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MODELLING OF INFORMATION SYSTEMS FOR MANAGING THE RESOURCE ALLOCATION

The article suggests and mathematically describes the two of allocating resources: proportional and priority on the basis of which a software product that allows to adjust the enterprise budget has been developed methods and tested.

Keywords: *information system; proportional method of resource allocation; priority method of resource allocation.*

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МОДЕЛЮВАННЯ ІНФОРМАЦІЙНОЇ СИСТЕМИ УПРАВЛІННЯ РОЗПОДІЛОМ РЕСУРСІВ*

У статі запропоновано та математично описано два способи розподілу ресурсів: пропорційний і пріоритетний, на основі яких створено і апробовано програмний продукт, що дозволяє проводити коригування кошторису підприємства.

Ключові слова: *інформаційна система, пропорційний метод розподілу ресурсів, пріоритетний метод розподілу ресурсів.*

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МОДЕЛИРОВАНИЕ ИНФОРМАЦИОННОЙ СИСТЕМЫ УПРАВЛЕНИЯ РАСПРЕДЕЛЕНИЕМ РЕСУРСОВ

В статье предложены и математически описаны два способа распределения ресурсов: пропорциональный и приоритетный, на основе которых создан и апробирован программный продукт, позволяющий проводить корректировку сметы предприятия.

Ключевые слова: *информационная система, пропорциональный метод распределения ресурсов, приоритетный метод распределения ресурсов.*

Introduction. Contemporary issues in the field of financial management of the enterprise is budgeting, or speaking in other words, the task of forming a comprehensive financial plan. Fuzzy goals and lack of planning technology lead to the fact that in spite of planning economic and financial services covering all the documents, it is still difficult to make operational decisions in management in relation to business and finance. Therefore, there is a need to develop a simulation model of information management system for resources distribution.

Literature Review. Modern production requires proper management. A number of publications refer to management methods and models of optimal control with limited resources: the method of the non-local improvement of polynomial optimal control problems; the method of local optimization of functioning element of a regional system; the model of the minimax resource allocation model for the management of financial resources of a dynamic organizational system; the resource allocation model-based application system (Buldana and Trunin, 2008; Burkov, 2004;

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Novikov, 2001; Novikov, 2005; Popov, 2003; Freidina 2010). According to different classification criteria (Malin and Mukhin, 2004), the management system described in this article is artificial, dynamic, complex, adaptive and automated (Aleksandrov, 1989; Ignatieva and Maksimtsev, 2000; Makasheva, 2009; Malin and Mukhin, 2004; Novikov, 2001).

The research objective is to create an information system for managing the allocation of resources, which allows for adjustments in budget estimates of an organization or an enterprise with regard to the choice of certain performance criteria.

Key research findings. Mathematical model of the control system consists of the model of object of management and the device model management (Freidina, 2010). Object of the control in this system is the procedure of resources reallocation according to the expenditure budget of the organization based on the selected performance criteria, their relationship to expenses and planned financing. And each of the items in the expenditures can affect the multiple criteria of efficiency, which implies splitting the article into a limited number of the subitems that is equal to the number of criteria by which this article is affected. Since resources are limited, then the solution of the problem involves such distribution articles, which could be maximally used and would fully finance the priority of the subitems costs. Device management system is designed for processing received information from experts, namely to determine the share of funding of the subitems of each expenditure budget and determine the weights, which show by how much it is necessary to increase financing of one or another priority subitem. For a given action in this system there is a list of performance criteria and their relationship to the expenditure budget of the organization. Control actions in the system are determined based on accumulation and processing of expert information on the financing subitems expenditures in each category and the weight coefficients showing by how much it is necessary to increase financing of one or another priority subitem.

Since the external impacts are considered as the planned amount of financing for each cost item, at the output we get the optimal allocation of resources according to the expenditure budget of the organization.

The analysis of expert information is based on the interval analysis of variational series, formed from the exposed by experts share of funding for each subitem in the expenditure budget of the organization in the first case and the weights for the subitems belonging to the selected priority criteria of effectiveness, in another.

