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## INFORMATION TECHNOLOGY OF RATIONAL RESOURCE ALLOCATION IN THE SYSTEM OF BUSINESS PROCESSES OF THE ORGANIZATION

The problem of rational distribution of investment resources among individual business processes of the organizational and technical system is considered taking into account the real characteristics of the primary data (in particular, the interval uncertainty of expert assessment). The **subject matter** of the study is the models and methods of information technology of rational distribution of resources in the system of business processes of the organization, the **goal** is to ensure the quality of organization management by creating applied information technology of rational resource distribution in the system of business processes taking into account the interval of expert assessments. The following **tasks** were solved in the work: the matrix method for assessing the level of efficiency of the hierarchical system of business processes of the organization was developed; methods and means of infographic analysis of aggregated indices of multidimensional objects and systems were developed; an optimization model of resource distribution in the system of business processes of the organization was developed; the applied information technology of rational distribution of resources in the system of business processes of the organization was created. The following **methods** were used as the basis of the research methodology: the matrix analysis was used for developing the matrix method for assessing the level of efficiency of the hierarchical system of the organization business processes as well as for developing methods and tools for the infographic analysis of aggregated indices of multidimensional objects and systems; the methods of linear programming and interval analysis were used for developing an optimization model of resource distribution in the system of business processes of the organization; the principles of system analysis were used for developing applied information technology, rational allocation of resources in the system of business processes of the organization. As a **result**, the methodical support of information technology for the rational distribution of resources in the system of business processes of the organization was developed. The place of the described models is shown in the process of supporting decisions on distributing resources in the system of business processes of the organization taking into account the interval of expert assessments.

**Keywords:** information technology, business process, interval methods, expert assessment.

### Introduction

The present trends in management reflect mainstreaming information technologies (IT) in the managerial decision loop. It is connected with the continuous growth of data amount on production objects and processes, the expansion of the organization and technical systems (OTS), and the spread of information technologies in general.

The desire to use all available information in the process of making decisions leads, on the one hand, to the increase in the degree of validity of managerial decisions, and on the other hand, to the inevitable increase in the role of man-machine decision support systems (DSS). In this case, the methodological support of such systems should reflect the entire range of uncertainties inherent in the decision-making process [1].

The number and variety of methods used to solve similar tasks are caused by the multivariate methods of formalizing individual functions and properties of the organization [2]. Practical application of such models and methods, as a rule, is characterized by a limited time for modelling, the lack of qualifications or information for efficient modelling, weak reliability in dealing with fuzzy data, and inter-level inconsistency between decision makers.

A separate circumstance inherent in the decision-making process in complex OTS is the use of expert assessments in a number of practical tasks as initial management information.

All these objective circumstances stimulate creating applied specialized IT for solving practical control problems on the basis of models and methods that take into account the real characteristics of the primary data (their volume, accuracy, uncertainty, and so on).

### Analysis of literary sources and problem statement

Among the urgent tasks of strategic management of OTS in the context of this study are the following:

- the task of assessing the efficiency of OTS internal structure and functional areas;
- the task of rational distribution of resources in the OTS business process system.

The problem of managing the efficiency of business processes [3] resulted in the whole scientific area where researchers consider various aspects. For example, the works [4, 5] deal with the general issues of business modelling, the work [6] focuses on the issues of economic and mathematical modelling, the works [7–10] highlight the problems of system efficiency assessment, the works [11, 12] emphasize the issues of the synthesis of OTS optimal control models, the works [13–15] are devoted to the development of methodological tools.

Despite the detailed and comprehensive study of the aspects of the above problem, the following tasks remain topical:

- the development of applied IT for solving practical tasks of managing the system of OTS business processes taking into account industry profile and current quality standards;
- the development of methodological support for such IT taking into account the real characteristics of the primary information (uncertainty, delay, inaccuracy, and so on).

### The goal and objectives of the research

The subject of the study is the models and methods of IT of rational distribution of resources in the system of OTS business processes, the goal is to ensure the quality

of the organization management by creating the IT of rational distribution of resources in the system of business processes taking into account the interval of expert assessments.

The tasks to be solved are the following:

1) to develop a matrix method for assessing the level of efficiency of the hierarchical system of the OTS business processes;

2) to develop methods and tools for infographic analysis of aggregated indices of multidimensional objects and systems;

3) to develop an optimization model for resource distribution in the system of OTS business processes;

4) to create an applied IT of rational distribution of the resources in the system of OTS business processes taking into account the interval of expert assessments.

### Matrix method for assessing the efficiency of the hierarchical system of business

According to [4], the system of OTS business processes can be represented by functional areas of activity (for example, the organizational structure of management, management system, marketing, the system of production organization, enterprise personnel, supply, marketing, etc.) [14].

Using the notation and logic adopted in [8], the methodology for assessing the level of relative efficiency of the hierarchical system of business processes in an organization taking into account the interval uncertainty of data.

The object of management (the base organization) is characterized by a set of vectors  $X_1, X_2, \dots, X_n$  that reflect the level of efficiency  $n$  of the organization business processes where each one consists of the components of relative indices of the efficiency of the corresponding business process:

$$\begin{aligned} X_1 &= [x_{11}, x_{12}, \dots, x_{1l_1}], \\ X_2 &= [x_{21}, x_{22}, \dots, x_{2l_2}], \\ &\dots \\ X_n &= [x_{n1}, x_{n2}, \dots, x_{nl_n}], \end{aligned} \quad (1)$$

where  $l_1, l_2, \dots, l_n$  are the dimensions of  $X_1, X_2, \dots, X_n$  vectors.

The component  $x_{ij}$  is the relative efficiency of the  $j^{\text{th}}$  component of the  $i^{\text{th}}$  business process and is assessed by experts by comparing to similar business processes of business rivals.

Proceeding from the essence of  $x_{ij}$  indices, the area of their admissible value is the interval  $x_{ij} \in [0, 1]$ , although it can be different depending on the grading scale chosen by experts. One corresponds to the maximum efficiency of the  $j^{\text{th}}$  component of the  $i^{\text{th}}$  business process in the group of assessed organizations.

