INFORMATION SYSTEMS AND INNOVATIVE TECHNOLOGIES IN PROJECT AND PROGRAM MANAGEMENT

Collective monograph edited by
I. Linde, I. Chumachenko, V. Timofeyev

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INFORMĀCIJAS SISTĒMAS UN INOVATĪVAS TEHNOLOĢIJAS PROJEKTU UN PROGRAMMU VADĪBĀ

Kolektīvas monogrāfija

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The monograph presents the achievements of Ukrainian scientists on enterprise management, the use of economic and mathematical modeling, information technologies, management technologies and technical means in the field of enterprise functioning and development and project management at enterprises.

The publication is recommended for professionals in the fields of economics, information technology, project and program management - for undergraduate and graduate students, as well as academics and teachers of higher education.

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CONTENT

INTRODUCTION

The key to successful activity of complex socio-economic and technical systems is their constant updating, adaptation to the changing conditions of the external environment, and appropriate self-regulation of the internal structure, processes, and technoalgies. Scientific and methodological developments offered in the monograph, measures for strategic development, the use of modeling and information technologies, project and program management technologies will all contribute to the improvement of existing processes and the development of new ones. This is what determines the relevance of the studies presented.

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The publication is recommended for undergraduate and graduate students, specialists in economics, management, information technology and project management higher education institutions.

1. INFORMATION SUPPORT OF LOGISTICS FOR THE VIRTUAL DISTRIBUTED ENTERPRISE

Fedorovich O., Kosenko V.

A comprehensive study related to the creation of information support for a virtual enterprise (VE) has been conducted. With this purpose, the life cycle of creating complex technology with the identification and elimination of "narrow" places is investigated at the beginning. The portfolio of VE orders is formed on the basis of the relevance and competitiveness of future products, as well as taking into account possible costs, time and risks of creating the high-tech products. Next is the choice of enterprises or their units as a part of implementing a distributed VE. The infocommunication networks and connections for transmission the control information, and also the large amounts of technical information between enterprises of VE are formed for solving tasks of production control. A study of the logistics chain "supply-production-sales" of high-tech products with the aim of reducing logistics costs has been conducted. The possible threats in the infrastructure of the VE, as well as factors affecting their elimination or neutralization are examined. The proposed approach should be used in the initial stages of creating a virtual enterprise when it is necessary to create a portfolio of orders for the production of competitive high-tech products.

Introduction

The results of the research are connected with the information support of the virtual enterprise (VE) in the aerospace industry, where the high-tech innovative products are manufactured. Due to its complexity, the task is divided into a number of stages. The life cycle of creating complex machinery is examined. The problem of constructing a portfolio of orders of the VE is solved. The condition of the market of high-tech products to identify new competitive products is studied for this analysis. The alternatives portfolio taking into account cost, time and risks of production are compared and evaluated. The part of the VE enterprise is selected taking into account the possible costs associated with adaptation of the enterprises to execute the portfolio. The information and communication systems for administration of the VE are formed. The cost and capacity of communication equipment for the transmission of control and technological information within the VE structure are taken into account. The production cycle of the VE is formed taking into account the logistics requirements. The characteristics of the logistics chain "supply–production–marketing" for each company in the composition of the VE are taken into account. The optimization of supply and sales processes is carried out to ensure the reduction of logistics costs and to increase competitiveness in the market of high-tech products.

The next production revolution is connected with the total computerization of production, starting from the stage of origin of the idea of a new product and ending with full automation and virtualization of the production cycle, taking into account the use of infocommunication and intelligent robotic systems. Virtual offices and enterprises have emerged that, thanks to Web technologies and distributed infocommunication systems, can quickly respond to market demands. For the study of logistic processes in virtual distributed production, the methods of system analysis, combinatorial theory, optimization methods, and simulation methods, agent modeling methods, precedent theory, and component design theory were used. To form a portfolio of orders, it is necessary to evaluate alternative order options and select the optimal portfolio. For comparison and selection of a portfolio of orders, the relevance of products is taken into account, which ensures the competitiveness of products in the market of new technologies. To compare the set of alternative variants of the order portfolio, the lexicographical ordering of options was used. For the formation of the composition of the performers of the enterprises of VE, a lot of possible candidates for the execution of the order. An optimization model of the choice of enterprises was used, taking into account the release dates, costs and risks.

In a distributed virtual enterprise, the main interactions of a managerial and informational nature are carried out through an extensive infocommunication system [9]. At the same time, the volume of information transmitted is mainly determined by the complexity of the product and technological control processes, which are implemented using a variety of control programs transmitted to remote robotic process equipment. The task of forming the network equipment for the organization of effective informational interactions between the managing office and the enterprises that became part of the VE has been solved. This takes into account the amount of information, bandwidth, communication channels and possible risks of information transfer.

VE enterprises are managed using a virtual office manager with the active use of information and communication links. A specific feature of planning and management in a VE is the minimization of vertical control links and the maximization of horizontal interactions, which ensure the transfer of large volumes of technological and control information for the effective functioning of the VE production [10]. Management is carried out according to possible control protocols that are implemented using infocommunication links. For the simulation of logistics management production VE, used the method of agent-based modeling (platform JADE). Man-made objects in the composition of the airspace for their normal operation must have a sufficiently reliable infrastructure, through which, raw materials, materials, electricity continuously goes into production. Disruption and failures in critical infrastructure (CI) can lead to production stoppages, and for responsible (category) facilities (power plants, treatment facilities, etc.) to their degradation and possible destruction [11]. Optimization of actions for elimination of vulnerabilities in VE is carried out. For dynamic modeling of logistic processes of supply and sale the method of simulation event modeling is used. The basis of the simulation is the components of the schedule of the main technological operations for all orders from the order portfolio of the VE. A method of simulation based on the propagation of "numerical" waves in transport networks is proposed for the simulation of transport service of the VE.

The proposed approach should be used in the initial stages of planning orders in the office of a virtual enterprise. At the same time, it is necessary to create a portfolio of orders, to choose the composition of the VE enterprises, to organize the information and communication structure of relations between the managing office and VE enterprises to perform management tasks and transfer technological information, ensure quality control tasks, organize logistics and supply processes, which is important for high-tech production. competitive products by aerospace enterprises [12 - 14].

1. Study of the life cycle of complex equipment creation

Creating modern complex equipment (CE) (aircraft, automotive, shipbuilding, etc.) is associated with a long-life cycle (LC) production (R & D, production preparation, production, operation, modernization, recycling). The feasibility of projects for the creation of CE is associated with possible “narrow” places that may arise at certain stages of the life cycle [15 - 17]. The “bottleneck” of the life cycle in this publication is understood as a place in the department of the life cycle stage, which is associated with a possible and rather severe deterioration in the values of the main logistic indicators (financial expenses, time, quality, risks), which affects the life of the life cycle, as well as the final production indicators (costs, product quality, terms, competitiveness). Therefore, the actual study, which examines and solves the problem of identifying, modeling and minimizing the “narrow” places of life cycle at the stage of the project for the creation of new equipment [18 - 20].

The analysis and study of typical LC during the creation of CE showed that to solve the proposed problem it is necessary to go through a number of stages. [21]:

1. Analysis and identification of “narrow” places of LC at the stage of project formation.

2. The study of "narrow" places to reduce them.

3. Possible neutralization of the influence of the remaining (unresolved) "narrow" places.

4. Lifecycle modeling with “narrow” places to predict and refine the values of the CE outcome indicators.

Рассмотрим, подробнее, каждый из этапов и предложим методы и модели решения поставленной задачи.

At the first stage, in order to determine the “narrow” places of the life cycle, it is proposed to conduct an expert assessment. In the first step, a group of experts is formed, which is divided into subgroups in accordance with the stages of the LC. With the method of "brainstorming" is formed a set S_i of potentially "narrow" places of the i-th stage. Next, experts evaluate the importance of logistic indicators for the i-th stage of the life cycle (C_i- costs, T_i - time, Q_i- quality, R_i- risks) and rank them in line with their importance. For example, for R & D, taken into account the specifics of this stage, we get:

$$C_1, T_1, Q_1, R_1. \tag{1}$$

For each j-th "narrow" place, taking into account the uncertainty associated with the formation of a new project, we conduct a qualitative assessment of the impact of the "narrow" places on the main indicators of the product. To smooth out possible conflicting assessments of experts, you can use, for example, the method of Electra. Let us present qualitative assessments of experts in the form of Latin letters (A – very strong influence, B – strong influence, C – weak influence, D – influence is present, E – influence is absent). Then each "narrow" place can be estimated by a vector with projections in the form of qualitative assessments of the impact on the main indicators of the i-th stage. Imagine a vector in the form of a "word", where the first letter corresponds to the most important indicator of the i-th stage of the LC, and the last – the least important. For example, suppose that for R & D phase identified five "bottlenecks" and obtained qualitative estimates for them in accordance with a number of indicators (1):

$$\begin{aligned}
&\text{1-st «narrow» place } B_{11}, C_{12}, B_{11}, D_{11}\\
&\text{2- nd «narrow» place } A_{12}, B_{12}, D_{12}, B_{12}\\
&\text{3- rd «narrow» place } D_{13}, C_{13}, C_{13}, B_{13} \qquad (2)\\
&\text{4- th «narrow» place } C_{14}, D_{14}, B_{14}, D_{14}
\end{aligned}$$

5- th «narrow» place $B_{15}, A_{15}, D_{15}, A_{15}$.

For further research of "narrow" places it is necessary to assess their criticality, which can be obtained after lexicographical ordering of the set of "words" (2). We get:

$$\begin{aligned}&A_{12}, B_{12}, D_{12}, B_{12}\\&B_{15}, A_{15}, D_{15}, A_{15}\\&B_{11}, C_{11}, B_{11}, D_{11}\\&C_{14}, D_{14}, B_{14}, D_{14}\\&D_{13}, C_{13}, C_{13}, B_{13}.\end{aligned} \tag{3}$$

Therefore, it is advisable to conduct a further study of “narrow” places in the order of criticality:

2, 5, 1, 4, 3.

Reducing the “narrow” places of a project requires additional resources (V), time (W), and has possible risks (P) that may arise during the project implementation [22]. Therefore, to optimize these additional costs, we use the method of integer linear programming. We introduce a Boolean variable $x_{ij} \in \{1;0\}$, where $x_{ij} = 1$ corresponds to the fact that at the i-th stage of the LC, the j-th “narrow” place will be eliminated. v_{ij} resources are spent on this, w_{ij} time with risk $p_{ij}; x_{ij} = 0$ corresponds to the fact that at the i-th stage the j-th “bottleneck” remains. Then, to optimize the costs associated with the elimination of "narrow" places, it is necessary to minimize the indicators:

$$\begin{gathered}V = \sum_{i=1}^{5} \sum_{j=1}^{N_i} x_{ij} v_{ij},\\W = \sum_{i=1}^{5} \sum_{j=1}^{N_i} x_{ij} w_{ij},\\P = \sum_{i=1}^{5} \sum_{j=1}^{N_i} x_{ij} p_{ij}.\end{gathered} \tag{4}$$

We will solve the task of optimizing additional expenses in two stages: minimization of individual (local) indicators (V, W, P); multiobjective optimization. To minimize the performance of V, W, P, we introduce restrictions. Then optimization of local indicators is associated with the introduction of objective functions and constraints:

$$\min V, V = \sum_{i=1}^{5}\sum_{j=1}^{N_i} x_{ij}v_{ij}\,,\ \ W \le W', P \le P',$$

$$\min W, W = \sum_{i=1}^{5}\sum_{j=1}^{N_i} x_{ij}w_{ij}\,, V \le V', P \le P', \tag{5}$$

$$\min P, P = \sum_{i=1}^{5}\sum_{j=1}^{N_i} x_{ij}p_{ij}\,,\ \ V \le V', W \le W'.$$

To conduct multi-criteria optimization of additional costs associated with the reduction of “narrow” places in the LC, we introduce a complex criterion in the form of additive convolution of local criteria: $K = \alpha_V \cdot \widehat{V} + \alpha_W \cdot \widehat{W} + \alpha_P \cdot \widehat{P}$, where $\alpha_V, \alpha_W, \alpha_P$ – "weight" coefficients, set by experts, which indicate the importance of individual criteria:

$$\alpha_V + \alpha_W + \alpha_P = 1,$$

$$\widehat{V} = \frac{V - V^*}{V' - V^*},$$

$$\widehat{W} = \frac{W - W^*}{W' - W^*}, \tag{6}$$

$$\widehat{P} = \frac{P - P^*}{P' - P^*},$$

where V^*, W^*, P^* – minimum criteria values obtained as a result of optimization in the first stage.

It is necessary to minimize:

$$\begin{aligned} \min K; K &= \alpha_V \frac{V - V^*}{V' - V^*} + \alpha_W \frac{W - W^*}{W' - W^*} + \alpha_P \frac{P - P^*}{P' - P^*} = \\ &= \frac{\alpha_V}{V' - V^*}\sum_{i=1}^{5}\sum_{j=1}^{N_i} x_{ij}v_{ij} + \frac{\alpha_W}{W' - W^*}\sum_{i=1}^{5}\sum_{j=1}^{N_i} x_{ij}w_{ij} + \\ &+ \frac{\alpha_P}{P' - P^*}\sum_{i=1}^{5}\sum_{j=1}^{N_i} x_{ij}p_{ij} - \frac{\alpha_V \cdot V^*}{V' - V^*} - \frac{\alpha_W \cdot W^*}{W' - W^*} - \frac{\alpha_P \cdot P^*}{P' - P^*}. \end{aligned} \tag{7}$$

To minimize the impact of the remaining “narrow” places, we will evaluate possible options for neutralization (reducing the impact). We introduce an integer variable x_{ije}, where the index i indicates, as before, the stage, j indicates a narrow place, e is a possible variant of neutralization of the narrow place, $x_{ije} \in \{1;0\}$, where 1 corresponds to the adoption of the e-th variant as neutralization ij-th narrow place, 0 - otherwise. Wherein:

$$\sum_{e} x_{ije} = 1,$$

which means the choice of one (specific) option to neutralize the "narrow" place. Then the criteria associated with the minimization of additional costs in the neutralization of "narrow" places, taking into account x_{ije}, will have the following form:

$$V = \sum_{i=1}^{5}\sum_{j=1}^{N_i}\sum_{e=1}^{N_{ij}} x_{ije}v_{ije},$$

$$W = \sum_{i=1}^{5}\sum_{j=1}^{N_i}\sum_{e=1}^{N_{ij}} x_{ije}w_{ije}, \tag{8}$$

$$P = \sum_{i=1}^{5}\sum_{j=1}^{N_i}\sum_{e=1}^{N_{ij}} x_{ije}p_{ije}.$$

As in the previous formulation of the cost optimization problem, the solution was carried out in two stages: minimization of local criteria, multicriteria optimization.

