Project-Time Resource Distribution of Socio-Economic Systems

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Abstract. The dynamics of change in the economic environment, uncertainty and risk significantly affect the development of socio-economic systems, which manifests itself in the need to allocate scarce resources to achieve the maximum level of projects` implementation.The method of resource distribution in complex socio-economic systems aimed at their optimum utilization is proposed in the study. The result of the division is the ability to make rational decisions on optimizing, distributing and managing material, financial and other resources, reducing the risk of negative consequences for essential services` provision and overall processes` functioning, their management.Our study allowed to prove that building of the optimal resource distribution model should rationally apply a geometric figure – a circle for determining the optimal resource costs according to their redistribution between projects or stages of projects taking into account the time criterion.After all, the circle has the smallest area of surface of the equivalent geometric figures. Applying this property to resource distribution as the trajectory for use of resource makes it possible to minimize resource consumption with time.The proposed method of distribution is practically implemented in the activities of a socio-economic system – a united territorial community to automate the process of allocation of the budget financial resources` distribution. This made it possible to achieve optimization of instantly important processes taking time criterion into account.The proposed method belongs to the complex processes` resource management and can be used to optimize the resource provision of the process in general and its subsystems in real time. It implies obtaining qualitative and quantitative process` estimations and increase the optimization level of resource costs.
Keywords:socio-economic system, optimization, resources, time criterion, project-time distribution management.

1. Introduction

Amid current management system reform, functioning and development of complex socio-economic systems, each of which has certain resource potential, are characterized by uncertainty and instability. The main objective of any system`s functioning is to ensure the resource distribution between different projects as funding lines in order to have even development over a long period of time. To fulfill the desire, it is necessary to model the process of complex socio-economic systems` resource distribution based on definite strategic benchmarks. The study objective is the suggestion of the method to measure project-time resource distribution of complex socio-economic systems in order to optimize their functioning and development. The analytical dependencies to calculate geometric figures volume, which represent the resource structure, used for the development of socio-economic systems (community, association of persons, team, structural unit, etc.) are applied as research tools. Graphical visualization of the distribution process model taking into account the time criterion, process` algorithm presentation of the project-time resource distribution proposed method`s practical implementation allow to track and control resource costs componentwise in real time.
Let us formulate several hypotheses to carry out the research and justify theobtained results.
We propose the following hypotheses for testing:

H: Efficient management of a complex socio-economic system is grounded on adherence to a specific trajectory of resource distribution

2. Material and Methods. Modelling of the process of socio-economic system`s project-time resource distribution.

The simulation of the project-time resource distribution process implies the consistent implementation of the following stages:
- selection of process` model;
- definition of process` stages;
- determination of the sequence of process` stages and terms of their implementation;
- definition of types of necessary resources;
- selecting the time period`s step of the rating scale in the range from 0 to 1;
- iteration regulation in the chosen interval of resource exploitation intensity level by formula:

$V = \frac{4}{3}\pi(a_n b_n c_n - a_{n-1} b_{n-1} c_{n-1})^3 (1)$

where $a_n b_n c_n$ – parameters of the axes of a volumetric sphere-shaped figure which values are the reflection of the selected resources (one of the resources corresponds to the time period), the linear unit;

n – type of resource, unit of quantity;

$\frac{4}{3}$ – dimensionless coefficient;

$\pi = 3{,}14$ – dimensionless coefficient.

– determination of every resource optimal quantity or the needs in total resource quantity;

– step-by-step resource management is carried out by the magnitude of each resource optimality parameter`s deviation.

We would like to note that the advantage of the proposed method is possibility to select a process` model, time period`s step of the rating scale in the range from 0 to 1, iteration regulation in the chosen interval of resource exploitation intensity level by formula (1); determine the optimal amount of each resource or needs in total resource quantity; stepwise resource management by the magnitude of each resource optimality parameter`s deviation.