A set of vectors (1) can be presented as the compound matrix  $\mathbf{X}_0$  of the following structure:

$$\mathbf{X}_0 = \begin{bmatrix} [X_1] & 0 & 0 & \dots & 0 \\ [ & X_2 & ] & 0 & \dots & 0 \\ \dots & & & & & \\ [ & & & X_k & & ] \\ \dots & & & & & \\ [ & & & & & X_n & ] & 0 & \dots & 0 \end{bmatrix}, \quad (2)$$

where  $X_k$  is the vector of maximum dimension from a set of  $X_1, X_2, \dots, X_n, l_k = \max_{i=1}^n \{l_i\}$ .

Let each  $n$  business process in the organization is characterized by the column vector of the coefficients of relative significance of a business process components

$$A_i = [\alpha_{i1} \quad \alpha_{i2} \quad \dots \quad \alpha_{il_i}]^T, \quad i = 1, 2, \dots, n, \quad (3)$$

where  $\alpha_{ij}$  is the coefficient of the relative significance of the  $j^{\text{th}}$  component of the  $i^{\text{th}}$  business process, and  $0 \leq \alpha_{ij} \leq 1, \sum_{j=1}^{l_i} \alpha_{ij} = 1, i = 1, 2, \dots, n$ .

A set of vectors (3) can be presented as the compound matrix  $\mathbf{A}$  built like  $\mathbf{X}_0$ :

$$\mathbf{A} = \begin{bmatrix} [A_1]^T & 0 & 0 & \dots & 0 \\ [ & A_2 & ]^T & 0 & \dots & 0 \\ \dots & & & & & \\ [ & & & A_k & & ]^T \\ \dots & & & & & \\ [ & & & & & A_n & ]^T & 0 & \dots & 0 \end{bmatrix}, \quad (4)$$

where  $A_k$  is the vector of the maximum dimension from the set (3).

The product of matrices  $\mathbf{X}_0\mathbf{A}$  is the square matrix with the dimension of  $n \times n$  which contains the relative efficiency  $n$  of business processes in the principal diagonal:

$$\mathbf{X}_0\mathbf{A} = \begin{bmatrix} X_1A_1 & X_1A_2 & \dots & X_1A_n \\ X_2A_1 & X_2A_2 & \dots & X_2A_n \\ \dots & \dots & \dots & \dots \\ X_nA_1 & X_nA_2 & \dots & X_nA_n \end{bmatrix}. \quad (5)$$

Let  $\mathbf{B}$  be determined as the matrix with the dimension of  $n \times n$  which contains the relative coefficients of the significance of business processes in the principal diagonal

$$B = \begin{bmatrix} \beta_1 & 0 & 0 & \dots & 0 & 0 \\ 0 & \beta_2 & 0 & \dots & 0 & 0 \\ \dots & & & & & \\ 0 & 0 & 0 & \dots & \beta_{n-1} & 0 \\ 0 & 0 & 0 & \dots & 0 & \beta_n \end{bmatrix}, \quad (6)$$

where  $\beta_i$  is the relative coefficient of the significance of the  $i^{\text{th}}$  -business process, where  $0 \leq \beta_i \leq 1$ ,  $\sum_{i=1}^n \beta_i = 1$ ,  $i = 1, 2, \dots, n$ .

The matrix  $\mathbf{X}_0\mathbf{A}\mathbf{B}$  contains weighted relative efficiencies of all business processes in the principal diagonal:

$$\mathbf{X}_0\mathbf{A}\mathbf{B} = \begin{bmatrix} \beta_1 X_1 A_1 & \beta_2 X_1 A_2 & \dots & \beta_n X_1 A_n \\ \beta_1 X_2 A_1 & \beta_2 X_2 A_2 & \dots & \beta_n X_2 A_n \\ \dots & \dots & \dots & \dots \\ \beta_1 X_n A_1 & \beta_2 X_n A_2 & \dots & \beta_n X_n A_n \end{bmatrix}. \quad (7)$$

The complex relative efficiency of OTS business processes can be found determining the trace of the matrix  $\mathbf{X}_0\mathbf{A}\mathbf{B}$ :

$$E = \text{tr}(\mathbf{X}_0\mathbf{A}\mathbf{B}) = \beta_1 X_1 A_1 + \beta_2 X_2 A_2 + \dots + \beta_n X_n A_n = \sum_{i=1}^n \beta_i X_i A_i. \quad (8)$$

**Interval extension.** When the expert assessments are presented as intervals, a set of vectors (3) is written as:

$$[A_i] = \left[ [\alpha_{i1}], [\alpha_{i2}], \dots, [\alpha_{in}] \right]^T, \quad i = \overline{1, n}, \quad (9)$$

where  $[\alpha_{ij}] = [\underline{\alpha}_{ij}, \overline{\alpha}_{ij}]$  is the interval coefficient of the relative significance of the  $j^{\text{th}}$  component of the  $i^{\text{th}}$  business process, and  $[\alpha_{ij}] \subset [0, 1]$ . It is obvious that the character of point estimations  $\sum_{j=1}^{l_i} \alpha_{ij} = 1$ ,  $i = \overline{1, n}$  for the

interval coefficients is not fulfilled but in the context of the task being solved is not significant.

The nature of the interval form of the coefficient  $[\alpha_{ij}]$  is caused by the procedure of expert assessing.

Along with the agreed point estimation, interval assessment can be used at various stages of the study. The idea of using data of this type consists in the natural desire of a researcher to take into account the uncertainty in solving the task. For example, if the LPP solution is unique in the interval context, the researcher gets, besides the decision itself, also a guarantee of the fact that it will remain unchanged under any combination of the interval coefficients of the model. The width of the intervals is assumed to be insignificant in comparison with the middle part of the corresponding intervals since otherwise the

problem will be actually set in the general form and cannot be solved by definition.