To simulate the material flows (MF) in the logistics of life cycle at all stages of creating the CE, we use the method of agent modeling. The structure of agents simulating lifecycle includes:

1. Agent "description of the LC stage".

2. Agent "MF source". Responsible for the formation of MF on the stages of the application of LC. Can generate applications deterministic and random (taking into account the initial uncertainty) for a given law of probability distribution.

3. Agent "the time delay of MF". Used to simulate MF time movement. The time delay is used to simulate execution of logistics operations of transportation.

4. Agent "MF activity". Is used to simulate the activity associated with the processing of MF (manufacturing).

5. Agent "MF passivity". Serves to simulate the delay (stop) of MF (warehousing, waiting in line, etc.).

6. Agent “narrow” place. Is used to simulate the negative effects of “narrow” places (delay for an indefinite period or longer than expected, the risk of MF stop, the appearance of a defect, etc.).

7. Agent “dispatcher”. Controls agents, and provides the count of system time in the event-driven simulation, creates and implements a list of future upcoming events.

8. Agent "statistics". Collects statistical data and results of simulation (values of the main logistics indicators, etc.).

Fig. 1 shows the structure of the simulation agent model.

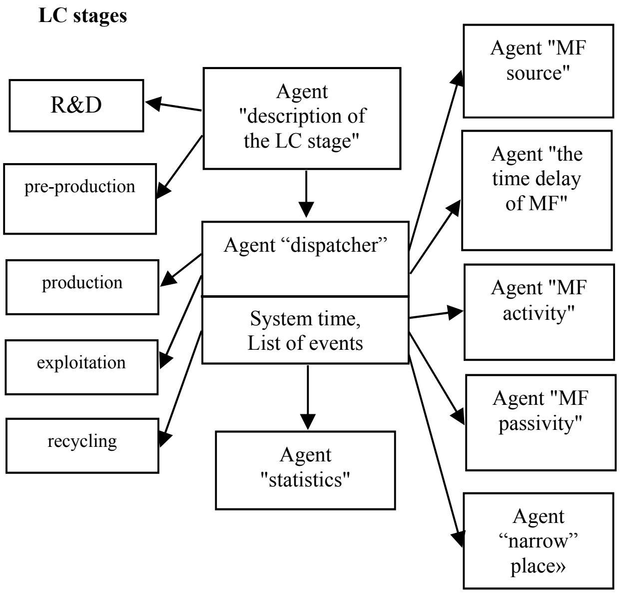

Fig. 1. Structure of the simulation agent model

2. Research of distributed virtual production systems for the production of high-tech products

One of the modern forms of organization of production is a virtual enterprise, which is created for the period of fulfillment of the portfolio of orders, formed at the request of the consumer market. A feature of the domestic production sector is the presence of idle production capacity, which allows to organize a temporary production system to fulfill a given portfolio of orders.

For the organization of a virtual production system (VPS) for the production of high-tech products, it is necessary to form the composition and structure of a virtual production system, to prepare a virtual production for the release of high-tech products [23, 24].

The formation of the VPS architecture assumes the availability of production capacity of enterprises that can be temporarily involved in the planned order portfolio (POP). Each of the enterprises can be characterized by a set of indicators that must meet the requirements of the planned portfolio of orders. A set of enterprises, applicants for receiving the order, we will present in the form of a base of precedents (BP), in which there are ready-made solutions (production facilities, technological processes). It is necessary to select such precedents from the BP that are most suitable in terms of their characteristics to the requirements of the POP, and also have the opportunity to participate in the execution of the order for the planned period.

The task will be solved in four stages:

1. Formal representation of the set of possible enterprises of candidates to the POP in the form of a base of precedents.

2. Formation of the composition of the virtual production system.

3. Optimization of costs associated with the adaptation of production to the requirements of the POP.

4. Modeling the functioning of the VPS.

To solve the problem of research, the methods of precedent theory, optimization methods and agent simulation modeling were used.

Let us evaluate each of the possible candidate enterprises for participation in the FAP, in the form of the following set of indicators:

1) The compliance of the product range of the i-th enterprise with the requirements of the RFB - NP;

2) The compliance of the production capacity and technological processes of the i-th enterprise with the requirements of the POP - RM;

3) The compliance of the time of production of the i-th enterprise with the time of order fulfillment in the POP - TR;

4) The compliance of the quality of the products of the i-th enterprise with the quality requirements of the POP - QP;

5) The compliance of the cost of production of the i-th enterprise with the requirements for the cost of the POP - SP.

At the initial stage, in order to select the necessary candidate enterprises for participation in the POP, we will use qualitative assessments of experts for each of the listed indicators.

Estimates will be presented in the form of letters of the Latin alphabet, with the following qualitative values:

A - the best value of compliance with the requirements of the POP;

B - good value of compliance of the indicator with the requirements of the POP;

C - satisfactory value of the indicator compliance with the requirements of the POP;

D - less satisfactory value of compliance with the requirements of the POP.

Each i-th enterprise, as a possible candidate for a POP, must be evaluated by experts and presented in the form of the i-th "word" with the meanings A, B, C, D, which will be entered in the BP.

Further, it is necessary to form the order of importance of the indicators for the subsequent selection of the composition of the VPS, using BP, for each i-th type of nomenclature. The assigned procedure will be the basis for the formation of the VPS composition when the POP is performed. We will use the lexicographic ordering of options, as a result of which, we will get an ordered set of enterprises according to the values A, B, C, D and taking into account the importance of the indicators. Consider an illustrative example.

Let the number of importance of indicators, will be as follows:

NP, PM, SP, QP, TP (9)

Disordered set of enterprises in the form of precedents in the BP has the form:

1. B, A, A, C, D	6. B, A, B, A, B	
2. A, B, B, C, C	7. C, A, A, A, A	
3. C, A, A, B, C	8. D, B, A, C, B	(10)
4. B, A, B, C, B	9. B, A, A, A, C	
5. A, B, B, D, C	10. A, D, D, B, C	

We produce the lexicographical ordering of options:

2. A, B, B, C, C
5. A, B, B, D, C
10. A, D, D, B, C
9. B, A, A, A, C
1. B, A, A, C, D
6. B, A, B, A, B
4. B, A, B, C, B
7. C, A, A, A, A
3. C, A, A, B, C
8. D, B, A, C, B

(11)

We discard the options with the worst D - values of the indicators. Will get:

2. A, B, B, C, C
9. B, A, A, A, C
6. B, A, B, A, B

(12)

4. B, A, B, C, B

7. C, A, A, A, A

3. C, A, A, B, C

If, the management of the VPS does not satisfy the estimates associated with the value of C, then we finally get:

6. B, A, B, A, B

The formed composition of enterprises that will participate in the fulfillment of orders must be analyzed from the point of view of carrying out adaptation, in order to fully meet the requirements of the POP. For this, it is necessary to carry out a number of activities for each j-th enterprise to ensure the release of the i-th product in the POP. There is a problem of optimization (minimization) of costs for carrying out activities.

Let us imagine the costs in the form of the objective function W. The limitation for the activities will be the time they are carried out, as well as possible risks, both internal and external. We introduce an integer variable x_{ij}, for which $x_{ij} = 1$ means that for the i-th product, the j-th event is selected from the POP nomenclature and $x_{ij} = 0$, otherwise.

Then the objective function will be as follows:

$$W = \sum_{i=1}^{n}\sum_{j=1}^{n_i} w_{ij}x_{ij}, \tag{13}$$

where n is the volume of the POP product range; n_i - the number of possible alternative activities that must be performed to organize the release of the i-th product from the POP nomenclature; w_{ij} - the cost of the j-th event for the i-th product from the range of POP.

As restrictions it is necessary to use:

1. Time to conduct a set of measures for the adaptation of enterprises to the production of products in the POP:

$$T = \sum_{i=1}^{n}\sum_{j=1}^{n_i} t_{ij}x_{ij}, \quad T \le T', \tag{14}$$

where T' – allowable time for product adaptation activities; t_{ij} . – time spent on the j-th event for the i-th product from the range of POP.

2. Risks associated with events (including risks associated with the allocation of funds for events):

$$R = \sum_{i=1}^{n}\sum_{j=1}^{n_i} r_{ij}x_{ij}, \quad R \le R', \tag{15}$$

where R' – the allowable risk value; r_{ij} – the value of the possible risk associated with the j-th event for the i-th product from the range of the POP.

It is necessary to solve the following optimization task:

$$\min W, \; W = \sum_{i=1}^{n}\sum_{j=1}^{n_i} r_{ij}x_{ij}, \tag{16}$$

subject to restrictions:

$$T \le T', R = \sum_{i=1}^{n}\sum_{j=1}^{n_i} t_{ij}x_{ij}, \tag{17}$$

$$R \le R', R = \sum_{i=1}^{n}\sum_{j=1}^{n_i} r_{ij}x_{ij}. \tag{18}$$

To simulate the functioning of the VPS, a structure of the simulation model has been formed, which is based on agent-based modeling. In addition to modeling material flows within the VPS, a study was conducted on the material flows of the entire logistics chain “supply-production-sales”. Therefore, the "agents" for the study of the functioning of the VPS include:

1. Agent "generation of orders" for the formation of orders of VPS using the requirements of middleware.

2. Agent "supply" simulates material flows in supply VPS.

3. Agent "component of the VPS" imitates the work of an individual element of the production structure of the VPS, used to execute the particular order.

4. Agent “sales and distribution” simulates the material flow distribution in the VPS.

5. Agent "orders control" simulates the sequence and time of execution of orders in the VPS in accordance with a specified fire protection.

6. Agent “monitor” generates a list of future events and ensures the system simulation time.

7. Agent "stats" collects statistics for each agent and all VPS in General.

8. Agent "results" gives the simulation results of time of execution of orders and statistics on the operation of individual elements of agent-based models (queues, delays, loading, etc.).

Fig. 2 shows a structural diagram of the agent simulation model for the study of the VPS.

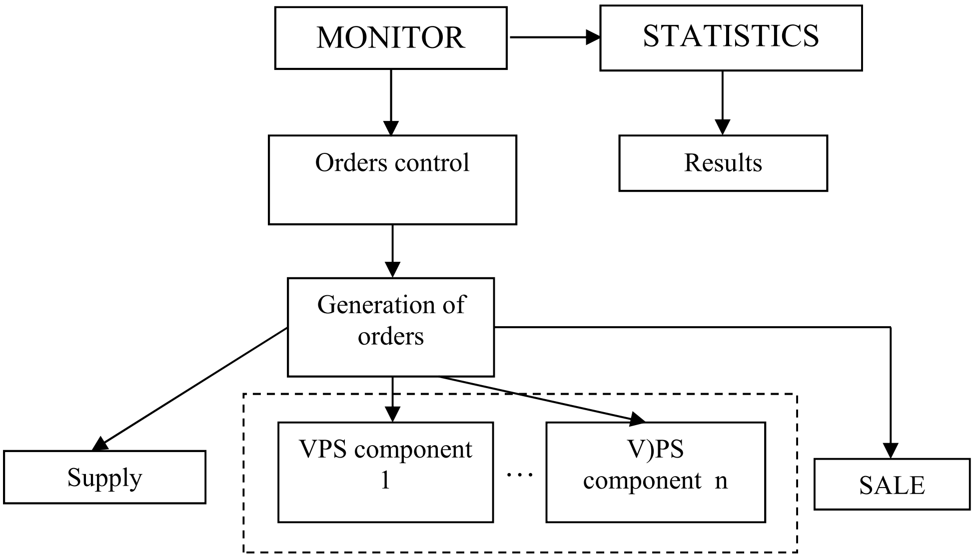

Fig. 2 Structural diagrams of the VPS agent simulation model

Enterprises selected in the first stage, which became part of the VPS, require preparation of production within a specific portfolio of orders. Let us highlight the main areas of preparation of the VPS: modernization (purchase of new) equipment and technological preparation of production; retraining (advanced training) and renewal of personnel.

The main criteria for evaluating the preparation of the VPS for the release of high-tech products are:

- financial costs W;
- preproduction time T.

To optimize (minimize costs and time) we use the method of integer (Boolean) programming. We introduce a variable x_{ij}, its value means:

$x_{ij} = 1$, if the choice is made for the i-th technology of the j-th equipment option;

$x_{ij} = 0$ – otherwise.

