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Modeling of control process of industrial organizations based on rating approach

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Abstract: The paper discusses the possibilities of modeling the control of industrial organizations based on rating approaches. There is a control center for control production facilities. It is proposed to organize the interaction of the control center with the facilities based on the rating score and then proceed to the rating control process. At the same time, the rating is used to analyze control, accounting, forecasting and regulation of the activities of the objects included in it in the analyzed production system. A model for the interaction of the control center in industrial production with the objects of the production system based on the classification criteria is formed. The structure of the interaction of the control center with the objects of the production system at rating control is given. Rating control mechanisms based on: control the distribution of resource support for the implementation of all areas of the main activity of the production system, control the coordination of interests of the control center and objects of the production system, and control the distribution of additional resource support for development, are considered. The block diagram of the implementation of mechanisms for rating control is given. The characteristics of modeling the interaction of the control center and objects of industrial systems are indicated. The results of rating assessment of industrial production objects are given on the example of growth in sales of enterprise products.

Keywords: production organization, model, rating approach, resource, management, control.

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Моделирование процесса контроля производственных организаций на основе рейтингового подхода

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Резюме: В данной статье рассматриваются возможности моделирования управления производственными организациями на основе рейтинговых подходов. Существует центр управления производственными объектами. Предлагается организовать взаимодействие центра управления с объектами с учетом рейтинговой оценки и затем перейти к процессу рейтингового контроля. При этом рейтинг используется для анализа, контроля, учета, прогнозирования и регулирования деятельности включенных в него объектов в анализируемой производственной системе. Сформирована модель взаимодействия центра управления промышленным производством с объектами производственной системы на основе критериев классификации. Приведена структура взаимодействия центра управления с объектами производственной системы при рейтинговом контроле. Механизмы рейтингового контроля основаны на: контроле распределения ресурсной поддержки реализации всех направлений основной деятельности производственной системы, контроле согласования интересов центра управления и объектов производственной системы, контроле распределения дополнительного ресурса, поддержке развития. Приведена структурная схема реализации механизмов рейтингового контроля. Указаны особенности моделирования взаимодействия центра управления и объектов промышленных систем. Приведены результаты рейтинговой оценки объектов промышленного производства на примере роста продаж продукции предприятия.

Ключевые слова: производственная организация, модель, рейтинговый подход, ресурс, управление, контроль.

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Introduction

Among industrial organizations, we can mark out those that are characterized by the presence of a control center.

The control center interacts with objects on a number of problems, related to achieving the goal of the effective functioning of the whole industrial system [1]. We will consider one of the key problems - resource support for the implementation of all types of core activities and the development of homogeneous objects that are considered as parts of the system.

It is advisable to organize the interaction of the control center with the objects on the basis of rating assessment and go to the rating control process in which the rating is used to analyze the control, accounting, forecasting and regulation of the activities of the facilities included in the analyzed production system [2].

The model of interaction of the control center in industrial production

The interaction of the control center with the objects of the production system is characterized by the following classification features:

- the type of rating assessment, depending on the organizer of the rating of objects: internal, external,
- the form of public reporting on the results of external rating: global rating, thematic rating,
- type of control action during interaction: change in the resource supply of the object, change in the rating status of the object,
- the interaction mode of the control center and objects: the main activity of the industrial system, development mode,
- the form of interaction of the control center with the facilities under rating control: administrative, with elements of decision support.

In the first case, the use of expert assessment methods with the dominant expert of the control center administration prevails, in the second case, decision-making support by the administration of the control center and objects using formalized modeling and optimization methods [3, 4] in combination with expert evaluation methods is organized.