A set of vectors (9) can be presented as a compound interval matrix  $[\mathbf{A}]$ :

$$[\mathbf{A}] = \begin{bmatrix} [A_1] & ]^T & 0 & 0 & \dots & 0 \\ [A_2] & ]^T & 0 & \dots & 0 \\ \dots & & & & & \\ [A_k] & ]^T & & & & \\ \dots & & & & & \\ [A_n] & ]^T & 0 & \dots & 0 \end{bmatrix}, \quad (10)$$

where  $[A_k]$  is the interval vector of the maximum dimension from a set (9).

Let us suppose that the elements of the matrix (6) are also presented in the interval form:

$$[\mathbf{B}] = \begin{bmatrix} [\beta_1] & 0 & 0 & \dots & 0 & 0 \\ 0 & [\beta_2] & 0 & \dots & 0 & 0 \\ \dots & & & & & \\ 0 & 0 & 0 & \dots & [\beta_{n-1}] & 0 \\ 0 & 0 & 0 & \dots & 0 & [\beta_n] \end{bmatrix}, \quad (11)$$

where  $[\beta_i] = [\underline{\beta}_i, \overline{\beta}_i]$  is the interval estimation of the relative coefficient of the  $i^{\text{th}}$  business process, and  $[\beta_i] \subset [0, 1]$ .

The matrix  $\mathbf{X}[\mathbf{A}][\mathbf{B}]$  contains the interval estimations of the weighted relative efficiencies of all business processes in the organization in the principal diagonal:

$$\mathbf{X}[\mathbf{A}][\mathbf{B}] = \begin{bmatrix} [\beta_1] X_1 [A_1] & [\beta_2] X_1 [A_2] & \dots & [\beta_n] X_1 [A_n] \\ [\beta_1] X_2 [A_1] & [\beta_2] X_2 [A_2] & \dots & [\beta_n] X_2 [A_n] \\ \dots & \dots & \dots & \dots \\ [\beta_1] X_n [A_1] & [\beta_2] X_n [A_2] & \dots & [\beta_n] X_n [A_n] \end{bmatrix}. \quad (12)$$

The interval estimation of the complex relative efficiency of business processes can be found determining the trace of the interval matrix  $\mathbf{X}[\mathbf{A}][\mathbf{B}]$ :

$$[E] = [\underline{E}, \overline{E}] = \text{tr}(\mathbf{X}[\mathbf{A}][\mathbf{B}]) = [\beta_1] X_1 [A_1] + [\beta_2] X_2 [A_2] + \dots + [\beta_n] X_n [A_n] = \sum_{i=1}^n [\beta_i] X_i [A_i] \quad (13)$$

Thus, the matrix method (with interval expansion) of assessing the level of the relative efficiency of the hierarchical system of OTS business processes is suggested; this method formalizes the hierarchical structure of the efficiency of business processes and, due to the matrix analytical form, enables assessing the efficiency of the structure of any order and dimension.

### Methods and means of infographic analysis of aggregated indices of multidimensional objects and systems

**The device for radial metric diagrams (RMD)** [13]. The RMD sets the  $n$ -plane metric space where the object is assessed, where  $n$  is a number of metrics  $p_i$ ,  $i = \overline{1, n}$  that are reflected in the diagram rays (fig. 1).

When several RMDs that assess the object as a whole are built, they form a hierarchical structure. As a result of the convolution of a separate low-level RMD, the generalized index is developed on the basis of the values of metrics and the coefficients of their weight (significance); the value of this index is then placed on the corresponding ray of the complex upper-level RMD, as shown in fig. 2. Similarly, for an integrated RMD, an integral index can be obtained.

