Simulation of agricultural enterprises based on the optimization of the components with the transformation - game model

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Abstract. This paper discusses the possibilities of change management algorithmization in the activities of agricultural enterprises based on the optimization of the components of the transformation - game model. Optimization models of the main components of the transformational-gaming analogue are proposed. Production of the facility at the enterprise is carried out by employees in the unit for a certain time. The cost of all category details for one employee is determined in accordance with the production plan, type of production and evaluation mechanisms. The block diagram of the weak link search algorithm is presented. It is shown how the optimization of the efficiency of the agricultural enterprise is carried out on the basis of a network rating.

1. Introduction
Analysis of the work and optimization of the agricultural enterprise can be carried out on the basis of various methods [1, 2]. In this paper, the use of a transformational-game approach is proposed. The system should take into account a production plan that reflects the objectives of the agro-industrial enterprise in achieving specific quantitative and qualitative indicators. To develop a module of the system responsible for the formation of the production plan, let's consider the hierarchy of entities responsible for the formation of the economic space of the agro-industrial enterprise [3]. But there is information that cannot be originally generated and defined as a constant - information that defines the production
and gaming process [4]. Therefore, models of optimization of the main components of the transformation-game analogue are proposed: Formation of the production facility for the unit; Definition of production categories for employees of the unit; Determining the sequence of parts within a category; Pricing of production details; Assignment of performance analysis for the production part; Determining the time for manufacturing the part; Forecasting the volume of production for an agricultural enterprise.

Let’s form the structure of these models.

1) Formation of the production facility for the unit.
An object of production (O) consists of many categories (C). Initially, the maximum possible number of categories is laid in the object. Their number should be greater than or equal to
\[ O \subset C_j, j = 1,2,\ldots, n; \]
\[ O \subset C_j, j = 1,2,\ldots, \sum_{i=1}^{n} St_i \]

Condition (1) means that the object consists of a certain set of categories. It shows that the unit consists of a set of employees. It provides each employee with a category of production inside the facility. Condition (2) defines the final set of categories for the unit object. So that, the set of categories within an object is directly determined by the number of employees of the unit [5].

2) Definition of production categories for group of workers.
Based on the above condition (1), the categories of the object relative to employees will be distributed, as indicated in (3).

\[ St_j \subset C_i, i,j = 1,2,\ldots, \sum_{k=1}^{n} St_k \]

3) Determining the sequence of parts within a category.
Suppose there is \( n \) - the number of parts that make up the category. It is necessary to build a sequence of their compounds to obtain the final product [6]. In order to structure the details relative to each other, it is necessary to compose a matrix of their sequential distance on a scale from 1 to \( m \), where \( m \) is the number of parts in the category. In the table 1 an example is shown of such a matrix. Columns are the number of details. Cells indicate the remoteness of each detail to the rest.

**Table 1. Matrix of the sequence of details in the final product.**

|   | 27 | 43 | 16 | 30 | 26 |
|---|----|----|----|----|----|
| 7 | -  | 16 | 1  | 30 | 25 |
| 20| 13 | -  | 36 | 5  | 0  |
| 21| 16 | 25 | -  | 18 | 18 |
| 12| 46 | 27 | 48 | -  | 5  |
| 23| 5  | 5  | 9  | 5  | -  |

The main condition is: within the same assembly cycle of the category you can use the required part once.

\[ F(x) = \sum_{i=1}^{n} \sum_{j=1}^{n} t_{ij} x_{ij} \rightarrow \min \]
\[ \sum_{i=1}^{n} x_{ij} = 1, i = 1,2,\ldots, n \]
\[ \sum_{j=1}^{n} x_{ij} = 1, j = 1,2,\ldots, n \]

\[ u_i - u_j + n x_{ij} \leq n - 1, i,j = 1,2,\ldots, n, i \neq j \]
\[ x_{ij} = 0 \text{ or } 1, i,j = 1,2,\ldots, n, i \neq j \]
Condition (4) is a function, where \( t_{ij} \) is the logical distance between details \((i,j = 1,2,\ldots,n, i \neq j)\), moreover, in the general case \( t_{ij} \neq t_{ji} \); condition (5) means that during the cycle the exit from the detail is carried out only once; condition (6) means that the entry into the detail is carried out only once; Condition (7) ensures the closure of the route and the absence of loops, where \( u_i \) and \( u_j \) – are some real values \((i,j = 1,2,\ldots,n, i \neq j)\); in the condition (8) there is a variable \( x_{ij} \) assuming a value of 1 if you are moving from part i to part j \((i,j = 1,2,\ldots,n, i \neq j)\) and 0 in a bad case.