The following classification features allow us to go on to characterize and formalize the mechanisms of rating control for this purpose, we introduce a number of notation:

$i = \overline{1, I} -$ numbering set of objects O_i in production system;

$y_{im}(t) -$ values of indicators of efficiency of activity of the $i -$th object obtained on the basis of the monitoring by the control center for the за $t -$ th period of operation of the production system;

$m = \overline{1, M} -$ the numerical set of indicators for monitoring; $t = \overline{1, T} -$ is a numerical multiple of the periods of functioning of the production system are monitored;

$a_{ij}(t) -$ values of indicators of efficiency of activity of the $i -$ th object obtained on the basis of monitoring for the $t -$th period of operation and the selected control center as a key for the internal rating assessment;

$j = \overline{1, J} -$ numerical set of parameters of the internal rating assessment of the main activity object the production system;

$r_{in} -$ the value of the internal rating assessment of the $i -$ th object in the $n -$th focus obtained on the basis of the ordering of objects O_i using integrated assessment $F_i = \varphi(a_{ij})$; $n = \overline{1, N} -$ numerical set of directions, the main activities of the production system; $\varphi(\cdot) -$ is a model for organizing objects O_i largest integral evaluation F_i;

$V^0 -$ resource support primary activities of the production system;

$V_n^0 -$ resource support organizational system in the $n -$ th main activity;

$V^g -$ resource support of production systems allocated in addition to the resourcing of core activities for its development;

$V_i^0 -$ resource support primary activities of the $i -$ th object of the production system;

$V_i^g -$ additional resource support for the $i -$th object;

$V_i^p -$ resource support for the development of the $i -$th object of the production system;

$\hat{V}_i -$ stated need of the $i -$th object of the production system in resource provision;

$x_{in} -$ volume output indicator focus on the $n -$th direction for the $i -$th object when it interacts with consumers;

$c_{in} -$ specific implementation costs of operating activities in the $n -$th direction for the $i -$th object;

$r_i -$ the value of the global external rating assessment of the $i -$th object;

$r_{il} -$ value of the external rating assessment of the $i -$ th object in the $l -$th cluster;

$l = \overline{1, L} -$ numerazione many thematic areas external rating.

By using these characteristics, the structure of the interaction of the control center with the objects of the production system when the rating control is shown in Figure 1.

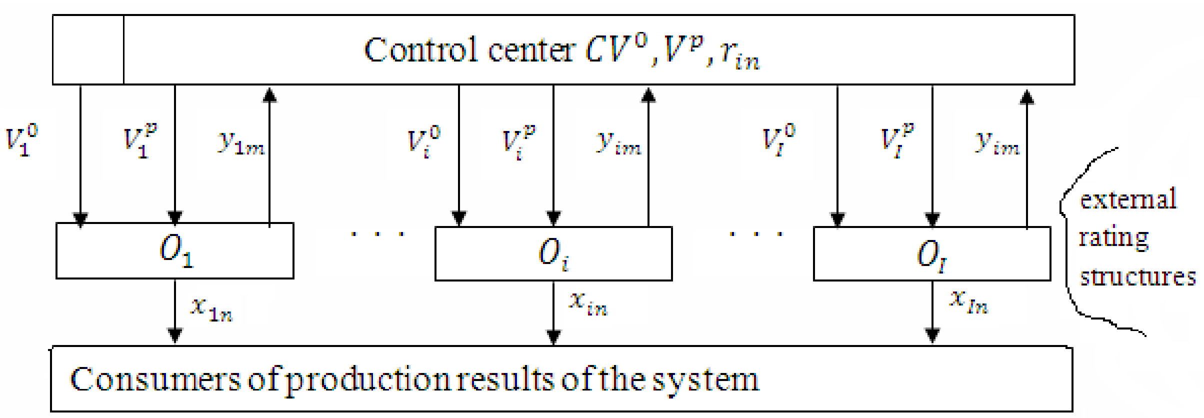

Figure 1. – The structure of the interaction of the control center with the objects of the industrial system in rating control

Characteristics of rating mechanisms for objects in production systems

Let's consider the features of the mechanisms of the rating assessment. They come from a third classification attribute. However, in the control of resource provision there is a need of coordination of interests of the control centre and close to the production system.