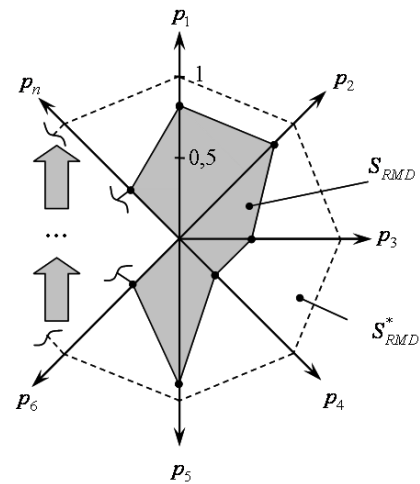


Fig. 1. RMD general view

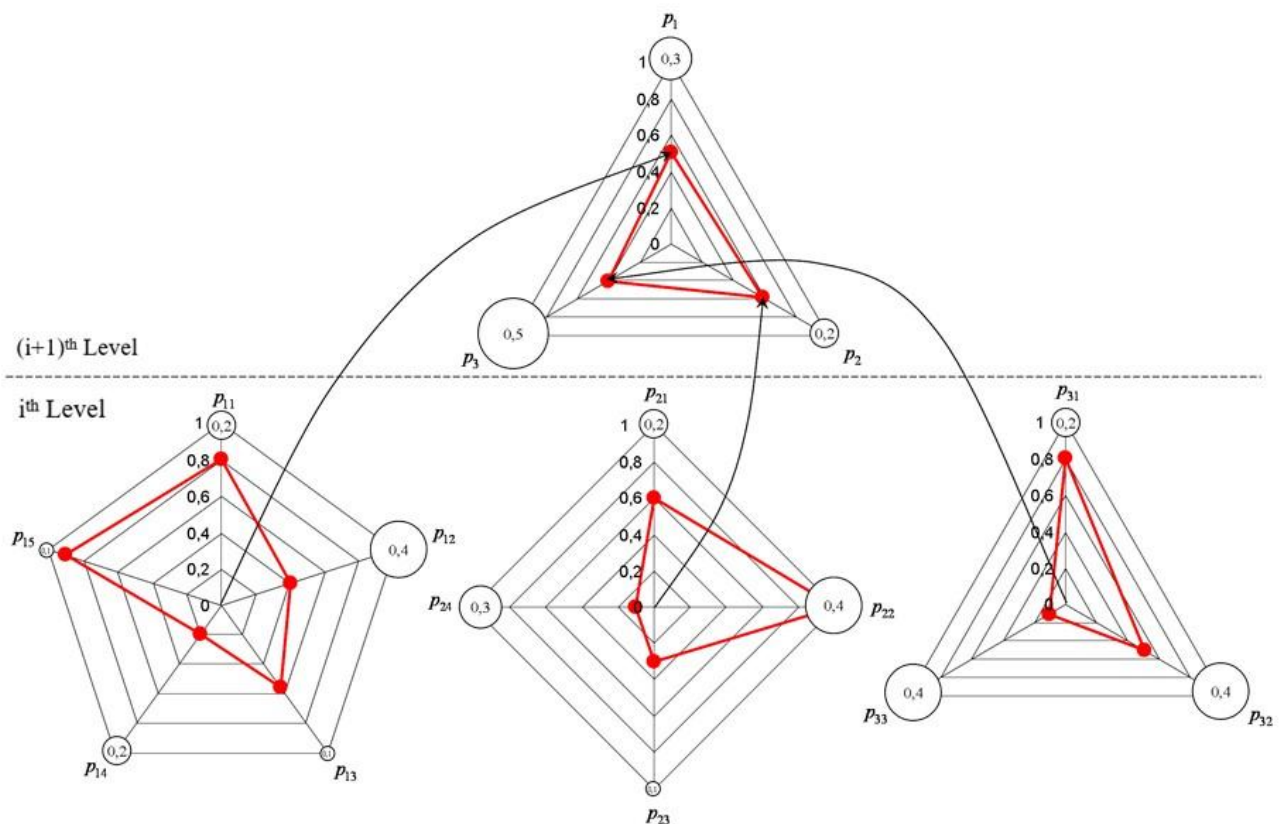


Fig. 2. The example of the convolution of radial metric diagrams

**The device for normalized diagrams (ND)** [13]. The ND is a column diagram of metrics  $p_i$ ,  $i = \overline{1, n}$  according to which the object is assessed, and the width of a separate column is equal to the corresponding weight coefficient  $\alpha_i$  of the  $i$ -th metric (fig. 3).

Similar to RMDs, NDs can and should describe the multilevel hierarchical system of indices (metrics) as shown in fig. 4.

Based on the results of a comparative analysis of two means of multivariate analysis of aggregated indicators of organizational and technical systems, namely, RMD and ND, the following conclusions can be drawn:

1) radial metric and normalized diagrams are graphoanalytical models and enables visualizing the structure and significance of aggregated indicators of the OTS;

2) NDs are linear (invariant), while RMDs are nonlinear (noninvariant) with respect to metrics (to the order of metrics);

3) when analyzing linearly aggregated indices, the ND area, in contrast to the RMD area, has the geometric interpretation;

4) when analyzing multilevel (more than two) aggregated indices, it is preferable to use ND due to the strictness of the graphoanalytical apparatus and the consequences of Section 3.

**The optimization model of resource distribution in the system of OTS business process**

The urgent task in the context of the chosen method of formalization is selecting the variant of the rational

distribution of investment resources among individual business processes of the OTS.

The presented problem can be reduced to the classical linear programming problem (LPP) in the following way [16].