The advantages of the proposed method are the following:

– method`s objects are any resources used to provide technical-technological process, socio-economic development or socio-economic institution (community) and their combination into essential systems or groups;

– selection of conformities for modeling resource needs can be done taking into account the time "lag";

– model building and practical implementation of the results are made using so called "saving" method of process` simulation;

– resource inflow regulation to support "scarce" variables of a resource system;

– visualization of essential resources at all stages of process management;

– step-by-step control of resource supply and outflows within a given time period.

With that, to measure the resource consumption, different process` models can be used, namely:

the "sphere" model allows to achieve even resource distribution in time;

the "ellipsoid" model should be used if resources are distributed unequally during period of time;

the "dome"model is used if there are two or more sources of resource supply.

Even project-time distribution is essential for the efficient functioning and development of complex socio-economic systems. That is why the "sphere" model (table 1) was chosen and applied to simulate the process of resource distribution and their further management.

Table 1. Models characteristics to determine resource consumption

Formula for measuring volume of sphere-shaped figure as a model
Circle
$V = \frac{4}{3}\pi R^3$, where R– radius of a circle, linear unit; 4/3 – dimensionless coefficient; π = 3,14, – dimensionless coefficient.
Ellipsoid
$V = \frac{4}{3}\pi abc = \frac{4}{3}\pi a^2 b = \frac{4}{3}\pi c^2 b$, де a – first (large) semiaxis of sphere-shaped figure, linear unit; b – second (medium) semiaxis of sphere-shaped figure, linear unit; c – third (small) semiaxis of sphere-shaped figure, linear unit; 4/3 –dimensionless coefficient; π=3,14 –dimensionless coefficient.
Dome
$V_{куп}\left(\alpha < \frac{\pi}{2}\right) = \pi(R^2 h - h\rho^2 - \rho h^2 - \frac{1}{3}h^3 + c\rho r - cR^2 arcsin\frac{\rho+h}{R} + cR^2 arcsin\frac{\rho}{R}$; $V_{куп}\left(\alpha > \frac{\pi}{2}\right) = \pi(R^2 h - \rho^2 h - \rho h^2 - \frac{1}{3}h^3 + c\rho r - cR^2 arcsin\frac{\rho-h}{R} - cR^2 arcsin\frac{\rho}{R}$. $\alpha = arcsin\frac{h-\rho}{R} + arcsin\frac{\rho}{R}$ де R – radius of the dome generatrix, linear units; r – radius of the dome base, linear units; ρ – distance from the dome base to the horizontal axis, which goes through the center of sphere generatrix, linear units; c – distance from the center of sphere`s arc generatrix to the vertical axis of the dome; h – height of dome; α – angle between the radii of sphere generatrix, which connects the center with the edges of genetrix segment

borders

Source: Grouped by the authors

Let us consider the details of project-time resource distribution. Firstly, clarification of the process` model selection aimed to determine the cost of resources: sphere, ellipsoid, dome, is made.

To simulate the process considering time and space, in accordance with the flowchart of the management method for project-time distribution (Figure 1), the stages and their sequence (for example, the levels of specification: (A) - "the formation of socio-economic system"); (B) - "resource distribution project"; (C) - "project coordination") are determined.

The next step is identification of every process` stage consequence and timing of implementation. Then the areas of resource distribution (projects) are determined. Selection of time interval is a crucial step, so the process is being evenly distributed in the interval from 0 to 1.

The regulation is held by means of iteration method in the chosen interval of each resource exploitation intensity level by formula (1) to single out every parameter of the stage, for example:

- stage «formation of socio-economic system» – A: $\mathrm{A}_1, \mathrm{A}_2, \dots, \mathrm{A}_n$ – parameters $\mathrm{a}_{11}, \mathrm{a}_{12}, \dots, \mathrm{a}_{nm}$;
- stage «project of resource distribution » – B: $B_1, B_2, \dots, B_n$ – parameters $b_{11}, b_{12}, \dots, b_{nm}$;
- stage «project coordination» – C: $C_1, C_2, \dots, C_n$ - parameters – $c_{11}, c_{12}, \dots, c_{nm}$ .determine necessary set of resources.