Therefore, the solution to the problem of resource provision it is proposed to use the following mechanisms: control allocation of resource support to implementation of all areas of the main activities of the production system; control the alignment of interests control center and production system in the allocation of additional security to development; control allocation of additional resource provision for the development of production systems with the greatest potential of changing their rating status [5, 6].

In the case of the first mechanism of rating areas in accordance with the magnitude of the internal rating r_{in} distributed resource provision V^0 between objects O_i. As a result, for each n-th main activities of the *i*-th object control center allocates resource support in the amount of $V_{in}^0, i = \overline{1, I}, n = \overline{1, N}$.

For such distribution, in addition to the ratings take account of the requirements in the resource security of the *i*-th object for an *n*-th main activities - $\hat{V}_{in}^0, i = \overline{1, I}, n = \overline{1, N}$. The second control mechanism is aimed at minimizing the total costs for the implementation of the core activities of all the objects included in the production system. While at the administration control center and objects have conflicting interests in the use of resource provision production system for the n −th focus (1):

$$V_n^0 = \sum_{i=1}^{I} V_{in}^0 \qquad (1)$$

and the total resource provision allocated to each object for the implementation of core activities (2)

$$V_i^0 = \sum_{n=1}^{N} V_{in}^0. \qquad (2)$$

By controlling the choice of the values $x_{in}, i = \overline{1, I}, n = \overline{1, N}$, it is necessary to achieve coordination of interests in allocating a larger resource for the main activity by the control center and saving it with the i −th object for development.

And finally, in the case of the third mechanism, rating distribution control is implemented, rating distribution distribution of additional resource support is V^g to those objects $i^1 = \overline{1, I^1} \in \overline{1, I}$, the development of which ensures the change of state with the greatest improving the value of the external rating (cluster of objects $O_{i_1}, i_1 = \overline{1, I_1}$, homogeneous objects competitive in the global environment).

Moreover, the change in state is achieved by changing a number of performance indicators y_{iml}, that affect the improvement of the external rating score in the l −th thematic direction $r_{i^1 l}$, which ultimately leads to the possibility of fulfilling the requirements of the control center to improve the rating position and prospective planning for moving to a higher cluster according to the global rating r_{i^1}.

In accordance with the second control mechanism, objects $O_{i^1}, i^1 = \overline{1, I^1}$ supplement resource provision $V_{i^1}^g$ with resource support for development due to cost savings for the main activity, which contributes to the fulfillment of the specified requirements of the control center [7, 8].

The implementation of rating control on the basis of the above mechanisms is ensured by a certain sequence of interaction between the control center and the objects of production systems.

First of all, the control center organizes monitoring of the performance of facilities according to indicators $y_{im}, i = \overline{1, I}, m = \overline{1, M}$, then selects a set of indicators a_{ij} for each direction of the main activity to calculate the value of internal rating ratings $r_{in}, i = \overline{1, I}, n = \overline{1, N}$, taking into account which the volume of resource support V_{in}^0 is determined, oriented to the needs of the *i*-th object in the resource v_{in}^0.

At the same time, a multitude of objects $i^1 = \overline{1, I^1}$, the set of objects is formed, participating in the distribution of additional resource support V^g to improve the thematic and integrated external ratings $r_{i^1 l}, r_{i^1}$ with volumes V.

Next, by coordinating the interests of the control center and the objects in the distribution of the resource supply V_n^0, the optimal values of the volume indicators of the results of the objects' activity during their interaction with consumers $x_{in}^*, i = \overline{1, I}, n = \overline{1, N}$ are determined and finally installed resource support of the main effectiveness and development - $V_i^0, V_i^p, i = \overline{1, I}$.

The block diagram of the implementation of mechanisms for rating control is presented in Figure 2.