Then the criteria for evaluating the preparation of the VPS can be represented as follows:

$$W = \sum_{i=1}^{n} \sum_{j=1}^{m_i} x_{ij}(w_{p_{ij}} + w_{k_{ij}}), \tag{19}$$

where m_i – a set of possible equipment options for the implementation of the i-th technology order book;

n – a set of technologies required to complete the order portfolio;

$w_{p_{ij}}$ – financial costs associated with the modernization of equipment on the selected j-th option for the implementation of the i-th technology;

$w_{k_{ij}}$ – financial costs associated with the retraining and upgrading of personnel, taking into account the choice of the chosen j-th equipment option for the implementation of the i-th technology.

$$T = \sum_{i=1}^{n} \sum_{j=1}^{m_i} x_{ij}(t_{p_{ij}} + t_{k_{ij}}), \tag{20}$$

where $t_{p_{ij}}$ – time spent on upgrading equipment for the j-th upgrade option to implement the i-th technologist;

$t_{k_{ij}}$ – time spent on staff retraining, taking into account the choice of the j-th equipment option for implementing the i-th technology.

The following statements of optimization problems are possible for the preparation of virtual production for the release of high-tech products.

Optimization of separate criteria (W, T). Necessary to find the minimum cost W:

$\min W, W = \sum_{i=1}^{n} \sum_{j=1}^{m_i} x_{ij}(w_{p_{ij}} + w_{k_{ij}})$ when performing time limit T:

$$T \le T', T = \sum_{i=1}^{n} \sum_{j=1}^{m_i} x_{ij}(t_{p_{ij}} + t_{k_{ij}}) \text{ and fulfillment of conditions: } \sum_{j=1}^{m_i} x_{ij} = 1, \sum_{i=1}^{n} \sum_{j=1}^{m_i} = n, \tag{21}$$

where T’ – allowable time for pre-production.

Necessary to find a minimum time T:

$\min T, T = \sum_{i=1}^{n} \sum_{j=1}^{m_i} x_{ij}(t_{p_{ij}} + t_{k_{ij}})$ at performance of restriction on expenses W:

$$W \le W', W = \sum_{i=1}^{n} \sum_{j=1}^{m_i} x_{ij}(w_{p_{ij}} + w_{k_{ij}}) \text{ and conditions: } \sum_{j=1}^{m_i} x_{ij} = 1, \sum_{i=1}^{n} \sum_{j=1}^{m_i} = n, \tag{22}$$

where W’ – allowable costs for pre-production.

Multi-criteria optimization. In this case, we use minimization of the complex criterion in the form of additive convolution of criteria W, T.

To assess the characteristics of the logistics chain (supply - production - sales) of the virtual production system, we will use simulation agent modeling. Create a set of modeling agents:

- the agent "supply" is responsible for the formation of applications in the form of batches of materials, raw materials and components for the execution of the VPS order portfolio;

- the agent “transportation of supply” is responsible for the formation of the material flow from the supply enterprises to the VPS;

- the agent “warehousing supplies” is responsible for intermediate storage of materials, raw materials and components during their transportation to the VPS;

- a complex agent “virtual production system” consists of agents “production of items” and agents “production technology”;

- agent "sales" forms an application for the structure of high-tech products VPS;

- the agent “transportation of sales” is responsible for the formation of the material flow from the VPS to consumers;

- agent “warehousing sales” is responsible for the formation of warehouses for the sale of high-tech products;

- the “planning” agent is responsible for the formation of plans for the implementation of the portfolio of orders (the formation of applications for the launch of individual orders);

- the agent “simulation results” is responsible for the formation of intermediate and final simulation results.

As a result of modeling, it is estimated:

- launch time of a separate order;

- time of production of the considered order;

- percentage of employment of equipment of the VPS at the fulfillment of each order from the order book;

- The percentage of idle equipment VPS;

- percentage of employment of the transportation system “supply”;

- the percentage of employment of the transport system "sales";

- loading of supply warehouses;

- loading of sales warehouses;

- time of receipt of completed orders (high-tech products) to consumers.

3. Study of management in the logistics of a virtual enterprise

The main interactions of a managerial and informational nature in a distributed virtual enterprise are carried out through an extensive system of information and communication links, including via the Internet. In this case, the volume of transmitted information is mainly determined by the complexity of the product and technological control processes, which are implemented using a variety of control programs transmitted to remote automated technological equipment. Therefore, there is the task of forming the composition of network equipment for organizing informational interactions between the managing office and the enterprises that are included in the VPS. As a criterion for evaluating network equipment when organizing information and communication links, you can use:

- the volume of information transmitted - V;
- time of transfer of control and technological information - T;
- bandwidth communication channels - P;
- degree of protection of transmitted information - Z;
- risks associated with the transmitted information - R;
- costs of organizing information and communication links - W.

Let, preliminary, at the stage of formation of a portfolio of orders, an assessment of the volume of transmitted information was done. Depending on the j-th version of the selected network equipment (hardware and software), the bandwidth of the communication channels P_j, the degree of information protection Z_j, the risks associated with the transfer of information R_j and the costs of organizing infocommunication links– W_j change.

Each enterprise has its own limited possibilities in choosing network equipment for fulfilling its assigned i-th order. We introduce a Boolean variable x_{ij}, the value of which is $x_{ij} = 1$, if the j-th option of network equipment is selected for the i-th order and $x_{ij} = 0$ otherwise. Then:

$$t_{ij} = \frac{v_{ij}}{p_{ij}}, T = \sum_{i=1}^{n} \sum_{j=1}^{m_i} t_{ij} x_{ij}, \tag{23}$$

where $\sum_{j=1}^{m_i} x_{ij} = 1$ means a mandatory choice of the network equipment option for order fulfillment by i-th enterprise.

$$W = \sum_{i=1}^{n} \sum_{j=1}^{m} w_{ij} x_{ij}, \tag{24}$$

where w_{ij} – the cost of the i-th enterprise to organize information and communication links when choosing the j-th option of network equipment.

$$R = \sum_{i=1}^{n} \sum_{j=1}^{m_i} r_{ij} x_{ij}, \tag{25}$$

where r_{ij} – risk of successful fulfillment of i-th order with the help of j-th version of network equipment.

$$Z = \sum_{i=1}^{n} \sum_{j=1}^{m_i} z_{ij} x_{ij}, \tag{26}$$

where z_{ij} – level of information protection of the i-th enterprise when using the j-th version of network equipment.

The following statements are possible for the optimization problem of choosing network equipment for organizing information and communication links of VE.

Optimization of individual criteria W, T, Z, R. As an example, consider minimizing the costs W for the organization of infocommunication networks of VE. Required:

$$\min W, W = \sum_{i=1}^{n} \sum_{j=1}^{m_i} w_{ij} x_{ij}, \tag{27}$$

under the conditions:

$$T \le T', Z \ge Z', R \le R',$$

where T' – allowable transmission time;

Z' – acceptable level of information security;

R' – acceptable risks associated with the transfer of control information.

As a result of optimization of separate criteria, we obtain the values: W*, T*, Z*, R*.

Next, a multi-criteria optimization was carried out, taking into account the importance of individual criteria.

VE enterprises are managed using a virtual office manager with the active use of information and communication links. Two main directions of management can be distinguished: management by vertical links; horizontal link management.

It should be noted that the feature of planning and management in the VE is to minimize the vertical connections of the control and maximize the horizontal interactions that are associated with the transfer of large amounts of control and technological information for the effective functioning of the production of VE.

Management is carried out according to possible protocols of management of the VE office, which are implemented using information and communication links. For example:

$$MT \rightarrow CI \rightarrow CC \rightarrow CTA \rightarrow M \rightarrow QC \rightarrow OC,$$

where the MT - the management team associated with the transfer of technological information on the enterprise VE;

CI - confirmation of the information received;

CC - checking the completeness and correctness of the information received;

CTA - execution of control technological actions for a specific order on the equipment of the enterprise VP;

M - continuous monitoring to monitor the implementation of production operations;

QC - quality control;

OC - order confirmation.

To simulate the logistics of production management of VE, use the method of agent-based modeling (platform JADE).

The structure of the agent simulation model contains the following agents for modeling the control in the VE:

1) "Agent virtual office". Carries out the planning and issuance of management teams to the EaP enterprises;

2) "Agent of the Criminal Code." Initiates the work of a specific VE enterprise;

3) "Agent PE". Simulates the issuance of confirmation of the inclusion of production equipment for the execution of the order;

4) "Agent PR". simulates confirmation of received control and technological information.

4. Study of threats and vulnerabilities in the infrastructure of virtual enterprise

A study of threats in the infrastructure of virtual enterprise has been conducted. The choice of a rational option for carrying out measures to neutralize threats and minimize damage in the event of threats has been made [25 - 27]. The structure of an agent-based simulation model has been developed to study the impact of threats and vulnerabilities in an EAP. The proposed approach eliminates the risks associated with the impact of aggressive external influences on the infrastructure of man-made objects in order to ensure their normal functioning in the conditions of moral and physical aging

To solve the problem of research, the following main steps are highlighted:

1. Identification of existing factors affecting the vulnerability of the VE infrastructure.

2. Selection and justification of a rational option of preventive measures to reduce possible damages in the VE infrastructure.

3. Modeling threats and vulnerabilities in the VE infrastructure.

To identify existing factors that affect negatively the infrastructure of the VE, we use the method of the theory of experiments, or rather, full-factor planning (FFP). Experts assessing threats and vulnerabilities should, for a particular man-made object, determine the critical infrastructure (CI) and the possible many factors (threats) that affect the normal functioning of an VE.

Next, it is necessary to formulate a FFP plan, in which factors take "two meanings" $(+1,-1)$. The presence of "+1" in the i-th line of the plan will indicate the impact of the j-th threat to the CI of the VE. Otherwise, "-1" means the absence of such a threat. Since the number of lines of FFP is $N=2^n$, (where n is the number of possible threats), in terms of experiments, a complete search of factors and their combinations is carried out. When planning for the emergence of possible threats, emergency specialists should give a predictable damage estimation for each threat (the PPF line) and, according to expert estimates, to form a column vector of damage values of CI VE.

Consider an illustrated example. Let a multitude of threats correspond to three factors (blocking of the railway (RW), an act of terrorism, a cyberattack on the railway control system). We formulate the FFP with $n=3$ factors and $N=2^3=8$ responses. Imagine the prognostic estimates of expert damages from threats in a scale of $(0 \div 10)$.

Let the factor x_1 corresponds to the blocking of railways, x_2 - the attack, x_3 - cyberattack on the railway control system. The corresponding FFP plan with projected threat estimates is presented in Fig. 3.

№	factors			responses	x_1x_2	x_1x_3	x_2x_3
	x_1	x_2	x_3	y			
1	-1	-1	-1	0	+1	+1	+1
2	-1	-1	+1	3	+1	-1	-1
3	-1	+1	-1	4	-1	+1	-1
4	-1	+1	+1	7	-1	-1	+1
5	+1	-1	-1	5	-1	-1	+1
6	+1	-1	+1	8	-1	+1	-1
7	+1	+1	-1	9	+1	-1	-1
8	+1	+1	+1	10	+1	+1	+1

Fig. 3. FFP for three threats

Using the FFP calculation formulas, as a result of the expert estimates obtained, it is possible to construct a non-full quadratic regression model of the form:

$$\begin{aligned}
y &= b_0 + b_1 \cdot x_1 + b_2 \cdot x_2 + b_3 \cdot x_3 + b_{12} \cdot x_1 \cdot x_2 + \\
&+ b_{13} \cdot x_1 \cdot x_3 + b_2 \cdot x_2 \cdot x_3 + b_{123} \cdot x_1 \cdot x_2 \cdot x_3 = \\
&= 5,75 + 2,25 \cdot x_1 + 1,75 \cdot x_2 + 1,25 \cdot x_3 - 0,25 \cdot x_1 \cdot x_2 - \\
&- 0,25 \cdot x_1 \cdot x_3 - 0,25 \cdot x_2 \cdot x_3 - 0,25 \cdot x_1 \cdot x_2 \cdot x_3.
\end{aligned}$$

Let us single out the existing factors causing the level of threats. The most significant factor in the example is x_1 - blocking the railway, at the second place is x_2 - terrorist attack, and in third place is x_3 - a cyberattack on the railway control system. The combined effect in the form of products of factors is unlikely in comparison with the main factors. The selection of existing factors will allow, in the future, justifying measures to reduce their influence or a possible neutralization in the CI of VE.

The significant threats factors identified at the first stage make it possible to focus on the justification of measures related to neutralizing threats.

For the threat of "blocking railways", let such events (for example) be as follows: a political decision, a referendum, a forceful decision. Possible combinations of these activities. Then the total number of possible options for activities $N = 2^n = 8$, where $n = 3$.

We will form a set of indicators to assess the effectiveness of carrying out possible measures to eliminate threats. These indicators can be: y_1 - possible damage from the threat; y_2 - costs of carrying out measures to neutralize (reduce) the threat; y_3 - time spent on neutralizing the threat; y_4 - risk of implementation of activities.

Imagine the value of indicators in the form of values of linguistic variables (letters of the Latin alphabet):

$$y_1 = \begin{cases} \text{A} - \text{large damage from the threat;} \\ \text{B} - \text{average damage;} \\ \text{C} - \text{minimal damage.} \end{cases}$$

$$y_2 = \begin{cases} \text{A} - \text{low threat neutralization costs;} \\ \text{B} - \text{average costs;} \\ \text{C} - \text{high costs.} \end{cases}$$

$$y_3 = \begin{cases} \text{A} - \text{short time spent neutralizing the threat;} \\ \text{B} - \text{average time;} \\ \text{C} - \text{long term.} \end{cases}$$

$$y_4 = \begin{cases} \text{A – minor risk,} \\ \text{B – average risk;} \\ \text{C – very high risk.} \end{cases}$$

In order to form variants of carrying out possible measures for eliminating threats in CI of VE, we will use the values of a binary counter. For example, $n = 3$, therefore the number of states of the counter is $N = 2^3 = 8$. Fig. 4 presents a table of the full set of options for activities. Here "1" means realization of action, and "0" means non-realization.