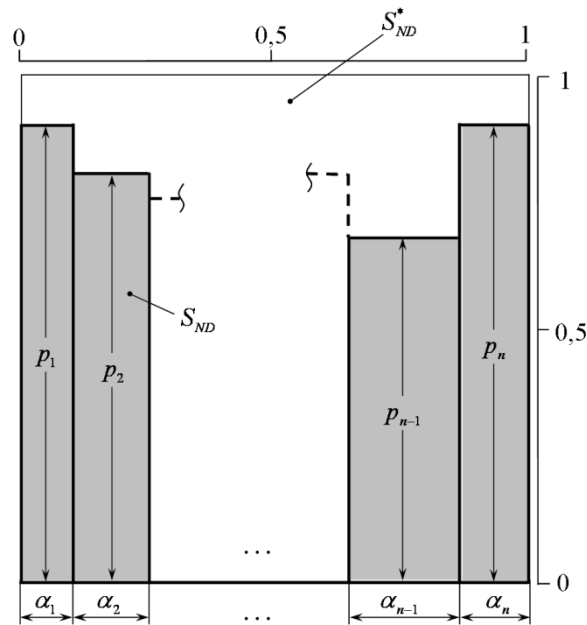


Fig. 3. ND general view

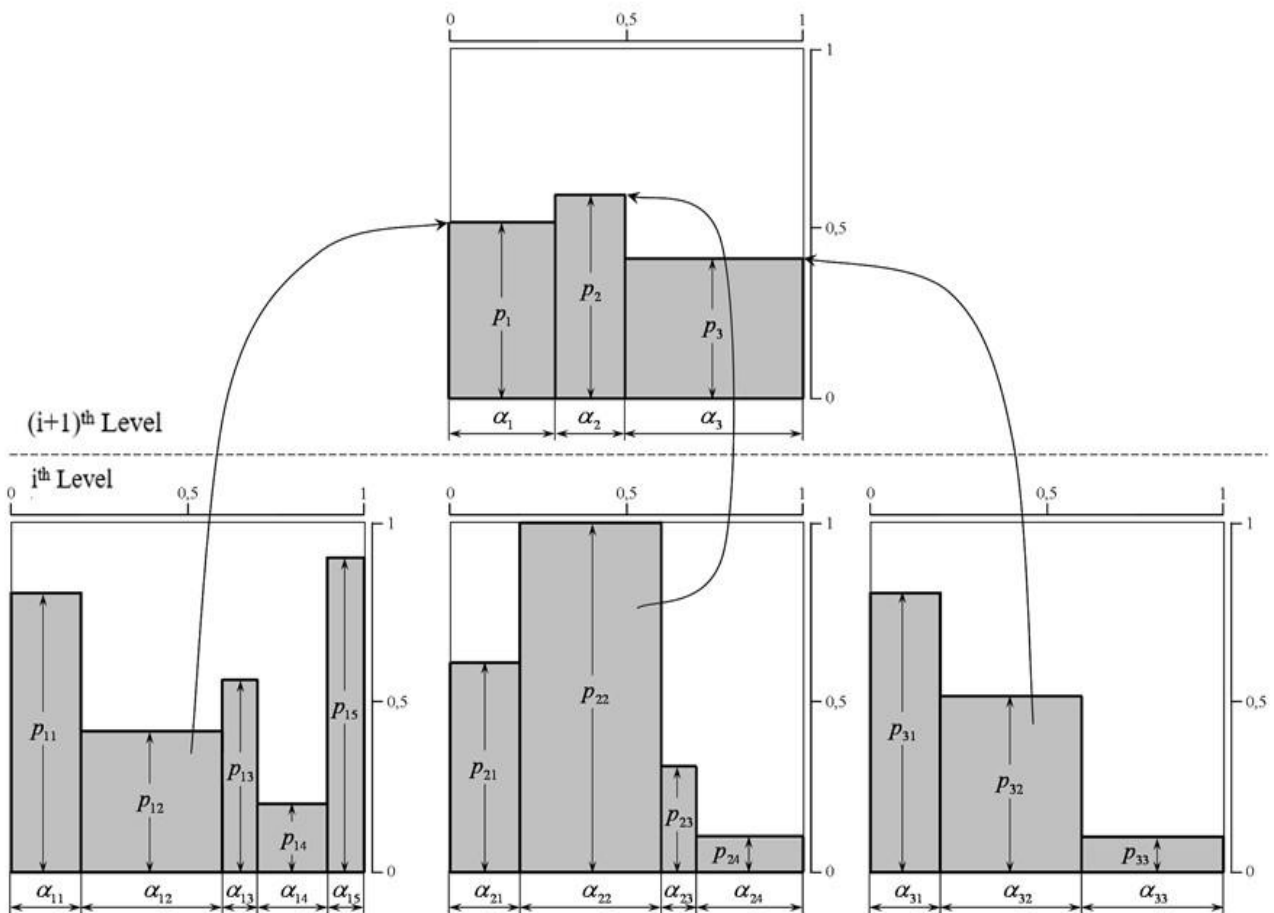
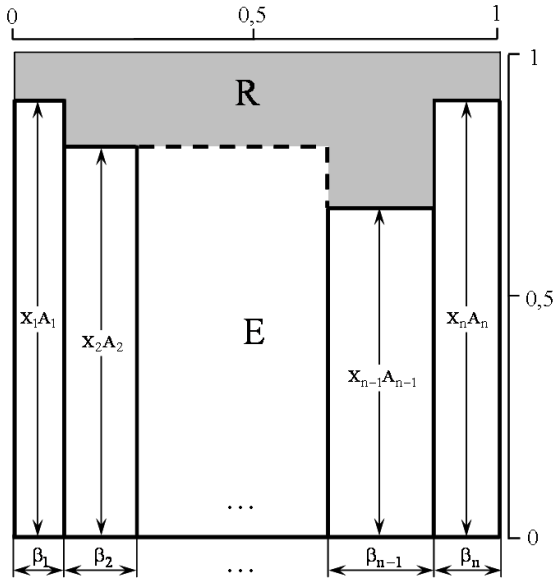


Fig. 4. The example of the convolution of normalized diagrams



Let a set of the elements of the main diagonal of the matrix **XAB** be presented as a normalized diagram as shown in fig. 5.



**Fig. 5.** The normalized diagram of the efficiency of OTS business processes

The complex relative efficiency of OTS business processes, according to (8), is numerically equal to the area of the figure *E* bounded by columns in the height that is equal to the level of the relative efficiency of the business process and in the width that is equal to the relative coefficients of the significance of the business process.

The area of the figure *R* which completes the figure of efficiency *E* to the square with the unit side characterizes the degree of the break, that is the difference between the ideal (reference) and the real state of the efficiency of OTS business processes.

The length of the break that is numerically equal to the area of the figure *R* in fig. 5, equals

$$R = 1 - E = 1 - \sum_{i=1}^n \beta_i X_i A_i . \tag{14}$$

Both the value of the break *R* and the value of the complex relative efficiency of business processes in the organization *E* can act as a functional in LPP up to a sign.

Let us formalize LPP in the standard form according to the set task and the notations introduced above.

Let *Q* be the vector of resources distributed for managing the marketability of the organization, whose components characterize the supplies of specific resources, for example, material, information, technological, personnel, and so on.

$$Q = [q_1, q_2, \dots, q_m], \tag{15}$$

where *m* is the amount of resource types.

Let *c<sub>ij</sub>* be the amount of the resource of the *i*<sup>th</sup> type necessary for increasing the efficiency of the *j*<sup>th</sup> business process by 1% (table 1).

**Table 1.** Initial data for LPP in the standard form

Resource type	Resource supply	A number of resource units for 1% growth of the efficiency of a business process (BP)				
		<i>BP</i> <sub>1</sub>	<i>BP</i> <sub>2</sub>	...	<i>BP</i> <sub><i>n</i>-1</sub>	<i>BP</i> <sub><i>n</i></sub>
1	<i>q</i> <sub>1</sub>	<i>c</i> <sub>11</sub>	<i>c</i> <sub>12</sub>	...	<i>c</i> <sub>1<i>n</i>-1</sub>	<i>c</i> <sub>1<i>n</i></sub>
2	<i>q</i> <sub>2</sub>	<i>c</i> <sub>21</sub>	<i>c</i> <sub>22</sub>	...	<i>c</i> <sub>2<i>n</i>-1</sub>	<i>c</i> <sub>2<i>n</i></sub>
...	...	...	...	...	...	...
<i>m</i> -1	<i>q</i> <sub><i>m</i>-1</sub>	<i>c</i> <sub><i>m</i>-11</sub>	<i>c</i> <sub><i>m</i>-12</sub>	...	<i>c</i> <sub><i>m</i>-1<i>n</i>-1</sub>	<i>c</i> <sub><i>m</i>-1<i>n</i></sub>
<i>m</i>	<i>q</i> <sub><i>m</i></sub>	<i>c</i> <sub><i>m</i></sub> 1	<i>c</i> <sub><i>m</i></sub> 2	...	<i>c</i> <sub><i>m</i></sub> <i>n</i> -1	<i>c</i> <sub><i>m</i></sub> <i>n</i>

The function of increasing the complex efficiency of business processes in the organization is chosen as the target function:

$$Z = \Delta E = -\Delta R = 0,01 \sum_{j=1}^n \beta_j X_j A_j y_j \rightarrow \max , \tag{16}$$

where *y<sub>j</sub>* is the amount of procedures aimed at increasing the efficiency of the *j*<sup>th</sup> business process.