The characteristics of modeling the interaction of the control center and objects of industrial systems

The modeling the interaction of the control center and objects of industrial systems is the basis for the implementation of rating control mechanisms [9, 10]. Rating control in accordance with the block diagram shown in Figure 2 is based on three classes of models of interaction of objects of the production system: streamlining; resource support; rating status. The first class of models is associated with methods for calculating the integral assessment of the object O_i with known values of indicators selected by the control center for conducting internal rating assessment

$$F_i = \varphi(a_{ij}) \tag{3}$$

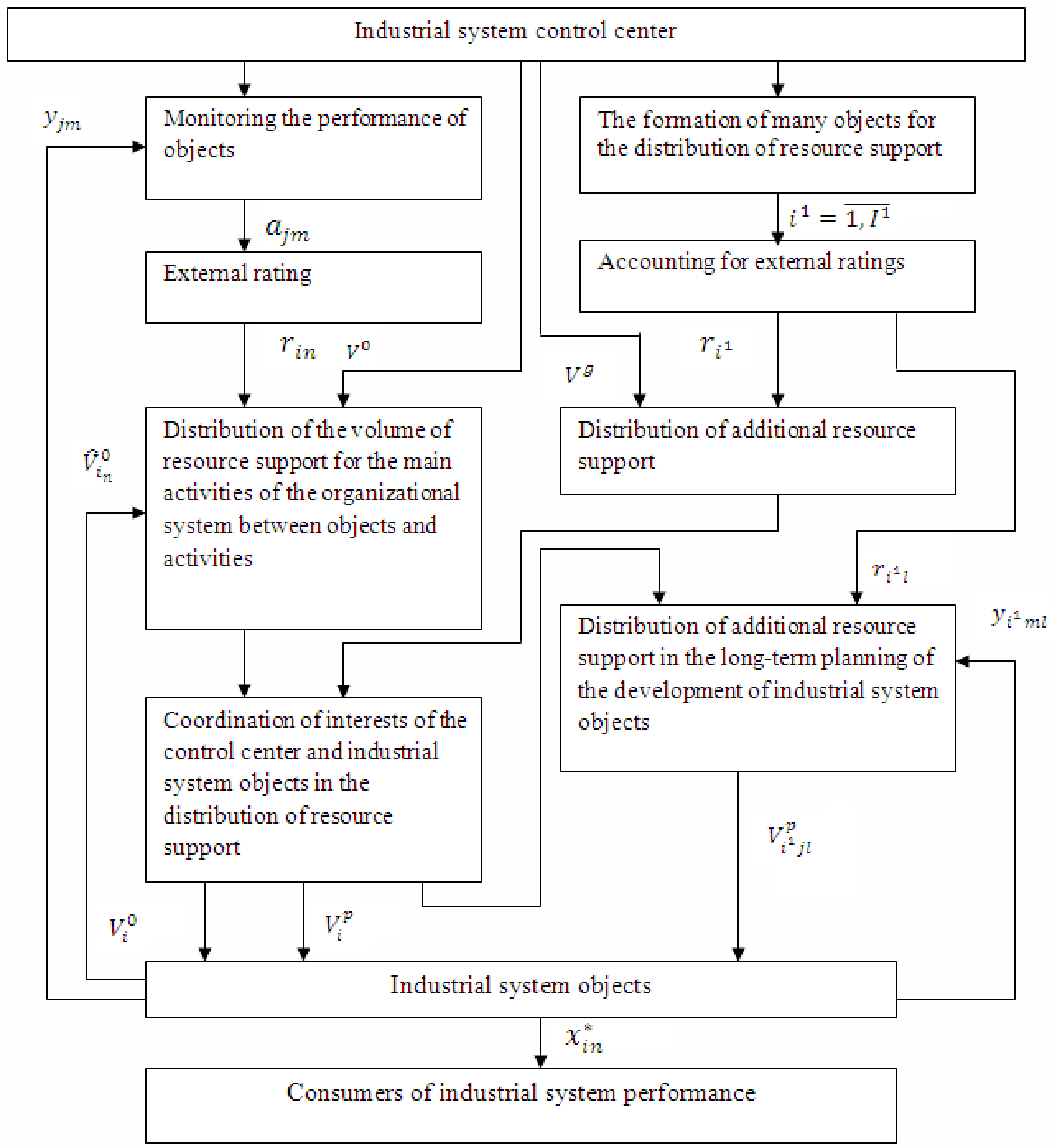

Figure 2. – The block diagram in the implementation of rating control mechanisms.