№	actions			indicators of actions			
	x_1	x_2	x_3	y_1	y_2	y_3	y_4
1	0	0	0	C	C	C	C
2	0	0	1	B	B	B	A
3	0	1	0	A	B	B	B
4	0	1	1	A	A	A	B
5	1	0	0	B	B	B	A
6	1	0	1	B	C	C	B
7	1	1	0	A	C	C	C
8	1	1	1	A	C	C	C

Fig. 4. A full set of actions to neutralize threats in CI of VE

Let, for example, experts have determined the importance of indicators for assessing possible options for neutralizing threats in the CI of VE and presented a series of descending importance of indicators: y_1, y_2, y_3, y_4, Then, in order to find a compromise option for carrying out measures to neutralize threats, taking into account possible inconsistency of indicators, let us use the lexicographic ordering of options. The initial set of options, taking into account the values of indicators (see Fig. 4), has the form:

1. C, C, C, C
2. B, B, B, A
3. A, B, B, B
4. A, A, A, B (28)
5. B, B, B, A
6. B, C, C, B
7. A, C, C, C

8. A, C, C, C

After the lexicographic ordering of the options we get:

4. A, A, A, B
3. A, B, B, B
7. A, C, C, C
8. A, C, C, C
2. B, B, B, A
5. B, B, B, A
6. B, C, C, B
1. C, C, C, C

(29)

We discard the options with the worst values of the indicators (for example, the values of linguistic variables C). Will get:

4. A, A, A, B
3. A, B, B, B

(30)

Thus, for events aimed at eliminating (neutralizing) threats, it is advisable to use 4 or 3 options for carrying out activities. In the case of a large dimension of the problem (complex CI, a large number of threats and vulnerabilities), we use the method of integer linear optimization with Boolean variables.

We introduce a variable x_{ij} that takes two values: $x_{ij} = 1$, if for the i-th threat, the j-th action was selected to neutralize it, otherwise $x_{ij} = 0$. It is necessary to fulfill the following condition $\sum_{j=1}^{n_i} x_{ij} = 1$, which means the mandatory choice of measures to neutralize the i-th threat, where n_i is the number of possible actions. Then, indicators for evaluating the effectiveness of measures related to threats in the CI of the VE will be as follows:

$$y_1 = \sum_{i=1}^{n} \sum_{j=1}^{n_i} u_{ij} x_{ij},$$

$$y_2 = \sum_{i=1}^{n} \sum_{j=1}^{n_i} z_{ij} x_{ij}, \qquad (31)$$

$$y_3 = \sum_{i=1}^{n} \sum_{j=1}^{n_i} t_{ij} x_{ij},$$

$$y_4 = \sum_{i=1}^{n}\sum_{j=1}^{n_i} r_{ij}x_{ij},$$

where u_{ij} – residual damage, which is associated with the occurrence of the i-th threat, after the j-th action (in the case of complete neutralization of the i-th threat by j-th action $u_{ij} = 0$); z_{ij} – costs associated with the j-th action to eliminate the i-th threat; t_{ij} – time spent on the j-th action to eliminate the i-th threat; r_{ij} – the risk of the j-th action to eliminate the i-th threat;

Let, the possible residual damage is used as a target function, after all measures have been taken to eliminate a variety of threats in the CI of the VE. During optimization, it is necessary to minimize residual damage:

$$\min\ y_1,\ y_1 = \sum_{i=1}^{n}\sum_{j=1}^{n_i} u_{ij}x_{ij}, \tag{32}$$

subject to the following restrictions:

$$\begin{aligned}
&y_2 \le y_2',\ y_2 = \sum_{i=1}^{n}\sum_{j=1}^{n_i} z_{ij}x_{ij},\\
&y_3 \le y_3',\ y_3 = \sum_{i=1}^{n}\sum_{j=1}^{n_i} t_{ij}x_{ij},\\
&y_4 \le y_4',\ y_4 = \sum_{i=1}^{n}\sum_{j=1}^{n_i} r_{ij}x_{ij},\\
&\sum_{i=1}^{n_i} x_{ij} = 1,\ \sum_{i=1}^{n}\sum_{j=1}^{n_i} = n,
\end{aligned} \tag{33}$$

where y_2', y_3', y_4' – restrictions related to costs, time (terms) and risks of carrying out actions to neutralize threats in CI of VE.

To simulate the impact of threats, we use the method of agent simulation. We define the set of agents in the simulation system:

- "agent – CI VE" - describes the composition and structure of CI of VE;
- "threat agent", used to initiate a possible threat; it is given in the form of an application according to a given distribution law (it is possible to use the statistics of the occurrence of threats for specific VEs);
- "agent – vulnerability" - indicates a "weak" place in the VE when a corresponding threat occurs (the place is indicated in advance in the description of the VE structure)
- "agent-transportation" imitates the transportation of goods in the CI of VE;
- "agent – warehousing" imitates warehousing of freights in CI of VE;

- “agent – production” imitates the production cycle in the VE;

- “agent-damage” assesses the damage arising during the implementation of threats in the CI of the VE;

- “agent – scenario” describes the scenario of the operation of the CI of VE in the case of a threat;

- “agent-dispatcher” - controls the course of event simulation (system time, list of events, etc.);

- “agent – results” - used to display intermediate and final simulation results.

The proposed approach should be used to study the impact of threats to the infrastructure of man-made objects of virtual production. This allows, in advance, formulating and implementing a plan of preventive measures to reduce the damage arising from the realized threats in the CI of the VE, assess the possible costs, terms, and risks associated with the implementation of a set of proposed measures.

Conclusions

In this work, we conducted a topical study of modern forms of organization of distributed enterprises, based on virtualization of production processes. Computerization of production, intellectualization of control processes, and robotization of technological processes led to a new class of businesses based on virtualization of production. Therefore, a comprehensive study on Informatization of virtual production gradually solved the major problems that arise when creating a virtual company. The life cycle of complex equipment, to identify bottlenecks and minimize the time and risk of creating complex machinery was examined. The formation of portfolio of orders, taking into account the competitiveness of new products on the consumer market of high-tech products, using modern optimization techniques was done. The techniques of case approach for the formation of candidates to the businesses for the implementation of the portfolio was used. The choice of rational variants of the composition, taking into account the costs associated with the adaptation of enterprises to the requirements of the portfolio was evaluated with the help of lexicographic ordering options. A study of management processes using an extensive network of information and communication enterprises-performers of the portfolio was provided. The choice of the network equipment against the criteria of cost, throughput, and risks of information transfer was held. Methods of system analysis, simulation modeling to study the logistic processes of «supply-production-sales» of the distributed virtual enterprise were used. A study of the infrastructure of virtual production and identified significant factors influencing the emergence of threats and vulnerabilities of virtual production with the use of methods of theory of experiments planning was provided.

The proposed approach is appropriate to use in the initial stages of the formation of virtual manufacturing system when it is necessary to form a portfolio of orders for the release date for the consumer market, high-tech products and to organize temporary enterprise, oriented to the needs of specific customers.

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2. MODELS AND METHODS OF MANAGEMENT A PROFESSIONAL LEVEL OF INTERNAL PROJECT PARTICIPANTS

Malyeyeva O.V., Nosova N.Yu., Artyuh R.V.

The work is devoted to the study of the processes of personnel management of the innovative project. The research is based on the use of methods of multi-criteria expert evaluation and semantic modeling. The classification of projects according to various characteristics is presented, which allows to take into account the specifics of the project and to determine the knowledge that the project team members need to have for its implementation. The main levels and elements of the organizational structure of the project personnel are defined. The semantic network was chosen as a tool to describe the subject area of the project. To build a semantic model of the content of the project, the constituent elements acting as objects of description were selected and the types of elements were determined. Based on the analysis of the network elements and their relationships, the structure of the semantic model of the project content is formed. The constructed model of the project content can be used to determine the classes of objects that correspond to the classes of knowledge for the project executors. The procedure of comparison of knowledge areas for project work and functional roles of the project management team is presented.

Introduction

For the successful implementation of the project, the formation of a suitable team and project executors is of great importance. The project team is a specific organizational structure that is formed during the life cycle of the project. The result of project management depends on how successfully the team is formed and how effectively the participants work, on the professional, organizational and personal qualities of each participant of the project [1]. Therefore, the management of professional knowledge is an important issue that must be considered in the formation and further management of the project team [2].

Special attention is paid to research and application of models and methods that allow to increase the efficiency of project participants. So, in the work of I. I. Mazur, V. D. Shapiro [3] the following methods of personnel evaluation are presented: tests for professional suitability, general tests of abilities, features of thinking, attention, memory and other qualities [4]. One of the important methodological questions is who should evaluate the employee. In this regard, personnel assessment methods are distinguished [5, 6], in which the manager deals with the assessment, and self-assessment methods are used.

Modern methods of personnel management suggest, on the one hand, the study of individual characteristics and abilities of workers to determine their potential, and on the other, the identification of quantitative and qualitative requirements for personnel, taking into account the prospects for the development of the organization, the emergence of new areas of work [7]. In the works of A.Ya. Kibanov [8], T.D. Zinkevich-Evstigneev, D.F. Frolov, T.M. Grabenko [9] presents the classification of methods used to analyze and build an organization's personnel management system.

Existing models and methods of project team management do not fully provide solutions to the problems of forming and managing a project team, taking into account its professional level.

The aim of the study is to develop models and methods for the formation of internal project participants with the necessary professional knowledge of the innovative project. To achieve this goal, it is necessary to solve the following tasks:

to develop a model of classification features of an innovative project;

to form a semantic model for presenting the content of the project;

to develop a method for distributing functional responsibility of the project team.

1. Model of classification features of an innovative project

In order to take into account the specifics of the subject area in the course of the project implementation and to determine the specifics of the project knowledge that executors must have in order to carry out a particular project, it is first necessary to classify projects according to a number of features [10].

The main classification features of the project are [11]:

- project class - determined by the composition and structure of projects in this subject area;
- type of project - determined by the areas of activity in which the project is carried out;
- kind of project - determined by the nature of the subject area of the project;
- scope of the project - by the size of the product of the project itself and the number of participants;
- project duration - for the duration of the project;
- the complexity of the project - according to the degree of complexity of the product and the technologies used.

The knowledge system of the project is determined in accordance with the classification features.

To form a knowledge model of a project, it is necessary to define a set of classification features set of and a set of their values [12].

So, the classification features forms a set of:

$$Kn^{gen} = \{P, Inn, Sph, Dur, Prod, Func, Sc\}, \tag{1}$$

where P – the main aim of the project; Inn− degree of innovation; Sph− branch affiliation; Dur− project duration; Prod − specifics of the final product Func − functional direction; Sc − scope.

In its turn, each element of the set is characterized by a number of possible values. The main goal of the project will be presented in the form:

$$P =< Com, unCom > \tag{2}$$

Where: Com − commercial project, unCom− noncommercial project.

According to the degree of innovation, the project can be presented:

$$Inn =< tinyInn, smInn, midInn, larInn, majInn > \tag{3}$$

where tinyInn − project with the smallest innovations (requiring new knowledge within the same profession),

smInn − project with small innovations (requiring new knowledge within the same branch);

midInn− project with middle innovations (requiring new knowledge within one science);

larInn − a project with large innovations. (requiring new knowledge beyond one science);

majInn − a project with major innovations (requiring new knowledge beyond modern concepts.)

By the branch affiliation, the project can be presented:

$$Sph =< Ind, Const, Tran, Edu, Tr, Comp > \tag{4}$$

where Ind – industrial project; Const – construction project; Tran – transport project; Edu – educational project; Tr – trading project; Comp – complex project.

By the duration, the project can be presented:

$$Dur =< shTerm, medTerm, longTerm > \tag{5}$$

where shTerm – short term project; medTerm – medium term project; longTerm – long term project.

By the specifics of the final product, the project can be presented:

$$\Pr od =< Ecom, Org, Tech, Social, Mix > \quad (6)$$

where Ecom – economical project, Org – organizational project, Tech – technical project. Social – social project, Mix – mixed project.

By the specifics of the final product, the project can be presented:

$$Func =< \Pr oduct, Technol, Finan, Re search, Marketing, Hr, Comb > \quad (7)$$

where Product – productional project, Technol – technological project, Finan – financial project, Research − research and development project, Marketing – marketing project, Hr – HR project, Comb – combined project.

By the specifics of the final product, the project can be presented:

$$Sc =< Inter, Nation, Terr, Local, Industr, Depart, Corp, Ent > \quad (8)$$

where Inter – international project, Nation – national project, Terr – territorial (regional) project, Local – local project, Industr – industry project, Depart – department project, Corp – corporative project, Ent − project of one enterprise.

Thus, each project can be described using the set of features and their meanings described above. For example, a non-commercial educational project with the smallest innovations, short-term in terms of time, which is social in its type, research and development in its functional area, and local in terms of scale, can be presented as follows:

$$\begin{gathered} Kn_{proj} =< P = Com; Inn = tinyInn; Sph = Edu; Dur = shTerm; \Pr od = Social; \\ Func = Re search; Sc = Local > \end{gathered} . \quad (9)$$

2. Semantic model of project content presentation

Since the problem of adapting the existing, previously formed and already worked out project team to a new project is being considered, the task is to formalize the description of the project's content in order to structure the knowledge of the executors and assess how the knowledge of the existing project team corresponds to that required for the project [13]. The solution to this problem is proposed by building a semantic network of project content.

Under the content of the project we will understand the work that must be done to obtain a product, service or result with the specified characteristics and functions. Determining the content of a project is a process in which a detailed description of the project and its product takes place. The content of the project also describes the results to be obtained and the work to be performed in order to obtain these results.