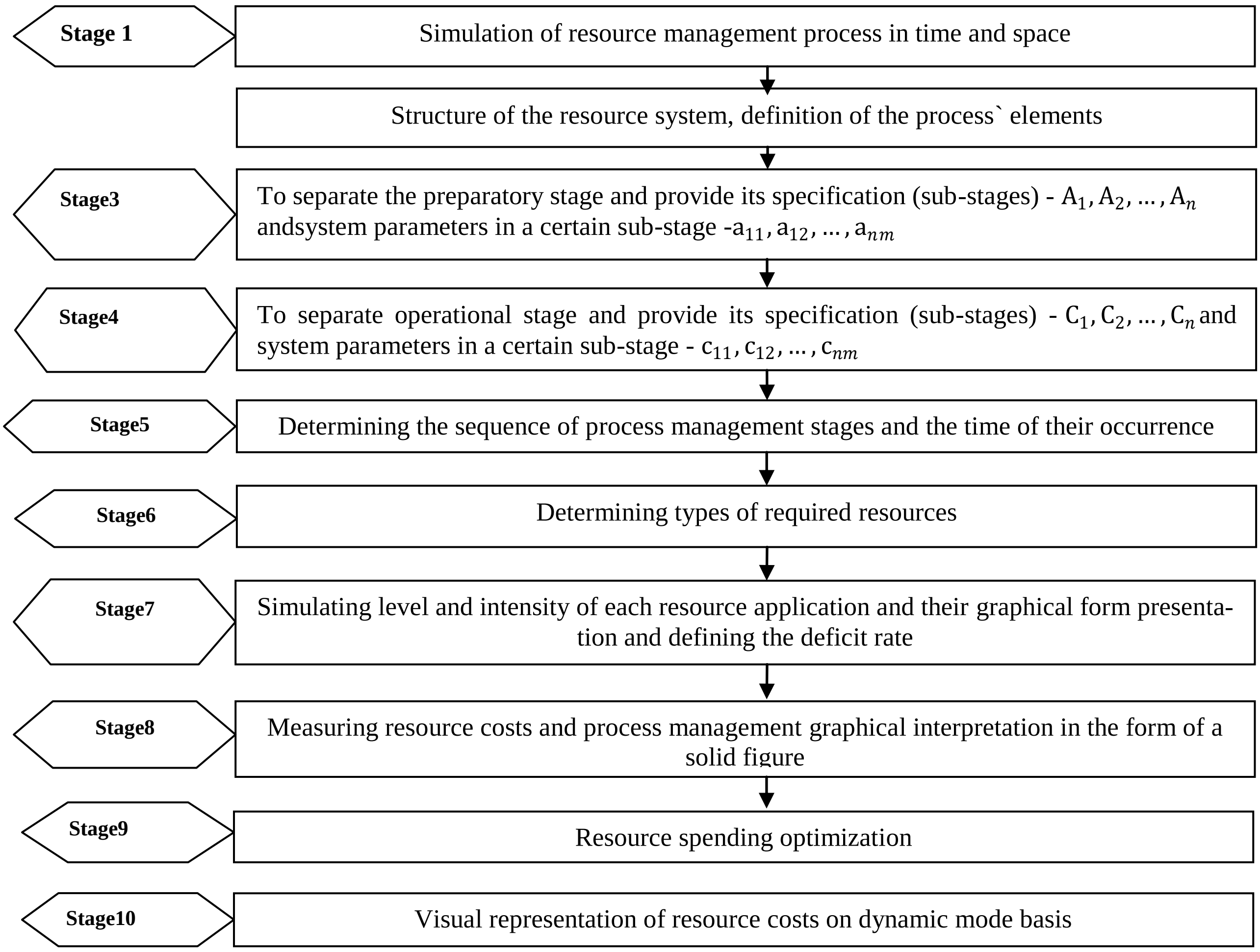

Figure 1. Flowchart of management method for project-time distribution

The next step is to decide the optimal amount of each resource or needs in the total number of resources in a graphical or tabular form and measure the deficit rate. To do this, one need to build a resource management model

(Figure 2).