Depending on the values of (3), the numbering set of objects $i = \overline{1,I}$ is ordered with the assignment of the rating r_i. There are a number of modifications to the model (1).

The first modification is to determine the rating according to the maximum value of the quantitative assessment of the integrated indicator.

That is, the highest rating will be given to the object that receives the highest total result. The integrated indicator is determined by the formula:

$$F_i^{(1)} = \sqrt{\sum_{j=1}^{J} a_{ij}^2}, i = \overline{1,I}. \tag{4}$$

According to this modification, the rating will be formed mainly by those detailed indicators whose quantitative ratings dominate regardless of their importance (weight) and characterize only certain aspects of the successful activity of the research object.

The second modification of the rating score is based on taking into account the weight of each detailed indicator $j = \overline{1,J}$:

$$F_i^{(2)} = \sqrt{\sum_{j=1}^{J} p_{ij} \cdot a_{ij}^2}, i = \overline{1,I}, \quad (5)$$

where μ_j – is the weight coefficient of the corresponding detailed indicator, $j = \overline{1,J}$.

The third modification implements the important principle of proportionality of detailed indicators by comparing them with the indicators of the object for which the corresponding aggregated indicator has the best (maximum) value in the sample.

Results

On the basis of the proposed approach we performed a simulation control of industrial enterprise. There is a control centre and ten control objects.

The rating indicators are used to assess the compliance of the current structure of the system the possibilities for successful economic development and financial sustainability of industrial systems.

The rating control has also been used to increase the level of sales of industrial company. In addition to the interests of the company in the control model took into account the interests of the main forces in the market: competitors, local authorities, shareholders, of the population as the end user of the company's products.

On the basis of an integrated evaluation is the analysis and control of financial stability of industrial organizations.

External rating of the industrial enterprise aimed at the implementation of functions such as planning and forecasting financial solutions, financial analysis, control of execution of production plans and objectives.

The internal rating control, in addition to the above tasks, provides realization of functions of regulation of financial activities and promoting implementation of target financial performance.

Figure 3 shows the sales of the company's products without the use of rating mechanisms (curve 1) and with use these mechanisms (curve 2). Figure 4 shows how varied ranking position of the industrial organization among the sampled 100 plants.

