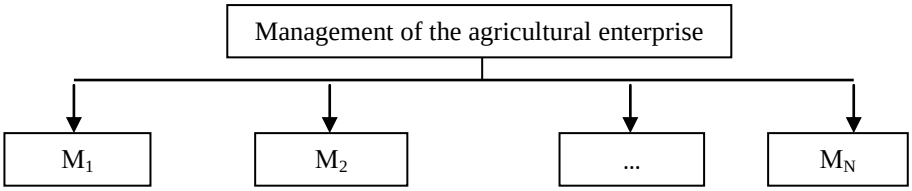

Figure 1. Two-stage fan management structure of the agricultural enterprise (Source: compiled by V.N. Shepel)

We believe that the income of *the i*-th manufacturer J_i is equal to:

$$J_i = c_i P_i - w_i L_i, \qquad (2)$$

where c_i – the price of the product, w_i – the average wage rate, L_i – the amount of labor.

The income of the agricultural enterprise is uniquely determined by the products that manufacturers produce:

$$J = J(P_1, P_2, ..., P_N) \to \max, \qquad (3)$$

where $P_1, P_2, ..., P_N$ – the production volume of 1,2, ..., *N* manufacturer. In view of (2), we have the following:

$$J = \sum_{i=1}^{N-1} J_i + (J_м = c_м P_м - w_м L_м), \qquad (4)$$

where $J_м$ – the income of the manufacturer, whose operation is studied, for example, using statistical modeling. Further, as a manufacturer, we will consider in detail a dairy cattle farm.

As for livestock farms, there is a separation of all the work into components, due to the formation of subsystems: feed preparation and feeding (FPF), water supply (WS), animal care (AC), production and processing of livestock products (PPLP), transportation (T) which perform specific tasks and achieve specific objectives (Fig. 2).

To facilitate the influence of the environment on the agricultural enterprise, external factors are divided into groups of direct and indirect effects. The direct impact group includes factors that directly affect the operation of the enterprise – consumers, suppliers, competitors, laws, and government agencies. The indirect impact group includes factors that may not have a direct immediate impact on the operation of the agricultural enterprise – these are international events, the state of the economy, socio-cultural factors, political factors, scientific and technical progress. The main characteristics of the environment are: complexity (*N*), mobility (S_0'), interrelation of factors ($S_0 = f(A_{01}, ..., A_{0r})$) and exposure time (*T*).

A simulation model of a livestock farm should allow determining the influence of the performance of decision makers, farm subsystems, as well as newly introduced elements on milk yield. To solve the set tasks, the structural scheme (Fig. 2) of the simulation model should include: a decision maker and subsystems for preparing food and feeding, water supply, animal care, receiving and processing animal products, transportation, and subsystem that is modeling the behavior of animals [7].

Figure 2 has the following notation: *X* – the effects of the external environment on the farm consisting of X_{1i} – the effects influencing the survival of the farm and they are taken into account mainly by the decision maker; X_{2i} – feed entering on FPF; X_{3i} – the volume of water entering on WS; *Y* – milk yield.

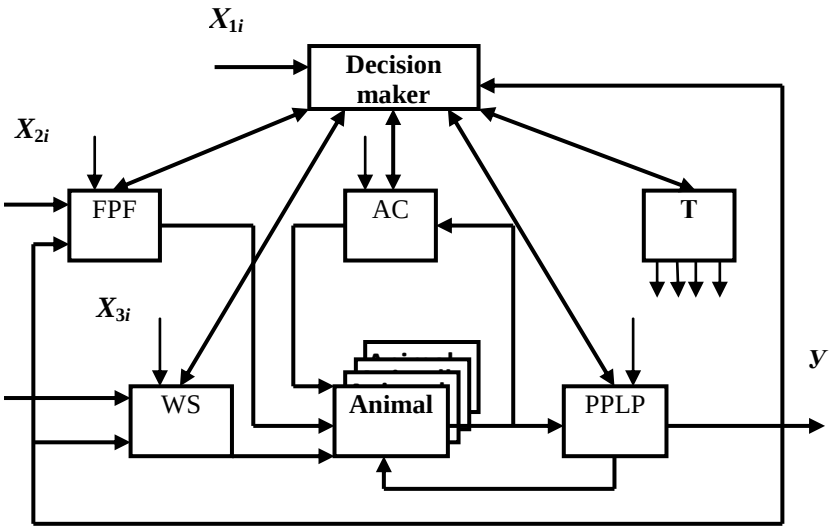

Figure 2. Structural scheme of the livestock farm (Source: compiled by V.N. Shepel)

6.5 Mathematical modeling of the agricultural enterprise

A formal model of the agricultural enterprise has been built, including a finite subset of variables $\{\vec{x}(t), \vec{v}(t), \vec{h}(t)\}$ along with mathematical relationships between them and characteristics $\vec{y}(t)$.

A list of mathematical schemes and applications for each of them is presented. This list contains continuously deterministic, discretely deterministic, discrete-statistical, continuous-statistical, generalized or universal approaches.

A – scheme is selected as a mathematical scheme for modeling the agricultural enterprise. *A* is a unit, and the connection between units (inside the enterprise and with the external environment *E*) is carried out with the help of the interface operator *R*. Any unit is characterized by the following sets: times *T*, input *X* and output *Y* signals, *Z* states at every moment time *t.*

7 Conclusion

A decision-maker of the agricultural enterprise must solve problems and tasks of strategic management, and he must have tools of the decision-making theory – a simulation model, developed and adapted to the subject area.

As a basis for building a conceptual model of the decision maker of the agricultural enterprise, it is proposed to use the mathematical function of the subject *{EV}*, which connects the expected specific value in any situation of choice with the properties of possible actions.

To describe the production processes taking place at agricultural enterprises we select the cybernetic approach.

A formal model of the agricultural enterprise has been built, including a finite subset of variables $\{\vec{x}(t), \vec{v}(t), \vec{h}(t)\}$ along with mathematical relationships between them and characteristics $\vec{y}(t)$.

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