Finally, LPP in the standard form will be the following: to ensure the maximum value of the target function (16) under limiting conditions

$$\begin{cases} \sum_{j=1}^n c_{ij} y_j \leq q_i, i = \overline{1, m}, \\ y_j \geq 0, j = \overline{1, n}. \end{cases} \tag{17}$$

The solution of LPP  $Y^* = [y_1^*, y_2^*, \dots, y_n^*]$  reflects

the optimum relationship among the amounts of procedures for increasing the efficiency of individual business processes in the organization.

Thus, the optimization mechanism for selecting strategies for increasing the marketability of an organization that is based on bringing the model of the strategic management of the business process efficiency to a linear programming model is suggested; this mechanism ensures the optimal distribution of resources among the amounts of procedures for increasing the efficiency of OTS individual business processes.

**Interval extension.** Suppose, that there is a set of strategies that consist of separate procedures aimed at improving business processes according to the cumulative principle.

The considered task with such assumptions can be reduced to LPP in the interval form.

A set of the elements of the main diagonal of the matrix (12) is presented as a normalized diagram for interval estimations (fig. 6).

The interval estimation of the complex relative efficiency of business processes in the organization according to (13) is limited from left by the area of the figure *E* (the sum of areas of shaded rectangles in fig. 6) and from right by the area of the figure *E* (the sum of areas of shaded rectangles in fig. 6). It is this evaluation that can serve as a functional in LPP, which in this case can be formalized in a standard form.

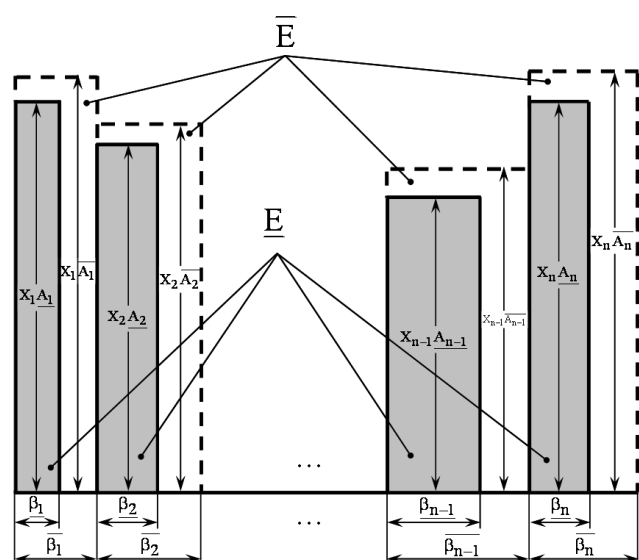


Fig. 6. The normalized diagram of the interval estimation of the efficiency of OTS business processes

The interval function of increasing the complex efficiency of the business process in the organization is used as a target function:

$$[Z] = [\Delta E] = 0,01 \sum_{j=1}^n [\beta_j] X_j [A_j] y_j \rightarrow \max, \quad (18)$$

where  $y_j$  is the amount of procedures aimed at increasing the efficiency of the  $j^{\text{th}}$  business process.

Finally, the interval LPP in a standard will be the following: to ensure maximal value of the interval target functions (18) under limiting conditions

$$\begin{cases} \sum_{j=1}^n c_{ij} y_j \leq q_i, \quad i = \overline{1, m}, \\ y_j \geq 0, \quad j = \overline{1, n}. \end{cases} \quad (19)$$

It is evident, that there is LPP with the linear interval function.

According to [17], the interval task (18) – (19) can be reduced to two deterministic problems.

Lower boundary problem:

$$\begin{cases} \underline{Z} = \max, \\ \sum_{j=1}^n c_{ij} y_j \leq q_i, \quad i = \overline{1, m}, \\ y_j \geq 0, \quad j = \overline{1, n}. \end{cases} \quad (20)$$

Upper boundary problem:

$$\begin{cases} \overline{Z} = \max, \\ \sum_{j=1}^n c_{ij} y_j \leq q_i, \quad i = \overline{1, m}, \\ y_j \geq 0, \quad j = \overline{1, n}. \end{cases} \quad (21)$$

The task (18) – (19) is solved by solving their lower and upper boundary tasks:

$$\{Y^* \in M_l(y) \cap M_u(y), [Z]_{\max} = [\underline{Z}_{\max}, \overline{Z}_{\max}]\}, \quad (22)$$

where  $M_l(y)$ ,  $M_u(y)$  are sets of points  $y = (y_1, \dots, y_n)$  of solutions of the lower and upper boundary task,  $\underline{Z}_{\max}$ ,  $\overline{Z}_{\max}$  are maximum values of the target functions of these tasks.

Any point from the set intersection  $M_l(y)$ ,  $M_u(y)$  is taken as solution point in (22), and the interval from the maximum of the target function of the lower boundary task  $\underline{Z}_{\max}$  to the maximum of the target function of the upper boundary task  $\overline{Z}_{\max}$  is taken as the maximum value of the target function  $[Z]_{\max}$ .

The advantage of this approach to solving the interval problem of conditional optimization lies in the possibility of applying traditional, well-developed methods for solving deterministic optimization problems [17].

The solution of LPP  $Y^* = (y_1^*, y_2^*, \dots, y_n^*)$  reflects the optimum relationship among the amounts of procedures for increasing the efficiency of individual business processes in the organization in the context of any parameters of the system within the target intervals.

### The results of modelling

The structure of the information technology of the rational distribution of resources in the system of OTS business processes is shown in fig. 7.

The results of modelling are illustrated with the example whose initial data are presented in tables 2 – 4.