The definition of the content of the project is carried out to ensure that the essence of the project is clearly understood by all stakeholders of the project. Typically, project content includes:

- description of product requirements;
- list and description of the project stages;
- list and description of tasks;
- list and description of project activities;
- the structure of the project executors, etc.

When describing the subject area, the concept of "ontology" is often used [14, 15]. An ontology is understood as a comprehensive and detailed formalization of the domain with the help of a conceptual scheme. Typically, such a scheme consists of a data structure containing the relevant classes of objects, their relationships, and the rules adopted in this area. One of the tools of ontology is the semantic network.

The construction of the semantic model begins with the selection of the constituent elements acting as objects of description. It should be noted that each element of the description can be single or represent a group of elements.

Based on the analysis of network elements and their interrelations, the structure of the semantic model of the content of the project is formed [16, 17]. It includes a description of the main objects of the project content, indicating the attributes of network nodes and types of connections (Fig. 1).

Nodes and links in the proposed semantic network have the following attributes:

- Name - a line of text (object name) of the corresponding node;
- ObjectClass - the class of the object of the corresponding node: Functional, Organization, Specification, Resource, Structural;
- ObjectType - the type of the object of the corresponding node: Central, Context, Group;
- SemanticType - semantic unit rank: Inform, Property, Excuter;
- Relation - the type of semantic connection between nodes.

As a result, the constructed model of the project content is used to determine the classes of objects that correspond to the knowledge classes for the implementers of the project.

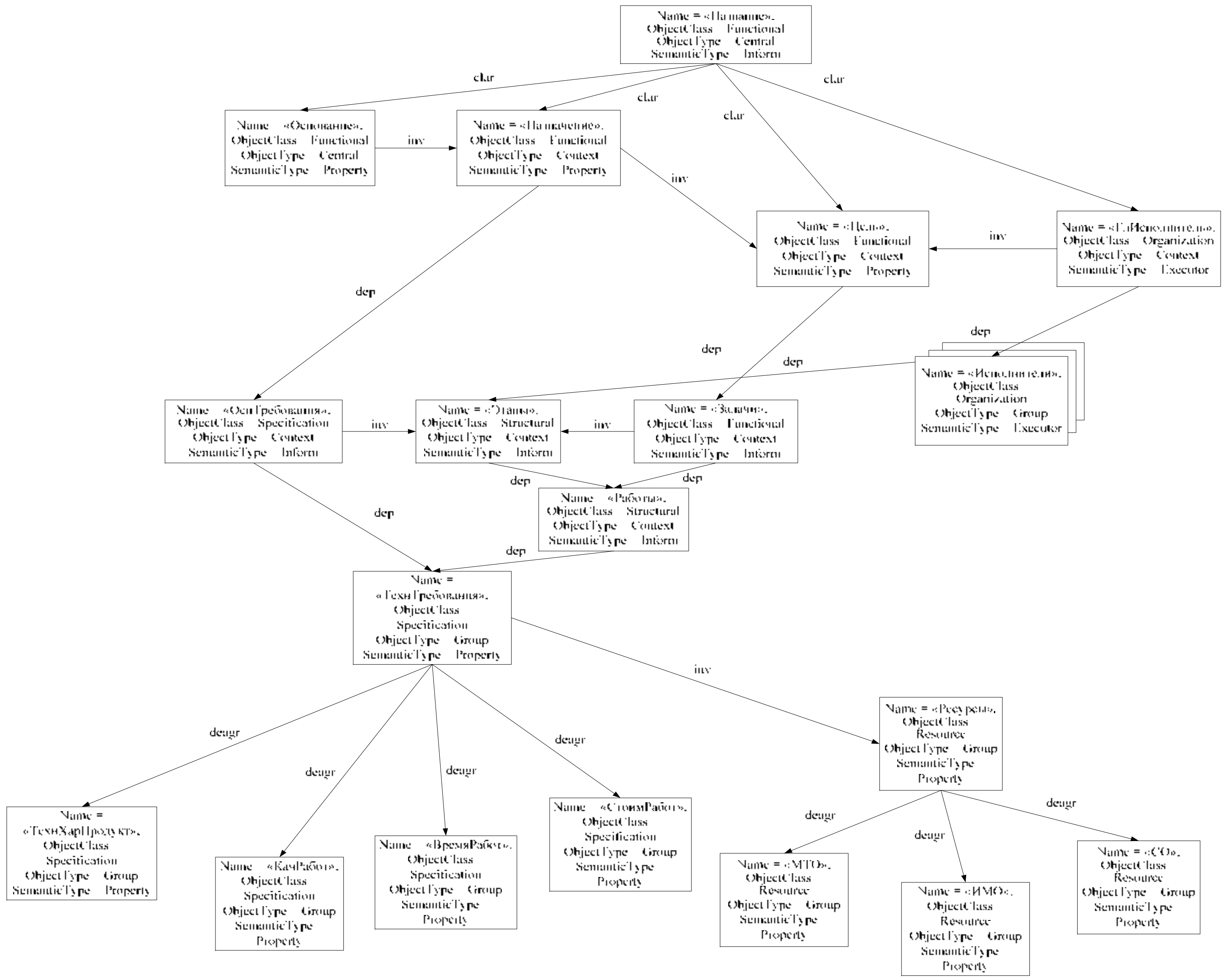

Fig. 1. Semantic network of the project content

For each of the semantic model classes, taking into account the classification features of the project, the necessary amount of knowledge that a different specialist must possess to fully realize their functions in the project is highlighted [18]. The resulting object classes were compared to the functional roles of the project management team. Next, the method of questioning each participant is to assess the compliance of the current knowledge of the specialist with the required project knowledge.

Based on the obtained results, it is decided to either finish the existing specialists, if the discrepancies are small, or hire another specialist, if the discrepancies are significant, or expand the team of specialists, since the existing team members need a fairly large amount of knowledge, and, therefore, the scope of work and responsibilities exceed the norm.

3. The method of distribution of the project team functional responsibility

Consider the main participants of the project activity. Project participants include individuals or organizations that directly perform a particular work in a project, i.e. specialists who are directly involved in a project.

The organizational structure of the project involves two levels: management and execution. In accordance with these levels, a structure is formed with two levels of functional tasks and the corresponding classes of knowledge about the project (Fig. 2).

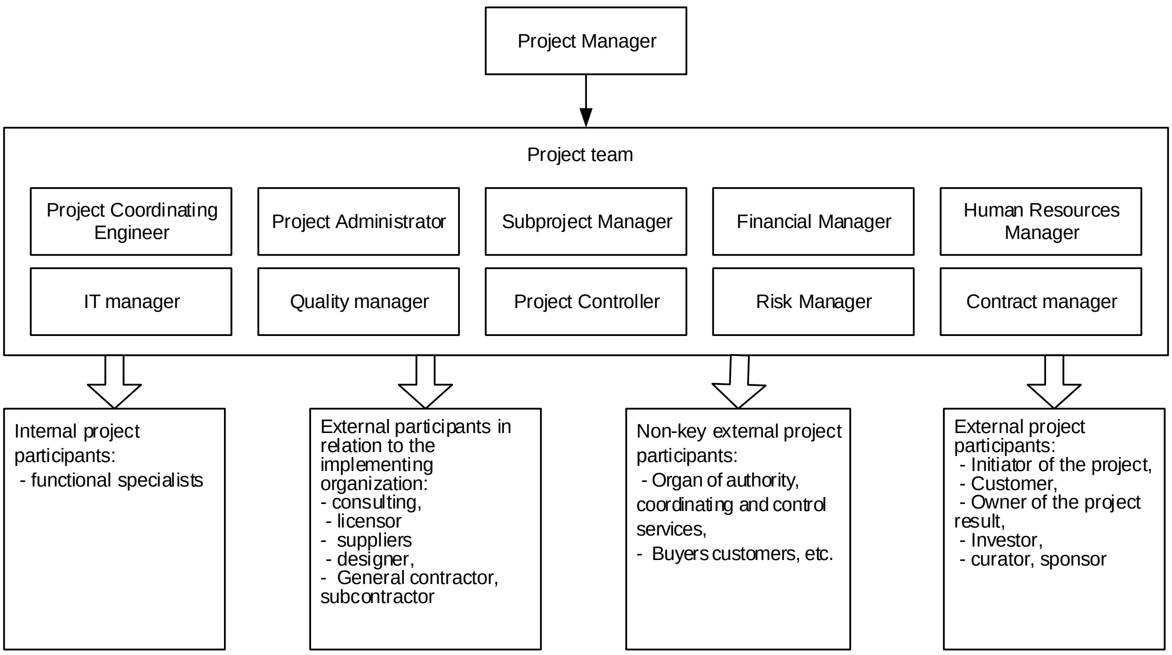

Fig. 2. Two-level organizational structure of management and project implementation

For the first level (management), the method of redistributing the project scope of work in accordance with the shares of a certain type of work of each member of the project management team according to the main criteria for evaluating managers is predicted.

This method involves the following steps [19]:

1) formation of the list of participants in the project team;
2) formation of the list of works in the project;
3) determining the set of estimates for the formation of the matrix of distribution of roles in the project management team;
4) determination of the coefficients of importance of each assessment for the performance of a job;
5) evaluation of participants for the performance of each type of work;
6) formation of the initial role assignment matrix in the project management team;
7) carrying out the procedure for rationing matrix elements;
8) formation of an agreed role assignment matrix for the project management team.

The main criteria for personnel evaluation are proposed to be used in this method: level of education; professional level, qualification level; level of theoretical knowledge; production experience and practical knowledge; organizational, managerial, psychological qualities.

A lot of assessments that are assigned to each participant and the coefficients of importance of these estimates are summarized in a matrix, which we will call the three-dimensional information matrix of roles in the project management team (Fig. 3) [20].

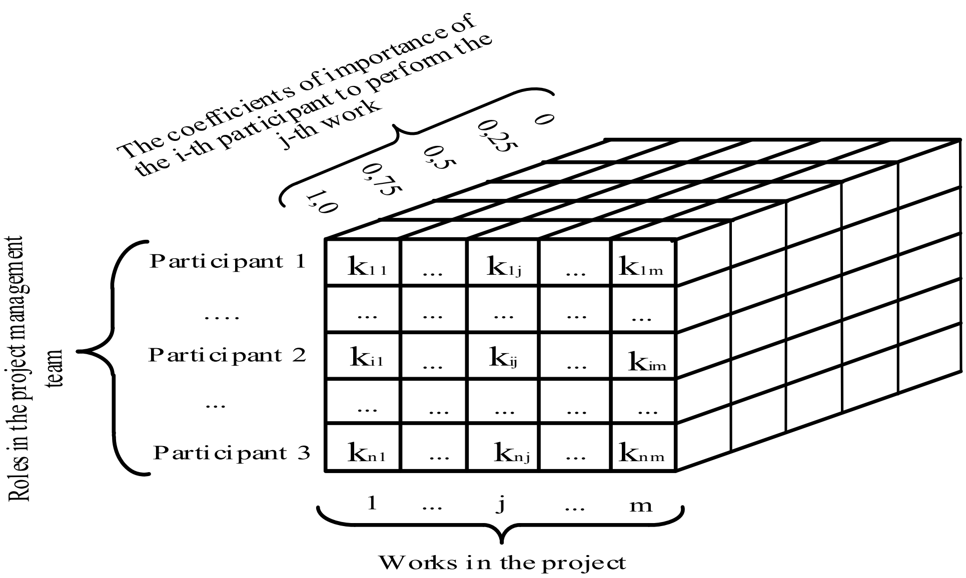

Fig. 3. Three-dimensional information matrix of roles in the project management team

In the three-dimensional information matrix of roles in the project management team, the elements of the horizontal axis are the project activities; the elements of the vertical axis are the roles in the project management team, the elements of the axis “in depth” are the coefficients of the importance of the team roles for the relevant works.

For example, the set of estimates for the role assignment matrix includes the elements [21]:

$$k_{ij} = \left\{k_{ij}^1, k_{ij}^2, k_{ij}^3, k_{ij}^4, k_{ij}^5,\right\}, \tag{10}$$

where k_{ij}^1 – conformity assessment of education of the i-th participant to the j-th work;

k_{ij}^2 – qualification of the i-th participant to perform the j-th work;

k_{ij}^3 – evaluation of theoretical knowledge of the i-th participant to perform the j-th work;

k_{ij}^4 – assessment, in accordance with the acquired experience of the i-th participant to perform the j-th work;

k_{ij}^5 – assessment of psychological, organizational and managerial qualities of the i-th participant to perform the j-th work.

To create the initial role assignment matrix in the project management team, a comprehensive (averaged) score should be calculated using the formula:

$$K_{ij} = \frac{\sum_{l=1}^{5} k_{ij}^l koef^l}{5}, \tag{12}$$

where k_{ij}^l – assessment of knowledge and skills of the i-th participant to perform the j-th work by the l – st criterion, $k_{ij}^l \in [0,1]$.

$koef^l$ – coefficients of importance of estimates by the l – st criterion.

Multiple integrated assessments form a preliminary assignment matrix for a project management team. $K = \left\|K_{ij}\right\|$.

Then, an iterative procedure for normalizing the distribution coefficients of the work is performed sequentially in rows and columns of the matrix (Table 1).