Scale intervals of continuous sign $R = (r_0, r_1, \ldots, r_t, \ldots, r_q)$ are characterized by the following parameters: the greatest $(a_{i\,\max}^{j})$ to determine the proportion of financing of the subitem j in the expenses i and $\chi_{k\max}$ to determine the weight factor of the priority subitem l expenditure k, and the smallest $(a_{i\,\min}^{j})$ to determine the proportion of financing the subitem j in the expenses articles i and $\chi_{k\min}^{l}$ to determine the weight factor of the priority subitem l expenditure k for the value of the characteristic. The optimal value of the interval h, which allows to reveal the characteristic features (patterns) of this phenomenon with the minimum number of intervals q ($q < n$), where n is the sample size; the value of r_0 is the beginning (lower limit) of the first interval; the value of r_t is the end (upper limit) of the t interval, which defines the beginning of a $(t + 1)$-th interval.

To determine the optimal value of the interval in the first approximation the formula by Sturges is used and for the solution of the problem of determining the weight of a priority *l* expenditure *k* we use the following:

$$h_k^l = \frac{\chi_{k\max}^l - \chi_{k\min}^l}{1+3{,}322\times\ln(n)}. \quad (1)$$

The beginning of the first interval is the value r_0, which is determined by the formulas (2) and (3). For solving the problem of determination of share financing of the *j* expenditure *i* (task 1) we use the formula:

$$r_{i\,0}^j = a_{i\,\min}^j - \frac{h_i^j}{2}, \quad (2)$$

as for the problem of defining the weight of a priority *l* expenditure *k* (task 2) we use the formula:

$$r_{k0}^l = \chi_{k\min}^l - \frac{h_k^l}{2}. \quad (3)$$

Building the scale intervals on the basis of the calculation of bounds continues until the value of r_j satisfies the following relations: the case of the solution of the problem of determining the share of financing of the subitem *j* of expenses articles *i* and the value in case of the solution of the problem of determining the weight of a priority subitem *l* of expenditure *k*. The relative frequency of v_t in the values of continuous characteristics in a given interval is defined as the ratio of the corresponding frequencies *m* to the total number of observations *n* where:

$$m_{i\,t}^j = \sum_{s=1}^{n} k_{i\,s}^j, \text{ where } k_{i\,s}^j = \begin{cases} 1, & a_{i\,s}^j \in (r_{i\,t-1}^j; r_{i\,t}^j]; \\ 0, & a_{i\,s}^j \in (-\infty; r_{i\,t-1}^j] \cup (r_{i\,t}^j; +\infty); \end{cases} (task\ 1) \quad (4)$$

and when considering the problem of the second type we use the formula:

$$m_{kt}^l = \sum_{s=1}^{n} k_{ks}^l, \text{where } k_{ks}^l = \begin{cases} 1, & \chi_{ks}^l \in (r_{kt-1}^l; r_{kt}^l]; \\ 0, & \chi_{ks}^l \in (-\infty; r_{kt-1}^l] \cup (r_{kt}^l; +\infty). \end{cases} (task\ 2). \quad (5)$$

Assessment of the consistency of the expert opinions is carried out on the basis of the consistency coefficient of Kendall calculated by the formula:

$$W = \frac{12}{n^3(m^2-m)}S, \quad (6)$$

where *m* is the number of the subitems; *n* is the number of experts; *S* is the coefficient of variation relative to the mean value. The value of the concordance coefficient varies from 0 to 1. The closer is *W* to 1, the higher is the coordination of experts' opinions (Jonson, Lion, 1981).

After the selection of the priority criteria of efficiency, determination of the funding share of the relevant subitems of each cost item and the weight coefficients for the priority subitems corrects itself for the task of allocating resources based on the selected criteria. Thus, it is necessary to take into account the weighting coefficients of the Finance subitem of the budget expenses of the organization belonging to the chosen criteria of efficiency. Let for each article *i* of the planned funding b_i, and in accordance with the relationship of the expenditure articles of budget and the criteria of efficiency of each article *i* is broken into a number of subitems. Then the allo-

cation of financial resources by subitem *j* of the article *i* can be formally described as follows:

$$x_i^j = \pi_i^j(a_i^j, \chi_i^j, b_i, B), \tag{7}$$

where $\pi_i^j(a_i^j, \chi_i^j, b_i, B)$ is the procedure of distribution of resources (planning). On the procedures for resource distribution, we assume that $\pi_i^j(a_i^j, \chi_i^j, b_i, B)$ is continuous strictly monotone increasing a_i^j, χ_i^j, b_i and B and strictly monotonically tumbles on $a_k^l, \chi_k^l, b_k, i \neq k$ (Popov, 2003), where $a_i^{j^*}$ is the share of funding to belong to any of the selected criteria of the effectiveness of the relevant subitem; $\chi_i^{j^*}$ is the weight of the subitem; b_i is the planned financing of the article, which considered the subitem; B is the budget of organization. An essential condition is that the available cash resources should be distributed in full, i.e.:

$$\sum_i \sum_j x_i^j = B. \tag{8}$$

To determine the required resource amount for each expenditure item in the budget estimates we use the mechanisms of proportional and priority allocation of resources. Under the proportional mechanism, the allocation of resources to each of these subitems will be made according to the formula:

$$x_i^j = C_i^j \times D, \tag{9}$$

where

$$C_i^j = \frac{k_i^j}{\sum_i \sum_j k_i^j}; k_i^j = \frac{a_i^{j^*} \times (1 + \chi_i^{j^*}) \times b_i}{B_{pr.st}}; B_{pr.st} = \sum_i \sum_j a_i^{j^*} \times b_i;$$

$$D = \begin{cases} B_{pr.nov}, & B_{pr.nov} \leq B \\ B, & B_{pr.nov} > B \end{cases}; B_{pr.nov} = \sum_i (b_i \sum_j ((1 + \chi_i^{j^*}) \times a_i^{j^*})).$$

other subitems of financing are determined by the following formula:

$$x_l^k = \frac{a_l^{k^*} \times b_i}{B - B_{pr.st}} (B - S), \tag{10}$$

where S is the amount of resources allocated to the subitem belonging to the chosen criteria of efficiency. Within the priority method of resource allocation we select the efficiency criteria, a person deciding on the priorities and the funding which is to meet these priorities. The first criterion is considered with the highest priority and is funding all the subitems belonging to this criterion:

$$x_i^j = a_i^{j^*} \times (1 + \chi_i^{j^*}) \times b_i. \tag{11}$$

Then goes the second by importance criterion and so on. If at any step of the funding any subitem that belongs to any criterion is over the budget, funding on the subitems is performed in a proportional way. If after the financing of the subitems related to the selected criteria, the budget is not fully used, the rest of the assets is distributed between the subitems proportionally. On the basis of the abovementioned models a program was developed, which is designed to control the distribution of resources in the budget of the organization and the reallocation of costs.

Thus, with only a slight increase in the funding of the subitems, belonging to the chosen criteria of efficiency, both ways of distribution got nearly the same results.

When you change the distribution of resources from the specified initial distribution of the selected criteria, the results do not differ by more than 3%.

Table1. **The formed budget**

N of item	Cost item	Proportional distribution, ths UAH	Priority distribution, ths UAH
1	Printing	419,223	419,257
2	Technological equipment	246,605	246,622
3	Equipment for departments	260,588	260,596
4	Furniture	203,357	203,369
5	Educational work	809,357	809,380
6	Spare parts of vehicles	123,303	123,311
7	Books	251,810	251,817
8	Travel	385,838	385,838
9	Diplomas, badges, liners	30	30
10	Repair	160,293	160,304
11	Car repair	86,312	86,312
12	Blinds, curtains	49,321	49,325
13	Equipment	25,820	25,821
14	Licensed software	250,989	251,002

Conclusions. Based on the analysis of the existing methods and models we suggest the mathematical model of the control system of resource allocation by expense of the selected performance criteria and describe all its functional elements. The first stage in the analysis of the received information from experts determines the share of financing of the relevant subitems for each cost item, as well as the weight factors for each subitem that belongs to the chosen criteria of efficiency. At the second stage, the solution of the resource problems of the allocation by expenditure items is suggested. Proposed and described mathematically are the two ways of resource allocation: proportional and priority. Then the information control system of resource allocation is developed, which allows for adjustments in budget estimates of an organization or an enterprise with regard to the choice of certain performance criteria, that are of verbal nature. This software is tested on real data and the results obtained are adequate to practice and can meet the goals set.

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