4) Determining the price of the manufacturing detail. Production of the object is carried out by employees in the unit for a certain time. The cost of all category details for one employee will be determined in accordance with the production plan, type of production and evaluation mechanisms. It is necessary to calculate the balance between the possible number of points earned and the cost of details [7, 8]. For this, it is necessary to compare the possible variants of production control methods for their quantity, maximum numerical estimated value and complexity, as presented in table 2.

### Table 2. Point grading.

| Type, \( Tp \) | The maximum amount for a given time, pcs., \( A \) | The maximal point, \( B \) | Difficulty factor, \( K \) |
|----------------|---------------------------------|-----------------|-----------------|
| Type of work 1 | 100                             | 1               | 1               |
| Type of work 2 | 10                              | 5               | 3               |
| Type of work 3 | 15                              | 5               | 4               |
| Type of work 4 | 5                                | 5               | 5               |
| Type of work 5 | 2                                | 7               | 10              |
| Type of work 6 | 1                                | 10              | 15              |

The maximum possible number of points that an employee can earn in a given time for a certain type of work \( (F) \) is calculated as follows (9):

\[
\sum_{i=1}^{n} Tp_i = (A_i \ast B_i) \ast K_i, i = 1,2,\ldots,n \tag{9}
\]

It is necessary to take into account the fact that not every employee can earn the maximum number of points, therefore it is logical to introduce a reduction factor, which can be set separately for both the employee and the unit as a whole (10):

\[
\sum_{i=1}^{n} Tp_i = (A_i \ast B_i) \ast K_i - L, i = 1,2,\ldots,n \tag{10}
\]

where \( L \) – reduction factor \( Tp_i > L > 0 \). Next, we need to determine the total \( (Sm) \) number of points that can be earned in all types of works (11):

\[
Sm = \sum_{i=1}^{n} Tp_j = ((A_j \ast B_j) \ast K_j - L, i,j = 1,2,\ldots,n \tag{11}
\]

Then we calculate the cost of each detail included in the category of the production object. The cost of details will increase in arithmetic progression in the order they follow.

We calculate the cost of the first detail, \( D_0 \) (12):

\[
D_0 = \left( \frac{Sm}{p} \right) \ast 0.1, D_n = \left( \frac{Sm \ast 2}{p} \right) - D_0; U = \frac{D_0 + D_n}{p} \tag{12}
\]

where \( P \) – number of details in a category. We calculate the cost of the last detail, \( D_n \). Then we calculate the value by which each subsequent detail will be more expensive than the previous one, \( U \).

5) Assignment of control for a manufacturing part. In order for the details to be available for production, the employee must master the appropriate technology. In other words, each detail or set of details will be associated with some of the many questions necessary for study. The result of such a control will determine the quality component of the part [9, 10]. We determine the number of questions to be monitored in the certain period of time for each type of activity, as well as their total amount, as shown in table 3.
Now we calculate the number of details (N) assigned to each activity (13):

\[ N_{F_i} = \frac{q_i + p}{r} \quad (13) \]

Details are assigned to the type of activity in the following order. Next, it is necessary to compare the details allocated to the subject with the available control events for it. Details are assigned to control event within the types of activities, also in the following order (14):

\[ Q_{ij} \leq N_{F_{ik}}, \quad i, j, k = 1,2, ..., n \quad (14) \]

where: \( j \) – the serial number of the control measure within the type of activity, \( k \) – the serial number of the part assigned to the type of activity, if \( k > j \), then \( j = 0 \).

Table 3. The structure of control of readiness for various types of activities.

| Objects, \( F \) | Number of questions per certain period of time, pcs., \( Q \) |
|------------------|----------------------|
| Type of activity 1 | 5                     |
| Type of activity 2 | 3                     |
| Type of activity 3 | 7                     |
| …                |                       |
| Total, \( I \)    | 15                    |

6) Determining the production time of the detail.

The production time of each part within the category is strictly defined. If an employee after a certain time for some reason cannot complete the production of the detail, then he falls into the category of weak links. The production time of a detail is limited by the date of the last controlling event assigned to it by the type of activity. Table 4 shows an example of the compliance of control measures and the time of their conducting with respect to a certain type of activity.

Table 4. Schedule of control events.

| Kind of activity | Date, \( D_t \) |
|------------------|-----------------|
| Controlling Event 1 | 01.10.19       |
| Controlling Event 2 | 5.11.19        |
| …                |                 |

We calculate the time limit (\( T_d \)) for each detail included in the category of the production object:

\[ T_d N_{F_{ik}} \leq D_t Q_{ij}, \quad i, k = 1,2, ..., n, \quad j = n \quad (15) \]