The first step of rationing elements:

$$K_{ij}^{(1)} = \frac{K_{ij}}{\sum_{j=1}^{m} K_{ij}}, i = \overline{1,n}, \; K_{ij}^{(2)} = \frac{K_{ij}^{(1)}}{\sum_{i=1}^{n} K_{ij}^{(1)}}, j = \overline{1,m},$$

t-th step of rationing elements

$$K_{ij}^{(2t-1)} = \frac{K_{ij}^{(2t-2)}}{\sum_{j=1}^{m} K_{ij}^{(2t-2)}}, i = \overline{1,n}, \; K_{ij}^{(2t)} = \frac{K_{ij}^{(2t-1)}}{\sum_{i=1}^{n} K_{ij}^{(2t-1)}}, j = \overline{1,m}.$$

The procedure ends when the inequality system is executed:

$$\begin{cases} \sum_{i=1}^{n} \left| \sum_{j=1}^{m} K_{ij}^{(2t-1)} - 1 \right| < \mu_1 \\ \sum_{j=1}^{m} \left| \sum_{i=1}^{n} K_{ij}^{(2t)} - 1 \right| < \mu_2 \end{cases}.$$

Here μ_1 - permissible total surplus (or lack of) performers for works, μ_2 - permissible total surplus (or shortage) of works for performers, $\mu_2 < \mu_1$.

Table 1. Matrix of redistribution of responsibility in the project management team

Role in the project management team	Number of work in the project					Surplus/ lack of performers
	1	…	j	…	m	
Participant 1	$K_{11}^{(2t)}$	…	$K_{1j}^{(2t)}$	…	$K_{1m}^{(2t)}$	$\left\lvert \sum_{j=1}^{m} K_{1j}^{(2t-1)} - 1 \right\rvert$
…	…	…	…	…	…	
Participant i	$K_{i1}^{(2t)}$	…	$K_{ij}^{(2t)}$	…	$K_{im}^{(2t)}$	$\left\lvert \sum_{j=1}^{m} K_{ij}^{(2t-1)} - 1 \right\rvert$
…	…	…	…	…	…	
Participant n	$K_{n1}^{(2t)}$	…	$K_{nj}^{(2t)}$	…	$K_{nm}^{(2t)}$	$\left\lvert \sum_{j=1}^{m} K_{nj}^{(2t-1)} - 1 \right\rvert$
Surplus/lack of works	$\left\lvert \sum_{i=1}^{n} K_{i1}^{(2t)} - 1 \right\rvert$		$\left\lvert \sum_{i=1}^{n} K_{ij}^{(2t)} - 1 \right\rvert$		$\left\lvert \sum_{i=1}^{n} K_{im}^{(2t)} - 1 \right\rvert$	

Conclusions

As a result of the analysis of existing models and methods of managing project personnel, the necessity of developing new and improving existing models and methods of managing the professional level of project participants taking into account the specifics of the project has been substantiated.

For the first time, a model of a project's knowledge structure has been developed, which, unlike existing ones, makes it possible to single out knowledge classes characteristic of this type of project. This ensures that the knowledge of the internal participants of the project is consistent with its content.

A method for distributing functional responsibility of the project team has been developed. A rational distribution of project work based on a balanced matrix will reduce the project implementation time, since each employee will clearly understand the scope of his actions and the actions of project team members will not overlap when performing work in a project. The values of the load factors of the project team members determine the scope of duties of each employee and clearly demonstrate his level of employment.

The results of the dissertation research are implemented in the practical activities of research organizations and research and production enterprises. The results of the work can be used for machine building and aircraft manufacturing enterprises.

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3. FORMALIZATION OF THE PROCESS OF FORMING A COLLECTIVE OF DISTRIBUTED TEAMS

Kosenko N.

The actual task of forming professional competences of human resources is considered taking into account the requirements of project activities and the characteristics of the dynamics of virtual teams. The significant differences of the virtual team building comparing with the classic and the existing problems in the field of virtual team building are considered. The method of selecting candidates for a project team was further developed by applying a theory of precedents, which allows one to take into account the professional experience of candidates taking into account the specifics of the formation of distributed teams.

Introduction

In control theory, team processes take place in four main areas: team formation, team development, definition of team roles and the formation of cohesion in the team. All these processes are interrelated and interdependent. In the current economic conditions flexibility, adaptability to rapidly changing market conditions, increasing productivity and ability to grow creatively is essential for the survival of the company. Today, more and more teams are distributed and there is a need to find new tools to engage and maintain relationships with such participants. Small businesses and startups often have to resort to the services of remote employees, which largely reduce the cost of doing business. Successful coordination of such employees fit many general principles of personnel management. Thus, to make the job of this kind of team the most effective, there is a need to use new strategies and modern digital tools in addition to the traditional management methods. According to the latest figures (December 2018) of the international labour organization, approximately 17% of employees in developed countries work remotely, in Japan this figure reaches 37% of the working population and in the U.S. – 32% [1].

There are three key elements in working with a remote team:

- project team;
- customer;
- project manager.

The specificity of distributed teams imposes certain requirements on channels and methods of interaction. When working with remote teams, there are several basic principles of work:

1) The need to stay in a single information field with all participants. The fixing of certain agreements between team members is of fundamental importance here; these agreements must also be agreed with the customers.
2) Systematic feedback collection. When working with remote teams it is necessary to take into account the time limits of work, the difference in time zones, the time for communication.
3) Synchronization between all participants.

You can select certain objects of attention, i.e. basic requirements for a project manager who works with a remote team:

- conciseness - the ability to express thoughts briefly and clearly. This is due to the fact that the communication channels are different and have their own characteristics. Application of active listening skills, correct analysis of the information received;
- punctuality - due to the fact that each participant has his own schedule, you need to take into account the importance of communication planning;
- confident use of software;
- propensity to trust - refers to the manager's behavior model and relies on the level of maturity of the team. Additional control of the remote team members is possible.

There are basic project manager tools when working with remote teams, which are especially actively used when you have to work on several projects at the same time:

- questionnaires for communication on control points;
- project acceptance methodology;
- personal task manager / calendar (automated time management);
- schedule of employment / availability.

Analysis of recent research and publications

There is a fairly large number of definitions of the “virtual team”, but there are few significant differences in these definitions. As a rule, a virtual team is a small group of people united by a common goal or task, but separated in space and (or) time and interacting with each other through computer technologies.

Despite the huge interest worldwide to the subject of team building and team work, questions of formation of effective virtual teams have been studied insufficiently. Problems of formation and development of distributed teams devoted to a number of foreign and domestic experts in the field of project management. Available publications can be divided into the following four types:

1. Theoretical works in which the virtual team is seen as a kind of conventional commands and thus, it can be applied the principles and methods of classic team building activities [3-7].

2. The publication, which deals with certain aspects of team building both traditional and virtual teams, but without a systematic relationship with other aspects [5; 8-10].

3. Narrow, practical publication, which is a particular case − history specific success (usually) or failure (less common). They are, as a rule, the question how the methods and principles of teamwork applied in this particular case, universal, and received the results of a representative [11; 12].

It should also be noted that such phenomena as freelance, start-up teams, virtual office, etc., are studied, as a rule, independently of each other; independent studies are carried out for each of these forms, although the principles of virtual team building obviously affect all these forms, each of them may require the formation of virtual teams. The principles of the formation of such teams, their main characteristics and methods should be the same. In the scientific literature, including devoted to team building, there is no separate direction, corresponding to the team building in the network - digital, virtual space. Such a generalized concept is called virtual team building (digital teambuilding) [2].

After analyzing the existing research, the following benefits and risks of virtual teams can be identified. The advantages of a virtual team include the following factors [2]: increased competence; mutual enrichment and supplement; increased creativity; flexibility; use of the advantages of freelance; cost reduction; acceleration of work processes. The risks and problems of a virtual team include the following: a control problem; organization problem; the problem of intercultural, ethnic and social contradictions, political differences; management transformation; the problem of "common language"; team building problems.

The authors [2] highlighted a number of identified and systematized aspects that significantly distinguish virtual team building from the classical one (Table 1).

Table 1 − Fundamental differences between virtual team building and classical team building

Feature	Classic team building	Virtual team building
Use of computer technology and the Internet	With more or less regularity	Permanent
Online communications	Complement personal communication	Replace personal communication
Team core	Leader or idea creator	Communicator or organizer
Control	Possible in any form	Mostly self-control
The role of the psycho-type and competencies of an individual participant	Important, but subject to correction due to team (joint) actions	Paramount importance
Collective decision-making	Possible in any form	Substantially difficult
Leadership	Any form of leadership and authority is possible.	The charismatic form of power is practically impossible, the sole leadership is difficult.
Team spirit	Formed in the process of direct communication and joint action.	Requires special procedures and special efforts
Team composition	Conventionally constant factor	Conditionally variable factor
Team borders	The borders of the organization (team members - employees of the same organization)	Absent

Thus, the problem of the formation of virtual teams and its effective interaction to achieve project goals in a high level of uncertainty and rapid changes of many factors requires further consideration.

General provisions for the formation of distributed teams

To effectively operate a virtual work team, a clear statement of purpose is needed, i.e. desired end result. Of course, the presence of a specific goal is necessary for any type of organization, but for virtual work teams, this principle is fundamental. Here the goal is what unites people and holds them together until the work is completed. At the same time, it should be clear, articulated and shared by all team members. After all, there are far fewer opportunities to clarify it, clarify in the process of working with virtual employees than with direct interaction. The virtual work team works within the framework of this task, without being distracted by any extraneous moments. Such an organization of work determines the main features of the interaction. All information exchanged between the participants relates

exclusively to questions and problems within the framework of the task. The scope of interaction and its quality here are limited by technical means. At the same time, satisfaction with the work of members of virtual work teams is connected precisely with the position of a person in the business structure of such a team. Since all the interaction here is focused on the task, for each member of the virtual work team, first of all, it is important how other team members evaluate their business qualities.
The process of forming a staff of virtual teams can be represented as follows (Figure 1).

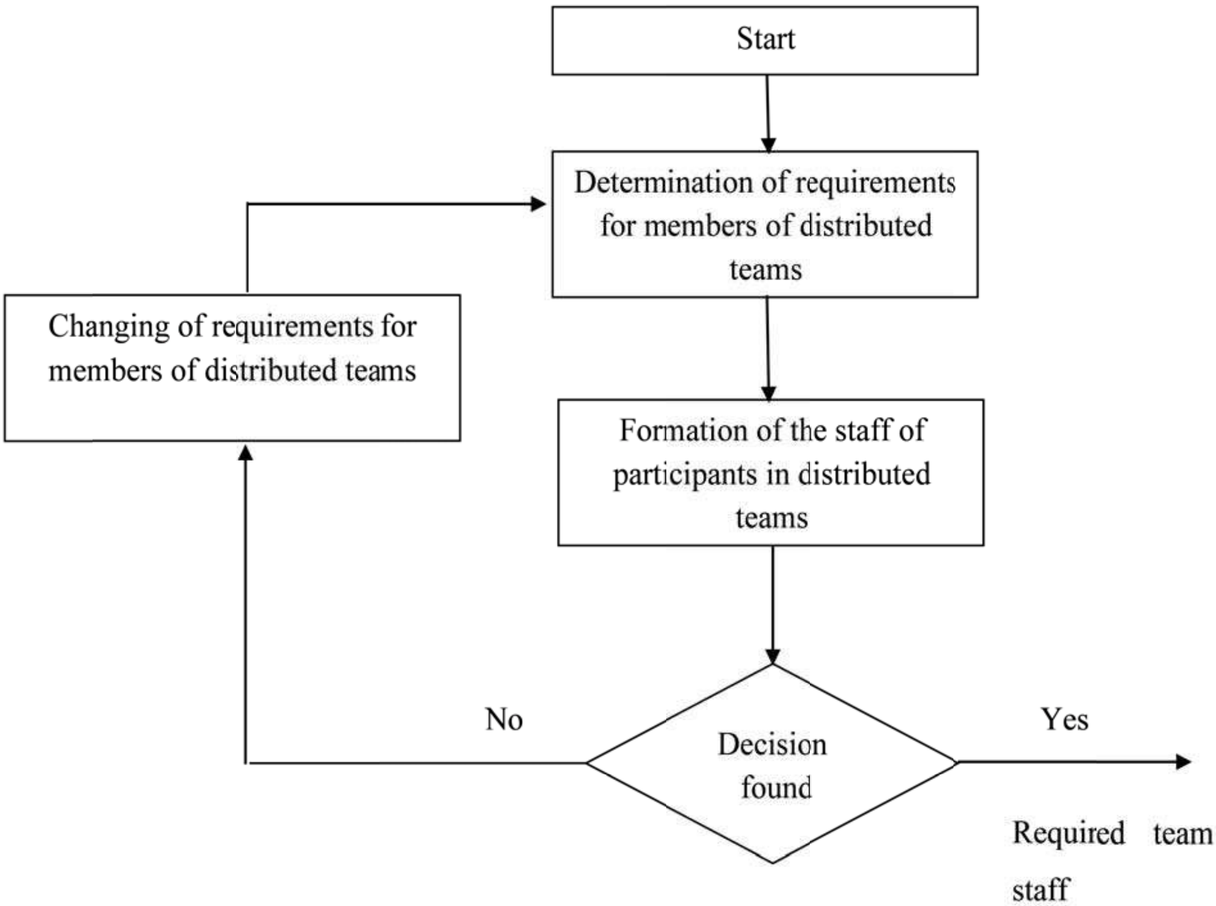

Fig. 1 - The process of forming the staff of virtual teams

The task of forming virtual teams is currently the least theoretically worked out, this is primarily due to psychological and social factors. In general, the task of selecting specific participants for remote teams consists of two stages. At the first stage, based on the project objectives, it is necessary to determine the range of potentially competent employees, and at the second stage, the selected virtual team is formed from the selected candidates. These tasks are closely interrelated and are solved on the basis of a deep system analysis of the goals and objectives of the project. In this case, the composition of a particular group of employees is completed taking into account the requirements arising from the nature and number of questions posed to the team.

The formation of a staff of virtual teams is understood as the task of choosing from some set of specialists (candidates for a team) the persons most competent in the circle of questions under consideration, and drawing up a workable remote team from these candidates. This task should be considered as a specific type of professional selection, in which by the degree of professional suitability is understood the degree of competence of the candidate.