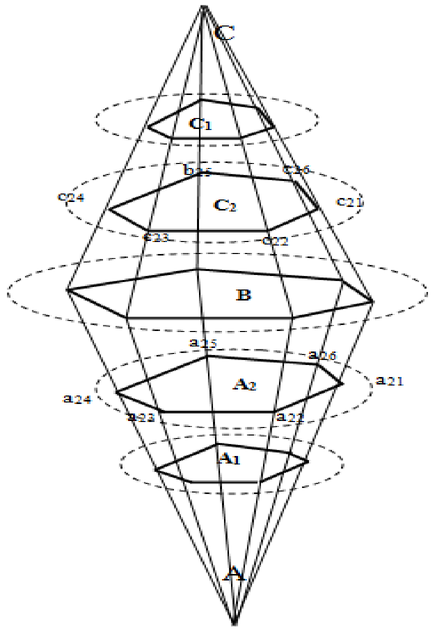

Figure 2. Graphical interpretation of planning patterns and resource application

To improve exploitation of resources at the certain stage of the process, sections of three-dimensional geometric configuration by planes perpendicular to the time axis corresponding to certain intervals, which number values reflect quantitative and qualitative parameters of resources, are determined. At each stage of the process, the plane that intersects volumetric figure perpendicular to the time axis, corresponds to resource parameters of the selected scale, which graphically displays the quantitative value of the resource at a certain stage of the process and indicates the value of the deviation of a certain parameter from the theoretical value.

The diagrams given in the planes sections A_1, A_2, B, C_1, C_2 indicate the quantitative and qualitative indices of resources supply for a particular stage of a process.

Measuring of the resources` amount can be represented by a set of spheres (Figure 3).

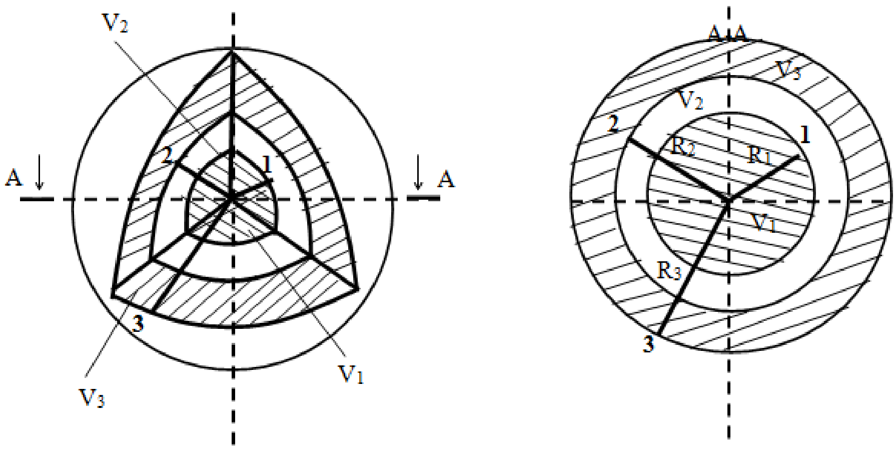

Figure 3. Graphical interpretation of resource amount measurement as a set of spheres

Step-by-step resource management is carried out by the magnitude of deviation from each optimality parameter. The diagram (Figure 3) reflects the dynamics of the process.

Proposed model allows to forecast resource costs with regard for time and to redistribute resources between related stages of the process.

Management activities concerning complex processes` management can be carried out both quantitatively and qualitatively, since the magnitudes of sphere-shaped figures` volumes are the reflection of financial, technical, technological or any other tangible and intangible resources. The difference in these spheres` volumes indicates the qualitative characteristics of resource costs based on the principle of "greater- less" and thus allows to regulate correlation between different types of resources.