7) Definition of a production plan for an agricultural enterprise. To use the rating component of the assessment of the activity of each individual link of an agro-industrial enterprise, it is necessary to determine the maximum possible results that each link can get during the production process in a certain time. The results obtained will serve as such a standard. Based on the deviation from the standard, a rating value will be calculated containing the quantitative and qualitative characteristics of an individual link. Thus, in the context of the developed system, it is necessary to take into account the production plan that reflects the goals set for the agro-industrial enterprise in achieving specific quantitative and qualitative indicators [11-13]. To develop a system module that is responsible for the formation of a production plan, we consider a hierarchy of entities responsible for the formation of the economic space of an agro-industrial enterprise with respect to the structure of a production-game model. The basis of the economic component is the smallest part of the system - the detail. But the detail cannot exist independently, it is in constant conjunction with two objects of the production process - the employee and the type of activity. Therefore, in a general sense, the production plan will...
be reduced to the total number of details produced by all employees of the agro-industrial enterprise in accordance with the optimized production plan for a certain period of time.

The forecasting of production volume (W) will be carried out in the following areas: Employee (st); Production unit (gr); Specialty (sp); Amount of production units (dp); Production Association (fc); Agro-industrial enterprise (un) (16) and (17):

\[
W_{st_i} = \sum_{j=1}^{n} P_j, \quad W_{gr_i} = \sum_{j=1}^{n} W_{st_j}, \quad W_{sp_i} = \sum_{j=1}^{n} W_{gr_j}, \quad i, j = 1, 2, \ldots, n
\]  

\[
W_{dp_i} = \sum_{j=1}^{n} W_{sp_j}, \quad W_{fc_i} = \sum_{j=1}^{n} W_{dp_j}, \quad W_{un} = \sum_{j=1}^{n} W_{fc_j}, \quad i, j = 1, 2, \ldots, n; \quad i, j = 1, 2, \ldots, n
\]

On the basis of these models, the proposed change management procedures in the activities of the agro-industrial enterprise in the form of search algorithms and elimination of the weak link. Let’s consider the procedure for finding the weak link. The criteria for the weak link are:

- Insufficient amount of funds (balance) for the production of the detail, at the time of the last test assigned to the detail.
- Deviation in the negative direction of the test result from the specified quality standard (Q).
- Figure 1 shows the weak link search algorithm.

![Weak Link Search Algorithm Diagram](image)

**Figure 1.** Structural diagram of the weak link search algorithm.

3. Results

On the basis of the results of monitoring the internal assessment of agricultural enterprises, it seems possible to analyze existing information for planning activities for the strategic development of a particular enterprise. 109 agricultural enterprises took part in monitoring the internal performance assessment. In accordance with this event, the investigated enterprise took 34th place out of 109 possible with 36.5 points. After analysis, it becomes obvious which of the areas this enterprise lags behind others with a higher ranking. To identify specific reasons that prevent this enterprise from taking a higher position, we will conduct a detailed analysis of each of the five areas of its activity.
Then, based on the analysis of the lines of activity carried out above, we rank them by the degree of effectiveness for the agro-industrial enterprise with respect to the formation of a position in the general rating table: scientific activities; trading activities; professional development activities; financial and economic activities; infrastructure. Let us show in practice the application of the algorithm of intellectual support for managerial decision-making on changing the position in the rating for a particular enterprise. Let's create a set of ThisPredp containing the name and value of the evaluation criteria for this enterprise in the Actx business areas. In this case, the limitation will be the time to achieve improvement in the value of a certain indicator. We create a set of Predpdxr containing the name and value of the evaluation criteria of all enterprises except this one. We run the weak link search algorithm. We will form a lot of Res resources. We determine the coefficients of importance of the obtained criteria. We calculate the number of points in the areas of activity of enterprise, after solving the problem: scientific activity = 14.87 points; trading activities = 11.56 points; professional development activities = 3.17 points; financial and economic activity = 13.89 points; infrastructure 44,245 points. The current rating value of the performance of the enterprise corresponds to 9th place in the overall rating table. We can transfer to a higher position in the ranking with minimal resources. The minimum cost of resources can be ensured by improving some criteria of the enterprise. This can be achieved by transferring the enterprise within each line of business to a higher place: scientific activity from 23rd to 22nd place; trading activity from 14th to 13th place; professional development activities from 18th to 17th place; financial and economic activity from 45th to 44th place; infrastructure from 68 to 67 place. That is why, the values of the criteria of the set Predpdx will be formed by comparing the criteria of the set of enterprises with the criteria of the enterprises that are higher in the rating list by areas of activity. We will use the value of the greatest criterion.

4. Conclusion
The analysis of monitoring - rating evaluation of the effectiveness of the agricultural enterprise is carried out. A structural - conceptual model of the activity of the agro-industrial enterprise, its units and subjects of the educational process based on the composition of the essential sets of the information environment has been formed. The structure of transformational - game modeling of enterprise activity efficiency on the basis of analysis of the functioning of the industrial economic system is proposed.

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