Formalization of the distributed teams' formation process

The formalization of the processes of preparation and formation of virtual teams is a necessary condition for the transition from subjective opinion to regulatory rules and models that ensure the reproducibility, reasoning and effectiveness of decisions made.

The selection of candidates for the virtual project team is proposed to be done on the basis of an analysis of the experience of their work in past projects that are close in content to the planned works. At the same time, unlike some well-known methods, the criteria for evaluating candidates should include criteria that characterize not only the subject (work specialization), but also the content of specific types of work within general competence. Thus, the composition of potential performers is formed, which can be considered as candidates for inclusion in the staff of distributed teams.

A formalized presentation of the above can be formulated as follows: if a description of a certain object $s \approx s_j$ is given and there is a correct description of it $l_j \approx \langle s_j, r_j \rangle$, then it can be argued that r_j is a similar (approximate) technical solution of a given description of the object, and the performers of these works have experience in performing the planned works.

The algorithm for forming the list of employees of virtual teams within the framework of the theory of precedent theory with experience in similar subjects can be represented as consisting of the following stages:

Stage 1. Formulate a description of the object of the new task in the form of its characteristics and parameters (technical specifications).

Stage 2. Determine the metrics of measuring the similarity of works.

Stage 3. Access to the database of the warehouse of precedents.

Stage 4. Search for a reference situation, within the specified proximity interval.

Stage 5. Selection of candidates (projects in which candidates participated, were successful).

Stage 6. Determine the professional characteristics of applicants for a given list of characteristic indicators.

The description of the object of new task should be concise, unambiguous and informative. In addition, the description of the object should specify the name of the adopted classification, purpose and values of the criteria for each characteristic. This is necessary for successful, effective work with the database of precedents.

When solving the task of searching for related work, a list of analogues with a different degree of similarity with the project under development is formed in accordance with a given measure of similarity in the form of a weighted measure of proximity of a pair of objects l_p and lq:

$$d_{pq} = \left[\sum_{j=1}^{n} W_i^2 \left(x_{pj} - x_{qi} \right)^2 \right]^{1/2}.$$

To determine the work and the corresponding list of potential performers, the analyst must describe the work of the planned project in terms of the concepts of existing categories. Thus, a search is made for similar types of work and an initial list of candidates for a project is formed from the list of executors of these works. Procedures for the implementation of these works are based on the sequence of the following steps, logically derived from the goal:

1) a description of the planned work, in the language of presentation of situations;
2) search for related works in the range of a given measure of similarity;
3) determination of the list of executors as potential candidates for a project with certain experience of similar works in the past.

The choice of the proximity measure is considered to be the key point on which the search for suitable use cases depends. In each specific task, the choice is made on the basis of its own set of rules, taking into account the objectives of the project. The proximity of objects is determined by the relationship of similarity between them.

Formally, the formulation of the task of forming candidates for a virtual team can be represented as follows. Let:

$\mathrm{V} = \{v_1, v_2, \dots v_n\}$ – a set of applicants for the formation of candidates in the virtual team;

$\mathrm{P} = \{p_1, p_2, \dots p_m\}$ – a set of functions that can be performed by the command.

Each applicant is characterized by a variety of characteristics: $R_{Vi} = \{r_1, r_2, \dots r_k\}$ and the ability to perform functions:$\mathrm{F}_V = \{f_1, f_2, \dots f_t\}$.

$K = \{k_1, k_2, \dots k_m\}$ – set of preset coefficients for the corresponding function.

The reserve coefficient [13] determines the minimum required number of candidates capable of implementing these functions. Possibilities of applicants to the virtual team are summarized in Table 2. [13].

Table 2 - Applicants abilities to perform relevant tasks

A / V	a_1	a_2	…	a_m
v_1	L_{11}	L_{12}		L_{1m}
v_2	L_{21}	L_{22}		L_{2m}
v_n	L_{n1}	L_{n2}		L_{nm}

L_{ij} – element of the matrix, which shows the ability of candidates to perform certain functions. If the i-th applicant is able to perform the j-th function, then L_{ij} = 1, otherwise L_{ij} = 0.

Determining a specific qualitative staff of a virtual team is a weakly formalized task, the solution of which is based mainly on the subjective assessments of project managers. The difficulty of determining general recommendations on the qualitative composition of candidates is due to the need to take into accounted the specific goals and objectives of the project.

In a number of practical situations, procedures for evaluating candidates are decided on an individual basis. In this case, it is assumed that the professional training of a specialist is known and satisfies the requirements of the organization. In this case, a portrait of an "ideal" specialist is formed with the parameters of his professional characteristics that meet the conditions and requirements of the work performed. After determining the required characteristics of the applicant, these characteristics of x_i are compared with those in the recruitment of the "ideal" employee. The candidate is tested according to the composition of the characteristics of the "ideal" employee x_e for typical types of work. For each characteristic, the magnitude of the discrepancy $\Delta X_i = x_{ie} - x_i$ is determined and the individual characteristic of the degree of proximity of the candidate and the "ideal" employee is determined:

$$P = \sum_{i=1}^{n} a_i \Delta X_i$$

where a_i significance coefficients of comparison characteristics, $\sum_{i=1}^{n} a_i = 1, \leq a \leq 1$. The values of the coefficients a_i are set by experts depending on the type of work and other special requirements affecting the value of the coefficients of significance.

Thus, the system of selection of candidates to the project team was considered according to the degree of closeness of the planned work and analogues of past developments based on the theory of precedents. The application of the principles of analogies makes it possible to increase the efficiency and shorten the term for selecting candidates for inclusion in the project team. According to the specific tasks of personnel management, the approaches under consideration can be used when it is necessary to select one best candidate from the list of applicants.

Conclusions

Considering the features of the life of virtual teams, it is necessary to note the great promise of such organizational forms due to their obvious advantages. First of all, virtual work allows you to combine the intellectual efforts of specialists, far removed from each other. The use of virtual work teams allows you to reduce time costs due to the possibility of round-the-clock work on the project, if you involve specialists living in different time zones. Experts predict that in the near future, virtual work teams will seriously compete with traditional organizational forms.

The issues related to virtual team building are considered, in particular, a method of forming teams is proposed, the participants of which work away from each other.

The professional competencies of human resources are a key factor in project effectiveness. Therefore, it is important to form these competencies taking into account the project specifics and peculiarities of interaction between distributed groups. The formation of project professional competencies has its own specifics in the process of managing a virtual team. Thus, competencies determine the effectiveness of project activities of members of distributed teams. A set of professional competencies is modeled for each project role. Consequently, the development of virtual teams takes place, including through the development of professional competences of the project's human resources.

The method of selecting candidates for a project team was further developed by applying a theory of precedents, which allows one to take into account the professional experience of candidates taking into account the specifics of the formation of distributed teams.

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4. MARKETING AND LINGUISTIC METHODS OF CREATING ADVERTISING MESSAGES FOR ENTERPRISES OF SMALL AND MEDIUM BUSINESS

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The main indicator of the economic efficiency of an enterprise is the profitability that generates profit. The well-known scientist P. Drucker noted that "Profit is not a cause, but a result. The result of effective business activities in the field of marketing and innovation"[1, p. 22]. The assessment of possible performance results in a timely manner allows avoiding financial problems, to adapt to economic changes, to prevent losses. In a market economy, profit is of particular importance. It not only characterizes the activity results of small business enterprises, but also serves as an intensifier.

An advertising message is one of the most important marketing factors that influence the formation of profits of small and medium-sized businesses. The effectiveness of advertising depends on the number of consumers who make the purchase, will become regular customers and will generate profits of the enterprise. "The basis of any advertisement is the need to force the client to break away from their affairs and think about something else" [2]. In connection with this important issue is the informative content and algorithm for building an advertising message, identifying mechanisms for achieving successful impact on the addressee by means of advertising communications.

But now, due to certain cultural and ideological circumstances, the trend of copying the marketing strategy of large enterprises aimed at advertising the brand of the enterprise is gaining popularity in the management of small and medium enterprises. This type of advertising usually contains a company name, logo, location and slogan. Its use is based on the assumption that a potential customer will remember the brand, and when he has the need or desire to purchase the products of this company, he will certainly remember the logo or slogan, which in theory should lead to the purchase. In such an advertisement, as a rule, there are no clear indications for potential customers that they need to do, and there is no incentive for an immediate purchase. However, the management of small and medium-sized businesses does not take into account that the marketing strategy of large enterprises for investing money in the creation and promotion of the brand is aimed at many other tasks that are not related to the rapid return of table 1.

In a harsh environment of limited financial and time resources for a small business, investing in an advertising message, the content of which is aimed only at forming the brand of the enterprise, its positive image, brand awareness and other similar image indicators that do not result in immediate profit from an economic point of view is ineffective and inappropriate.

Table 1 - List of tasks in the field of marketing for large enterprises and small and medium-sized businesses

The tasks of a large enterprise, solved through advertising as a component of marketing	The tasks of small and medium-sized businesses, solved by advertising as a component of marketing
Satisfaction of owners and board of directors; satisfaction of shareholders; the formation of an attractive form for the media; formation of corporate style; to receive prizes and decorations for the most striking advertising; obtain additional PR; making a profit.	Making a profit.

For example, today in the typical regional center of Ukraine with a population of 300 thousand there are very roughly 70 (!) participants of one or another type of small business in the service sector. A similar situation is observed on any market of services - from advertising agencies to institutions providing travel services. However, they are all of the same type in their essence. Thus, each of the tourism companies operating in the city spends money on creating its own logo, its own style and slogan, but in general, they do not differ from others.

Since it is almost impossible for a small business enterprise to enter the market with a unique product offer, the question arises as to how it can successfully formulate its marketing strategy with the help of advertising. The answer to this question lies in the plane of implementation of a certain algorithm of action, which involves such steps:

1) *clear definition of the target audience of the enterprise.* The most common mistake of small and medium-sized business management lies in the use of advertising campaigns designed to reach a very broad audience, resulting in significant overrun of the marketing budget. Therefore, one of the main tasks in developing an advertising campaign for small and medium enterprises is to clearly define its target group and its main unsatisfied needs;

2) *clear and understandable positioning of the enterprise exclusively for the target*

audience, because understanding of intentions of its potential consumer allows the company to position itself only for a certain target group;

3) *development or modification of the product of an enterprise in order to maximally meet the needs of its target audience based on the high value of the product, and not at the expense of the lowest price,* which will contribute to the formation of pricing with high margin and, accordingly, will form a high profit of the enterprise;

4) *orientation of the system of distribution of goods or services of the enterprise on direct sales* that allows forming a system of communication between consumers and the enterprise in the framework of the concept of marketing of trust, which promotes the formation of trusting relations between the enterprise and the consumer and, as a result, the implementation of repeated sales. This, in turn, reduces the company's costs of finding and attracting new customers;

5) *the use of only those marketing measures that enable accurate determination of the return on investment in these measures.* This approach avoids road costs and is ineffective in the context of small and medium-sized enterprises business brand promotion;

6) *development of a system of marketing communications between consumers and the company,* which encourages the implementation of repeated sales and attract new customers or client from among relatives, friends or colleagues of regular customers, which, in turn, reduces the cost of the enterprise to find new customers.

The structure of an advertising message created in accordance with the communication using the principle of direct sales must comply with the following rules:

1. In the advertisement, you must indicate the offer.

2. In an advertisement, you must indicate the reason that prompts the recipient to respond immediately to an advertisement.

3. The promotional message should contain clear instructions on how the consumer should answer.

4. The text of the advertisement must be convincing and "sell", not general and blurry.

5. The main purpose of advertising appeal should be to make a potential customer the next step in communication with the enterprise.

6. When creating an advertising message, you should refuse the purposeful formation of the brand of the enterprise.

But not all small and medium-sized businesses adhere to these rules. Thus, most of them in their advertising message do not indicate a clear proposal. The text of their advertisement contains a sentence that is allegedly meant. For example, advertising a company positioning itself as a metal service center, contains the name of the company, the period of stay in the market, the schedule of the enterprise and some facts about the service provided. In such a sample of advertising offer is only implied – when the consumer needs a service, this company is able to provide it. This pattern of advertising messages used by most of the enterprises of small and average business. However, the main task of such enterprises in the development of advertising messages using the method of direct communication with the consumer is to make a clear proposal that requires an immediate response. For example, an enterprise can use the "gift with purchase" method in its advertising message or offer to receive a free gift in case of a response to an advertising message, but in any case such offer must be interesting and attractive for a potential consumer.

The promotional message should have clear instructions on how the consumer should respond, since the lost consumer will not take any action. The reason for the ineffectiveness of most unsuccessful advertising campaigns is that the consumer was given unclear instructions on further actions in the advertisement, or the advertisement message did not contain any instructions at all.

Any marketing tool for small and medium-sized businesses, such as media advertising, postcard, mailing list, company website, social media on the Internet, telephone conversation, etc., should clearly target the potential consumer through a range of decisions and actions taken. Therefore, every advertisement of an enterprise must broadcast to the potential consumer, what further actions are expected from him, what exactly he can do and what and when he will receive a result.

Today's information space is oversaturated with advertising, so an advertising message in order not to leave out the attention of potential consumers who are under constant informational pressure should not contain subtle hints, instead it must broadcast convincing text using the ordering style of speech, which affects emotional factors of perception man.

Emotional factors - this is the basis of behavior of buyers of goods or services, based on the influence of the emotional component on human behavior. Emotional factors are internal motivators at the level of the subconscious, which influence the person's decision to purchase regardless of its social and material status, that is, they are identical in the algorithm of their influence as a representative of the management of the company in the B2B sales system, and a retailer representative in the B2C segment. The most common mistake in the development of advertising appeals by small and medium-sized businesses is the false idea that consumers of their goods or services make purchasing decisions based solely on rational, logically grounded arguments, rejecting the influence of emotional factors when making a purchase. Everyday consumer behavior of each person is guided mostly by emotions, and then, if necessary, after the fact of purchase, is justified by logical arguments.