The proposed method of project-time resource distribution of socio-economic systems provides balanced management of resource application for complex dynamic processes.

3. Results. Testing project-time resource distribution method of complex socio-economic systems

Practical implementation of the suggested resource management method is studied by the example of socio-economic institution`s (community) budget.

The proposed resource management approach allows to provide resource cost optimization within a given period t, which is one of the geometric figure`s parameters. To form the budget, certain "projects" have been defined, which are the items of a community budget - the areas of financial receipts` distribution.

For the resource cost optimization we used the formula of sphere`s volume,which has the largest volume in case the equivalent size geometric figure has minimum area of the outer surface. The ratios between the axes of this geometric figure are represented by equation:

$$a= b= c= R.$$

To reach the optimal volume of resource consumption the management of a, b, $c$parameters is used.

a– parameter, which corresponds to proportion of education funding at a particular step of time period, linear units;

b – parameter, which corresponds to the proportion of healthcare funding at a particular step of time period, linear units;

c –time parameter, linear unit.

One fiscal year period should be chosen as a time period. The sequence of process` stages and timing of their implementation are determined by the schedule of budget receipts.

Selected step of period in the interval from 0 to 1 was due to the possibility of monthly step-by-step funding.

Regulation of each resource exploitation intensity level in the selected time interval was made by iteration method by formula (1).

For interconnection of measurement units, each parameter was determined within the interval (0; 1). It is necessary to confine the step`s equality by scales of parameters a, b, c, that is, each step on time axis has to correspond to similar steps on axes of expenditure for each separate unit (resource).

The optimal amount of resources spent for education and healthcare was measured in the time interval of 2017 fiscal year.

Monthly structure of budget expenditures was illustrated by the example of Bilenkivska community of Zaporizhzhia region in 2017 [1] –Table 2.

Table 2. Structure of budget expenditures of Bilenkivska community of Zaporizhzhia region in 2017 on the expenditure side

Time period, months		Expenditure side			
		Education		Healthcare	
Parameters					
c		a		b	
Step of time period	Months of year	mln UAH		mln UAH	
		real value	optimized value	real value	optimized value
0,083	1	2,9	1,6	1,3	0,7
0,166	2	1,9	3,2	0,8	1,4
0,249	3	1,0	4,8	0,4	2,1
0,332	4	0,8	6,4	0,3	2,8
0,415	5	2,9	8,0	1,3	3,5
0,498	6	1,9	9,6	0,8	4,2
0,581	7	2,9	11,2	1,3	4,9
0,664	8	1,5	12,8	0,7	5,6

0,747	9	0,6	14,4	0,3	6,3
0,830	10	0,6	16,0	0,3	7,0
0,913	11	2,3	17,6	1,0	7,7
1,000	12	19,2	19,2	8,4	8,4

Graphical interpretation of the resource distribution (of budget expenditures of Bilenkivska community of Zaporizhzhia region) is presented in Figure 4.

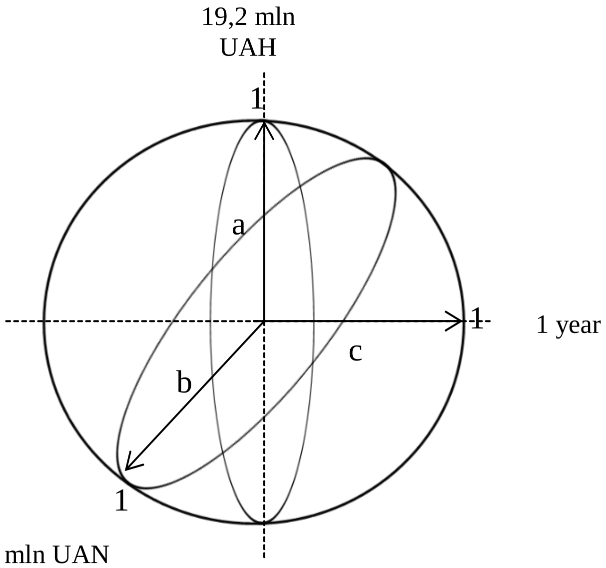

Figure 4. Graphical interpretation of the resource distribution (of budget expenditures of Bilenkivska community of Zaporizhzhia region)

Suggested method of resource management allowed to optimize the distribution of community budget`s financial expenditures for education and healthcare within the reporting fiscal period. The proposed method also implied determination of the optimal distribution according to other items of budget expenditures and achieving their optimization in a particular time interval.