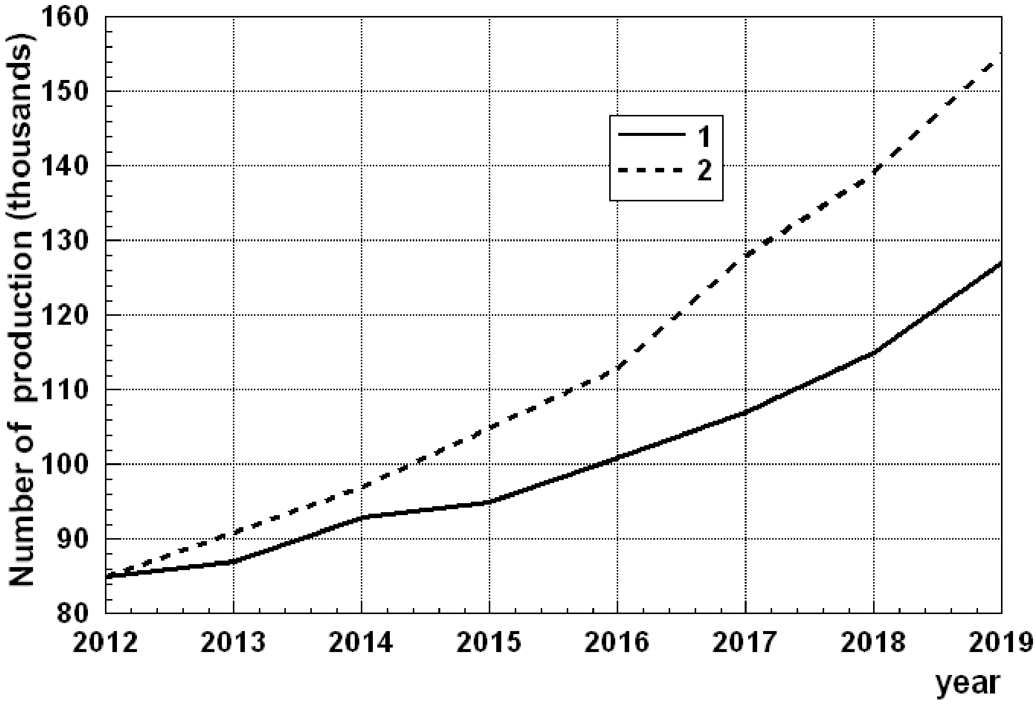

Figure 3. – The dependence of the number of products on the without and with rating control

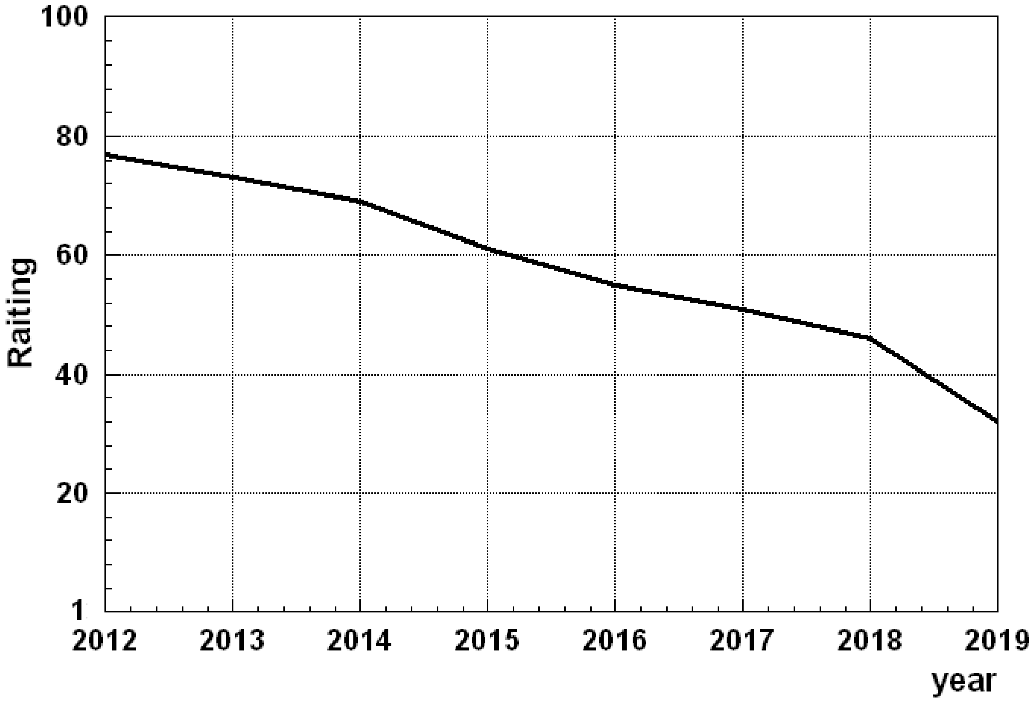

Figure 4. – The change in the rating of the industrial organization depending on the year

Conclusion

The decision-making process during the control of industrial enterprises is influenced by both certain classification features of such interaction, and rating control mechanisms aimed at the efficient distribution of resource support, coordination of interests of the control center and objects of industrial systems, change in the rating status of objects. In order to model the interaction of production systems with the control center, it is advisable to use three classes of models: streamlining, resource support and rating status.

Each class is characterized by different structures and parameters of the mathematical dependencies of rating estimates on other indicators of the performance of objects and volumes of resource support, which entails the multivariate implementation of rating control mechanisms. The results are presented that demonstrate the effectiveness of applying rating approaches as an example of increasing sales volumes of products.

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