Table 2. Interval relative coefficients of the significance of OTS business processes

Business process	Relative coefficients of significance	Value
Marketing	$[\beta_1]$	$[0,34;0,36]$
The system of production organization	$[\beta_2]$	$[0,64;0,66]$

Table 3. Initial data for 2D LPP (example)

Resource type	Resource reserve	Specific quantity of the resource pecypca for 1% of efficiency growth	
		$BP_1$	$BP_2$
$q_1$	20	2	5
$q_2$	40	8	5
$q_3$	30	5	6

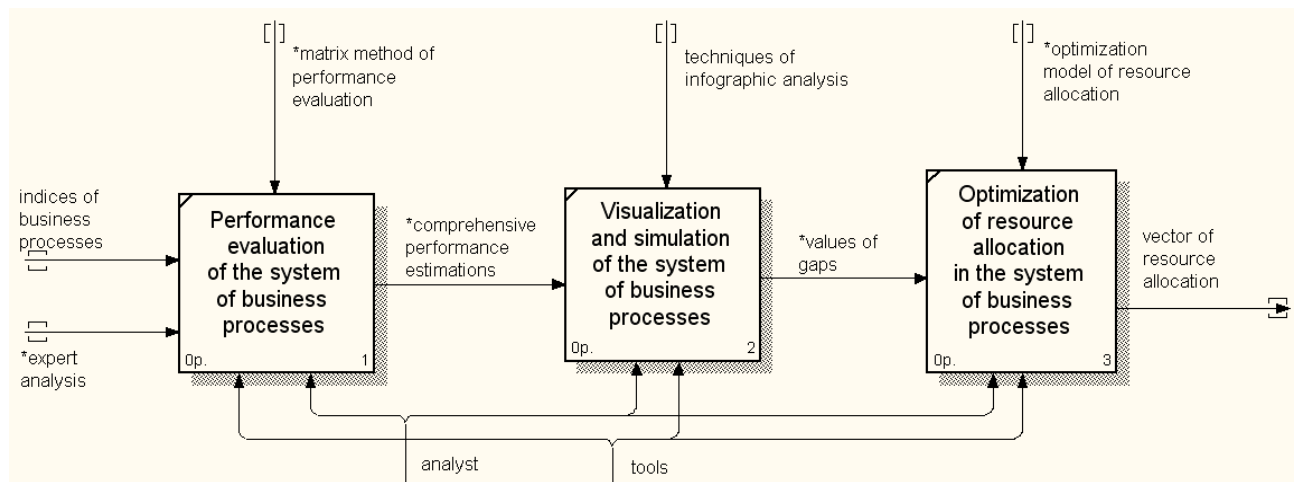


Fig. 7. The structure of the information technology of the rational distribution of resources in the system of OTS business processes

Table 4. The structure and features of business processes

Business process	The components of a business process	Relative efficiency of the component $x_{ij}$	Interval relative coefficient of significance of the component $[\alpha_{ij}]$
1. Marketing	1.1 The system of marketing organization	1	[0,17;0,19]
	1.2 The system of marketing research	0,9	[0,17;0,19]
	1.3 Assortment policy	0,8	[0,15;0,17]
	1.4 Pricing policy	0,8	[0,15;0,17]
	1.5 Communication policy	0,7	[0,15;0,17]
	1.6 Distributive policy	0,8	[0,15;0,17]
2. The system of production organization	2.1 Employment volume	0,8	[0,9;0,11]
	2.2 The main technologies used	0,8	[0,11;0,13]
	2.3 Innovations in the production process	0,8	[0,11;0,13]
	2.4 The degree of mastering the available technologies	0,8	[0,12;0,14]
	2.5 Technological base of an enterprise	0,9	[0,14;0,16]
	2.6 Production planning system	0,8	[0,13;0,15]
	2.7 The system of production quality support	0,8	[0,13;0,15]
	2.8 Labour productivity	0,7	[0,9;0,11]

The interval estimation of the complex relative efficiency of the business process in the organization is written according to (7):

$$[E] = tr(\mathbf{X}[\mathbf{A}][\mathbf{B}]) = [0,74216;0,89322].$$

The normalized diagram of the efficiency is presented in fig. 8.

The interval target function is written according to (18):

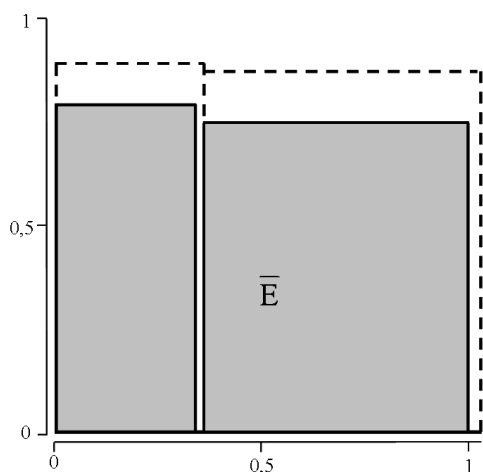
$$[Z] = 0,01 \cdot [0,34;0,36] \cdot [0,788;0,888] \cdot y_1 + 0,01 \cdot [0,64;0,66] \cdot [0,741;0,869] \cdot y_2 \rightarrow \max,$$

and limitations are written according to (19):

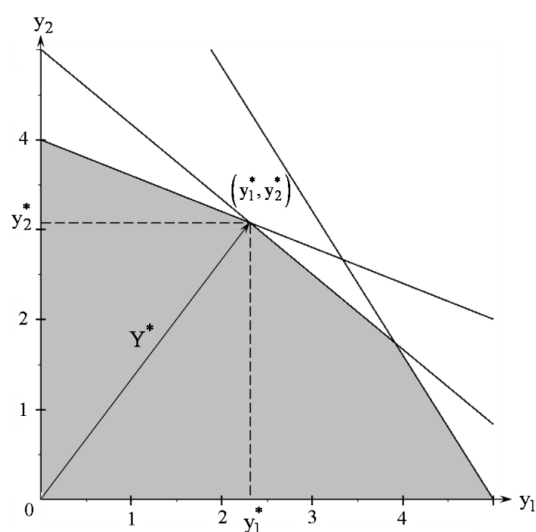
$$\begin{cases} 2y_1 + 5y_2 \leq 20, \\ 8y_1 + 5y_2 \leq 40, \\ 5y_1 + 6y_2 \leq 30, \\ y_1 \geq 0, \\ y_2 \geq 0. \end{cases}$$

For solving the lower (20) and upper (21) tasks the simplex method is used, this method is implemented in the simplex package of the system of the computerized algebra Maple (fig. 9).