4. Discussion

To deepen our understanding of the problem, let us consider theoretical and practical aspects of complex socio-economic systems` resource distribution.

H. Haken, the founder of "Synergetics," proposed important scientific interpretation of the "complex systems" concept. He states that "complex systems may be described as those that consist of a large number of parts, elements or components which can be both homogenous and heterogeneous. Components or parts can be combined in a more or less complex way. Different branches of science give numerous examples of systems called complex. Some of them are quite simple, while others are complex. Socio-economic systems belong to them" [2, p. 18].

Scholars like Loginov D. andNäpinen L. provide general philosophical analysis (from the Synergetics point of view) of the design engineering modelling process` problem . This analysis is philosophical, not technical one. The scientific discussion presented in the aforementioned studies forms the theoretical foundations and philosophical motivation for the further research in this field. Synergetics (interpreted by H. Hacken) is considered as one of the most up-to-date and promising research programs focused on the search for general laws of evolution and self-organization of complex systems of any kind, regardless of the specific nature of their elements or subsystems [3-4].

Heylighen F. considers Synergetics as science about self-organization of complex systems and their ability to adopt to environmental changes [5].

W.Weidlich offered practical implementation of synergetic methods in social sciences. He notes that "It seems obvious that reality, including the animate and inanimate worlds (living and inanimate nature), is divided into layers (stratified) with varying degrees of organization. Higher, more macroscopic layers are complex, and therefore "are located above" lower, microscopic layers. If the organizational structure of the layer is such that it as a whole is characterized by qualitatively new characteristics, which are not presented in the lower layers, then it is accepted to define this sphere as a system. The system is "more than just the sum of its components", which are not features of parts, but only of the system as a whole" [6, p. 30-31].

W. Weidlich`s important scientific research concerning its practical application is substantiation of a significant "downward" interactions of the "whole - part". The scholar points out that the "collective field" strongly influences the possible behavior of an individual through the formation of certain benchmarks and the introduction of interactions into cultural traditions. Practical implementation becomes possible due to this expansion and limitation of available information, partial elimination of decision-making as for problems already defined by the society structure, as well as by activating the latent qualities of individuals [6, p. 32, p. 37-38].

Viability and self-sufficiency are important properties of a socio-economic system. According to R. Ashby [7], the viability should be understood as the ability of a system to overcome the uncertainty. Researcher S. Beer [8] singled out the types of viable subsystems and proved that every viable system should have distinctness.

Scholars likeByhovets, E.N., Klimanov, S.G., Kryanev, A.V., Sliva, D.E. [9] propose the method of resource distribution amid their scarcity on the basis of a dynamic change of their share. The proposed mathematical model predicts the dynamics of the resource shares for the transition process from one system`s equilibrium state to another. In our oppinion, this distribution is uneven because it depends on the system`s state, but not the need for a certain amount of resource provision. Therefore, the problem to define the method that balances available resources and the need for them for each element of the system arises. The method of distribution proposed in the study allows to solve this problem.

Khayrullin R. has proposed mathematical model that allows to manage the resources of utility companies in the residential sector to improve service quality [10]. We admit that even resource distribution in the field is complicated, since it depends on the number of inquiries that cannot be predicted in advance. Therefore, for the activity, the model of resource distribution gets more complicated because of the unpredictable flows of customer inquiries.

The issue of resource allocation is not just about financial resources. The issue of labor resources distribution for the particular project implementation is of particular relevance. It should be noted that the purpose of project management is to complete the project in the shortest possible time in compliance with the available resources, without violating the priority of certain stages of implementation. The authors like Arık, O.A., Köse E.A., Forrest, J.Y.-L.B. [11] in order to meet all the requirements for the implementation of a particular project, to distribute labor resources by creating staff coalitions, which reduces the time of the project milestones` completion. This raises the problem of the balance of the project owner interests who wants to complete the project with the least time expenditure and contractors seeking to get relevant level of remuneration. Similar studies were conducted by Pantuza G. Jr. [12], who considered the problem of scheduling employee distribution based on the criteria of minimizing the number of employees and the total time required to complete all tasks. The paper shows that it is possible to use limited staff and complete all tasks in time, thus optimizing resources application.

Scientific research of Shahbazi B., Akbarnezhad A., Rey D., Ahmadian Fard Fini A., Loosemore M. [13] is devoted to the labor resources` distribution improvement taking into account employees` career opportunities. The scholars introduced an innovative model that optimizes the relationship between productivity and career opportunities. The advantage of the model is possibility to choose optimal job distribution based on their preferences, but it can lead to labor resources imbalance. This mainstreams the issue of even resource distribution and equilibrium achievement.

Bushuev S.D., Yaroshenko R.F., Yaroshenko T.O. dealt with the issues concerning management of the systems` development programs. Scholars examine multi-vector management that provides balance, strategic orientation and achievement of effective results of funds distribution [14].The authors propose to use concentric multi-vector management models. Their key tools are timely change of management paradigms, comprehending life cycle philosophy for well-timed adjustment of management system, team creativity, development of knowledge and excellence center, understanding of driving forces and threats. Each of these elements is a component of success, and the formula for success is determined by the synergy of their interactions. That is, the models are certainly important because they take into account a number of subjective factors which determine functioning of a complex socio-economic system and the prospects for its development. In our opinion, the prerequisite for the effective operation of any socio-economic system is to determine the amount of funding for success components and funds distribution for a specific period of program`s or project`s implementation. This task is solved based on our research by practical fulfillment of the proposed method of resource distribution.

Significant amount of theoretical and practical studies about functioning and development of complex socio-economic systems confirms the interest of scholars in this problem. In order to ensure socio-economic system`s viability and self-sufficiency, it is necessary to construct a model and form mechanism for optimal resource distribution according to the time criterion and funding areas (projects). This is defined as the main task of the study.

The proposed method of resource distribution is related to the known resource management method (Pat. 2614581RU. IPC G06Q10 / 02; Improved Accounting System and Appropriate Method / Cholac Umit Mirad (USA), Ozisik Metin Gurgel (USA), Rubert Timothy (USA)) [15], which includes determining the stages of process management, identifying intangible resources, determining the stages of their management, determining the availability and intensity of resource application, improvement according to certain resource parameters.

Another well-known way of resource management (Pat. 2643479RU, IPC G06F19 / 00, Platform which individually manages resources based on the contextual concept of user plans and goals / Jarvis Mark D. (USA), Lord Christopher J. (USA), Elman Adam (USA), Patti Ashwin (USA), Uppala Anantha Dipthi (USA), Omotosho Adedamola (USA), Liukkonen-Olmiala Tea (USA), Patel Sveta K. (USA), Pandid Milind S. (USA) [16], including signal coding for information presentation, distinguishing process stages, their sequence and timing; types of resources, their availability and intensity of application, forecasting of the resource use, managing resources consumption in a passive mode, both in time and space. On the basis of the detailed analysis of the above-mentioned patents, it is possible to distinguish common features and disadvantages in comparison with the method of resource distribution proposed by us (Table 3).