**Fig. 8.** The normalized diagram of the efficiency of two business processes in the organization (example)



**Fig. 9.** The graphic presentation of restricting conditions with the use of graphical tools

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The obtained optimal solution  $Y^* = (y_1^*, y_2^*) = \left(\frac{30}{13}, \frac{40}{13}\right)$ ,  $[Z] = [0,021; 0,025]$  reflects the proportions for distributing resources for corresponding strategies under any combination of initial data within the given intervals.

## Conclusions

The problem of rational distribution of investment resources among the individual business processes of the organizational and technical system is considered.

The structure of applied information technology for the rational distribution of resources in the system of business processes of the organizational and technical system is developed taking into account the interval of expert assessments.

The methodological support of the developed information technology comprised:

- the matrix method (with interval extension) for assessing the level of the relative efficiency of the hierarchical system of OTS business processes that formalizes the hierarchical structure of business processes and enables assessing the efficiency of the structure of any order and dimension;
- the methods and means of infographic analysis and visualization of aggregated indices of multidimensional objects, in particular, normalized efficiency diagrams;
- the optimization model (with interval extension) of resource distribution in the system of OTS business processes.

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## ІНФОРМАЦІЙНА ТЕХНОЛОГІЯ РАЦІОНАЛЬНОГО РОЗПОДІЛУ РЕСУРСІВ В СИСТЕМІ БІЗНЕС-ПРОЦЕСІВ ОРГАНІЗАЦІЇ

Розглянуто задачу раціонального розподілу інвестиційних ресурсів між окремими бізнес-процесами організаційно-технічної системи з урахуванням реальних характеристик первинних даних (зокрема, інтервальної невизначеності експертних оцінок). **Предметом** дослідження є моделі і методи інформаційної технології раціонального розподілу ресурсів в системі бізнес-процесів організації, **метою** – забезпечення якості управління організацією шляхом створення прикладної інформаційної

технології раціонального розподілу ресурсів в системі бізнес-процесів з урахуванням інтервальної експертних оцінок. В роботі вирішені наступні **завдання**: розроблений матричний метод оцінювання рівня ефективності ієрархічної системи бізнес-процесів організації; розроблені методи і засоби інфографічного аналізу агрегованих показників багатовимірних об'єктів і систем; розроблена оптимізаційна модель розподілу ресурсів в системі бізнес-процесів організації; створена прикладна інформаційна технологія раціонального розподілу ресурсів в системі бізнес-процесів організації. В основу методології дослідження покладено такі **методи**: матричний аналіз – при розробці матричного методу оцінювання рівня ефективності ієрархічної системи бізнес-процесів організації, а також при розробці методів і засобів інфографічного аналізу агрегованих показників багатовимірних об'єктів і систем; методи лінійного програмування та інтервального аналізу - при розробці оптимізаційної моделі розподілу ресурсів в системі бізнес-процесів організації; принципи системного аналізу - при розробці прикладної інформаційної технології раціонального розподілу ресурсів в системі бізнес-процесів організації. В **результаті** розроблено методичне забезпечення інформаційної технології раціонального розподілу ресурсів в системі бізнес-процесів організації. Показано місце описаних моделей в процесі підтримки прийняття рішень щодо розподілу ресурсів в системі бізнес-процесів організації з урахуванням інтервальної експертних оцінок.

**Ключові слова:** інформаційна технологія, бізнес-процес, інтервальні методи, експертне оцінювання

## **ИНФОРМАЦИОННАЯ ТЕХНОЛОГИЯ РАЦИОНАЛЬНОГО РАСПРЕДЕЛЕНИЯ РЕСУРСОВ В СИСТЕМЕ БИЗНЕС-ПРОЦЕССОВ ОРГАНИЗАЦИИ**

Рассмотрена задача рационального распределения инвестиционных ресурсов между отдельными бизнес-процессами организационно-технической системы с учетом реальных характеристик первичных данных (в частности, интервальной неопределенности экспертных оценок). **Предметом** исследования являются модели и методы информационной технологии рационального распределения ресурсов в системе бизнес-процессов организации, **целью** – обеспечение качества управления организацией путем создания прикладной информационной технологии рационального распределения ресурсов в системе бизнес-процессов с учетом интервальности экспертных оценок. В работе решены следующие **задачи**: разработан матричный метод оценивания уровня эффективности иерархической системы бизнес-процессов организации; разработаны методы и средства инфографического анализа агрегированных показателей многомерных объектов и систем; разработана оптимизационная модель распределения ресурсов в системе бизнес-процессов организации; создана прикладная информационная технология рационального распределения ресурсов в системе бизнес-процессов организации. В основу методологии исследования положены следующие **методы**: матричный анализ – при разработке матричного метода оценивания уровня эффективности иерархической системы бизнес-процессов организации, а также при разработке методов и средств инфографического анализа агрегированных показателей многомерных объектов и систем; методы линейного программирования и интервального анализа – при разработке оптимизационной модели распределения ресурсов в системе бизнес-процессов организации; принципы системного анализа – при разработке прикладной информационной технологии рационального распределения ресурсов в системе бизнес-процессов организации. В **результате** разработано методическое обеспечение информационной технологии рационального распределения ресурсов в системе бизнес-процессов организации. Показано место описанных моделей в процессе поддержки принятия решений по распределению ресурсов в системе бизнес-процессов организации с учетом интервальности экспертных оценок.

**Ключевые слова:** информационная технология, бизнес-процесс, интервальные методы, экспертное оценивание