Table 3. Common features and disadvantages of the patented solutions in comparison with the proposed in the study project-time distribution

Title	Patent 2614581RU	Patent 2643479RU
Common features	specification of process` management stages; specification of the necessary resources; specification of each resource`s management stages; identification of availability and intensity of resource application; process` improvement	specification of process stages; specification of process` sequence and project deadline; identification of types of resources; identification of availability and intensity of resource applicationin time and space
Disadvantages	impossible to: model process'; take into account changes of the resource quality in the managerial process; substitute resources as well as only intangible resources` management	Absence of the process` modelling stage; Method`s application only for simulation platform of resources`self-management, simulation values, information;application of encoded management signals, aimed only atprocess` self-management without affecting external resources, but coordinated with them; the impossibility of taking into account amount of work, only determining the list and the sequence of its performance, defining work schedule; inability to choose the regularity of resource control

Analysis of common features and disadvantages of the patented solutions presented in Table 3, allows us to mark distinguishing features of the proposed in the study project-time distribution: computer processing of the input parameters of technical, technological and economic process` characteristics in space and time, selection of process model; selection of time period step in the range from 0 to 1, calculation of scales for constructing radius vectors which reflect each resource`s data; step by step construction of radius vectors corresponding toeach resource`s data and their graphic portrayal; iterative regulation and graphic portrayal of each of the resource`s application intensity level and / or total amount of resources in want; comparison of calculation and input data of process` parameters; determination of each resource`s optimal amount and / or total amount of resources in want; step by step registration of the process parameters`of deviation from optimal one and resource management according to the received data.

Based on the analysis of theoretical and practical research dealing with the issue of resource distribution, we can make a conclusion about urgency and need to solve the problem that exists in all life areas. The proposed method of project-time resource distribution is universal, because it allows to manage different types of resources at the stages of a particular project implementation: material, labor, etc. It also allows setting a time criterion, that is, determining the duration of project realization and allocating resources accordingly.

Thus, we propose in the article the method of resource management which, by simulating the process and building a multifactor dynamic model, taking into account resource costs` cyclical, interrelated and coordinated nature, allows to improve the qualitative and quantitative technical, economic and technological characteristics of the process, increases the level of cost optimization , provides a real-time visualization and visual reflection of the resource management process.

5. Conclusions

Conducted research allows to conclude that mitigation of uncertainty and risk impact on the activity and development of complex socio-economic systems is possible by simulating their resource distribution based on the assumptions of equality and optimality. The proposed project-time resource distribution of complex socio-economic systems confirms the formulated hypothesis, which confirms the possibility of resource management based on the time criterion, interconnections and coordination of resource costs, to obtain and analyze qualitative and quantitative estimates of the process` stages and increasereal-time level of costs optimization.

Significant advantage of the proposed project-time resource distribution of complex socio-economic systems is possibility to manage resources based on the time criterion, interconnections and interconnectivity of resource costs, to receive and visualize qualitative and quantitative estimates of the process` stages and to increase the optimization level of resource expenditures in real time.

The universality of the proposed method (for complex socio-economic systems, projects implementation aimed to form new models and new types of products and services development) should be noted as well.

Practical implementation of project-time resource distribution method was carried out by the example of a united territorial community, namely: modeling the distribution of community budget receipts by areas (projects) taking time into account. The analysis of community`s financial resources` real distribution has shown significant unevenness of this process in time and in certain areas (projects) of funding.

Suggested method implies regulating equitability of community resources and determining deviation of the real situation from the "ideal" one. Besides, timing distribution modeling makes it possible to adjust funding options at every process` step and to achieve process optimization as quickly as possible.

The direction of further research is process` automation for project-time resource distribution based on information technologies, which will optimize the process of managerial decision making, proceed from reactive to innovative management.

6. Authors contribution

Pereverzieva Anna Vasylivna: Options of the sphere-shaped figures to determine the resource cost have been analytically described. The implementation of the proposed method using a specific example has been made. Visualization of the proposed method has been performed, as well as calculations using a specific example. Contribution - 50%.

Volkov Volodymyr Petrovych: The idea to createmethod of resource management based on the sphere-shaped figures, to develop optimization algorithm based on the modeling of the resource distributionprocess . Contribution - 50%.

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