There are five main emotional factors that control most of human behavior, including the adoption of consumer decisions. It is a sense of pride, love, sense of guilt, greed, fear. An advertising message from a small and medium business enterprise should ideally affect all five emotional factors associated with the perception of the target audience with the product or service of the enterprise. For example, an advertising message from a company that provides services for the additional development of school-age children and whose target audience is the parents of children from 7 to 12 years of age, should affect all five emotional factors: 1) *a sense of pride* - in an advertising message is shown ow parents congratulate the child with excellent ratings in the diary and how their parents boast of the success of their child to their relatives, friends, colleagues and parents of other children; 2) *love* - in a promotional message it is argued that if parents really care about the future of their child, they must necessarily provide her with the program of additional development provided by the firm; 3) *feelings of guilt* - the reference in the advertisement is given to the fact that today, when parents are mostly engaged in matters of material support for the family, it is very difficult for them to find free time that can be devoted to the development of their child; 4) *greed* - in a promotional message it is stated that the high score of a child on an external economic activity will facilitate admission to budget places at the higher educational institutions, which in turn will help to receive a scholarship; 5) *fear* - in an advertisement, it should be noted that it will be difficult for children to enter a prestigious institution of higher education if they do not have the required level of knowledge.

Different categories of consumers motivate different forms of linguistic influence. For sales departments and teams for negotiating large enterprises, such tasks are performed by consulting marketing companies in cooperation with industrial psychologists and other experts on these issues. In their work, they rely on the results of focus groups, surveys and consumer interviews, monitoring salesmen 'communications with buyers. Since for a small and medium-sized enterprise to hire a consulting firm for thorough analysis in this area may be economically disadvantageous, it is necessary to develop their own stock of language templates that resonates with the way of thinking and broadcasting their own target audience.

When developing the text of an advertisement for small and medium-sized businesses the following questions should get answers:

1. What is the real desire to satisfy a potential consumer with a product or service of an enterprise?

2. What words or phrases are synchronized with this desire of the potential consumer?

3. What properties or features of an enterprise or product of an enterprise give the right to be a means of meeting the true desire of a potential consumer?

4. How can you relocate the benefits of an enterprise or its product to a higher value in the perception of a potential consumer?

5. How can the most profitable to present the price of the product of the enterprise?

6. How can an enterprise position itself as an expert in a field that other consumers trust?

The development of an advertising message containing convincing "selling" text, taking into account the influence on the five above-mentioned emotional factors that govern the consumer behavior of a person, should correspond to such an algorithm:

1. *A promotional message should immediately attract and capture the attention of the potential consumer.* The consumer's emotional and captivating product-related history, provocative questions, or specific intrigue promises can be of interest to the consumer.

2. *Constructing of communication and understanding with a potential client*. People make purchases from businesses they know, what they like and whom they trust. Developing an advertising message based on the facts, figures, characteristics and benefits of a product or service, without building a certain relationship and understanding with a potential client, is a common mistake among small and medium-sized businesses. As a means of constructing such a link in an advertising message must be the history of the enterprise and the history of product creation.

3. *Creating a sense of trust from the potential consumer.* The potential consumer needs to feel confident that the company's advertising message deserves attention. Advertising of the same product can get diametrically opposite results, if one of the companies that advertise it uses the trust and respect of the target audience, and the second one is unknown to anyone. As an instrument for creating a sense of trust in potential customers in an advertisement, the company must indicate the participation of the company in certain industry associations, forums, and events, to indicate distinctions for achievements in this field.

4. *Identify the problem of the target audience and synchronize the advertising message with this problem.* Each person from among the target audience that pays attention to the advertising message, there is a certain problem that affects the content of advertising: disappointment, deceived hopes, failures, repetitive, excitement, embarrassment and the like. But for most people from the potential target audience, this is not an urgent and acute

problem. Therefore, the advertising message should clearly outline the problem, raising the status of this problem in a very acute and urgent.

5. *Statement on the existence of a solution to the problem of the target audience.* After the problem is outlined in the advertisement and its status is raised to the urgent one, it is necessary to demonstrate the means of its solution. As such a product is a product or service enterprise. If you display a product or service in an advertising message too early, then the target audience will not lay the foundations of easy perception of the product as a means of solving the problem, if it is too late - the target audience may lose in its perception the mental connection *"problem-solution"*.

6. *Establishing expectations of potential customers.* After the announcement states that there is a solution to the problem of the target audience, this decision should be divided into several parts that outline the road map of the consumer movement from the problem to its complete solution.

7. *Use social evidence in a promotional message.* When a product or service is advertised, there are always objections and doubts in the mindset of a potential consumer that can be described by such statements*: "I do not have time for this"* or *"It will not work for me".* To combat the internal consumer denial mechanism, targeted social evidence is used - the responses of satisfied consumers are selected, supported by facts and examples.

8. *Demonstration in a promotional message benefits from the use of the product.* The main motivator for buying a consumer of a product of an enterprise is not the characteristics or benefits of this product in it, or the aim of owning this product as such, but obtaining the benefits of these characteristics or product benefits or ownership of the product. For example, for a consumer from the target audience of young people aged 15 to 25 who buys a remedy for acne, the main factor in the purchase is not that the product is easy to use (product characteristic), and not that it is able to cure acne quickly and qualitatively (advantage), and that after a quick and qualitative treatment a young person will be beautiful and attractive (benefit from advantage). Therefore, in an advertising message, an enterprise must demonstrate at least one benefit that the consumer receives from the characteristics or benefits of the product.

9. *Construction of a high value of a product in the perception of a potential consumer.* As you know, the consumer purchases decision when the value of the product in his perception is much higher than the price of the product. Formation of the value of a product of an enterprise in an advertisement is in the plane of the formulation of an irresistible commercial proposal. If you set a ten-point scale for evaluating the attractiveness of a

proposal in a company's advertising message, then 1 is a basic, simple proposition that does not cause any rush, and 10 is an absolutely exciting proposal that cannot be abandoned. When creating an advertising message, you must try to make an offer that meets the criteria for the highest score, since even a well-done advertising appeal can completely fail if it brings a potential consumer to a commercial proposal that does not cause enthusiasm and the desire to purchase the product or service.

10. *Statement in the advertising message guaranteeing the absence of risks.* One of the important reasons for ignoring potential advertisers' offerings in a promotional message is that they feel that their third-party risk factor may be affected by their use of the advertised product or service. The advertising message must provide a warranty statement, which should be expressed strongly, be easy to perceive, to assure the unmistakable decision. Of paramount importance is the fact of existence in the advertising message of the guarantee assurance, and not the conditions of its provision, so it is simply declared.

11. *Setting an offer deadline in an advertisement.* Since in the consciousness of a potential consumer there are always objections and doubts, one of the manifestations of which is the unconscious desire to postpone the adoption of a consumer decision for later, the advertisement must clearly set the term of the offer, which will motivate the potential consumer to act immediately, and not yet "think" or something "check". The tool for motivating a quick response to an advertising message may be a bonus for a quick decision or a large discount for the first X people who responded to the offer within a specified time interval.

12. *The call to action* is developed in accordance with the principles of direct communication with the consumer and prompts him to make the first step in the process of communication with the enterprise, depending on what purpose the enterprise confronts with the advertisement message - telephone call, visit to the office or shop, prompt purchase, etc.

The effectiveness of advertising appeals for small and medium-sized businesses is largely due to some or other innovative approaches to their creation, aimed at suggesting new emotional images to a person [3]. For this purpose, advertising texts use not only certain marketing, designer, psychological techniques, but also specific linguistic tools that make the advertising text original, creative and expressive. Text is the most important component of any promotional message. In the theory of communication, advertising text is perceived as a special verbalized form of mass communication; speech act, determined by certain intentions of the positive. The main goal, communicative intention of the addressee - the creator of the advertising text - is the creation of a successful speech act, that is, ensuring the reliability, stability and efficiency of the communication process [4, p. 34].

Creating an effective advertising appeal requires an accurate selection of linguistic resources, as well as the strict observance of the principle of expediency and the problems of the culture of speech. The observance of certain linguistic norms is a pragmatically significant requirement put forward in the ad text, since the incorrectly compiled advertising message prevents the implementation of its target setup. However, often in advertising messages there may also be deviations from all kinds of norms. It should be noted that in the communication activity in general and in advertising in particular, certain norms, if any, are constantly violated. Copywriters consider these violations to be quite feasible if it increases the profit of the firm. For example, the call "Tanya, let's roll to Egypt!" is perfectly appropriate for a small tourist service company, although it contains a slang verb and a shortened form of appeal, which is widely spoken in the spoken language. Deviation from linguistic or communicative norms always causes the recipient's interest.

Especially often on the verge of what is allowed is positioned advertising, which uses various techniques of language wordplay, which is understood as a conscious violation of language norms, laws of functioning of language units in order to enhance the expressiveness of the advertising text, giving it more expressiveness to attract the attention of viewers, listeners, readers to a product or service [5]. And if large enterprises and well-known brands refer to the regulatory aspects of advertising messages are sufficiently protected, the restrictions for small and medium-sized businesses are much less. The main thing is that advertising does not violate ethical standards.

The language of an advertisement tries to expressly influence the recipient at all levels of the language system. Let's highlight some characteristic patterns. Significantly affects the perception of the consumer by the advertisement its *phonetic organization*. The correct sound organization of the ad text contributes to remembering its content. It should be accurate, expressive and cute, so as not to distract a potential consumer from the information contained in the advertisement. Phonetic expressiveness is achieved by means such as rhyme, repetition of sounds - alliteration or assonance (*Жизнь хоро**ша**, когда пье**шь** не спе**ша** (Life is good when you drink slowly*), onomatopoeia (*Вусаті експерти обир-р-рають «Люкс»* (*Whiskered experts choose "Lux*") (animal feed advertising); *Жжук. Магазин гаджжетів (ZhZhuk.Gadgget shop); Shoe shop «Топ-топ» (Pitter-Patter);* food enterprise «*Ням-ням» (Chow-chow)*), sound symbolism, paronymic attraction, language game based on phonetic similarity of words (*ПодкреПИЦЦА с PeppePIZZA; ОТТОГИ. Оттого и вкусно!*). These phonetic means are designed to create a certain emotional mood of the consumer.

In order to attract the attention of the addressee in the advertising of small and medium-sized businesses are used such graphical tools as the allocation of a single morpheme in a particular word, small and large letters (*ШипШина – інтернет-магазин шин, дисків, акумуляторів з доставкою (Spike-Tire – the online store of tires, wheels, batteries, delivery)*), the elements of Latin (***Doza**прався!(Doza-fill in!)* – energy cocktail advertising ***DOZA***), numbers, special symbols (mathematical, chemical, economic, etc.). (+*, –, $, &* etc.): *ТераФлю Лар Спрей.* ***5*** *действий от боли в* горле *(TeraFlu Lar Spray. 5 actions for sore throat*), font highlighting, indentation, underlining, strikethrough, inverted letters, accents, etc.

For the realization of pragmatic tasks in advertising messages a *word-building game* can be used that includes various ways of creating occasional and potential words. (*Пора крышеваться! (It's time to roof)* – advertising of the company selling metal tiles; *Ново-фруктово, ягодно-выгодно (Newly-fruity, berry-profitly)* – advertising of the whole-year-round store of fresh fruit), and also play with the inner form of the word (private clinic *СТОМАТОЛОГ і Я (STOMATOLOG&I)*), word reduction means (*BIBABO* (short for billiards, bar, bowling), etc.

A special place in the advertising message belongs to the *vocabulary*, which has the greatest effect among linguistic means. A characteristic feature of the advertising texts of small and medium-sized businesses is the use of not only all strata of colloquial and literary words, and sometimes even vernacular, slang, vulgarism, jargon, which act as a kind of "hook": *The Chinese will be shocked!* (advertising of a cafe, which offers sushi); *For us not rust!* (plumbing store advertising). In advertising appeals are widely used stylistically colored words, borrowings, phraseological combinations, etc. for example: *Say HELLO to fruits! The scent of the sea knee-deep*. To provide imagery and expressiveness to the advertising text, copywriters turn to metaphors, personages, paraphrases, hyperbole, epithets, etc., using a game with precedent phenomena - widely known texts, expressions, names, situations (for example, advertising of a small business optics contains an allusion to the O. S. Pushkin's verse "Autumn": Dull time - glasses charm), playing ambiguity - providing the ad text of at least two variants of interpretation through the use of multivalued words, homonyms, etc. (for example, the advertisement of a shoe store: *We will find a pair for men and women*). Proper selection of expressive means for creating an advertising appeal ensures its success and popularity.

Equally important role in the design of advertising messages of small and medium business is played by *morphological resources*. Advertisers use equally all parts of the language: nouns containing information about the advertised product; adjectives and adverbs that evaluate the properties of goods or services and emphasize their uniqueness; pronouns, the use of which contributes to the convergence of the target audience with the commodity producer; verbs that inform about the necessary actions to be performed by the consumer or the actions performed by the advertised product or service. It should be kept in mind that verbs have a latent dynamics and more than nominal portions of the language as a driving force. Often there is also a morphological game, which consists in the use of non-standard grammatical forms of words, for example: *The most toy-shop* (advertising of a children's store of toys).

In order for an advertisement to be remembered more effectively, its *syntax* should be fairly simple. It is advisable to use short and simple sentence structure. Often used non-verbal, nominal, incomplete sentences (*First-rate windows for houses and apartments*!). Among the verb constructions should be dominant incentives (*Build fast - live for a long time*!; *Fresh Bar. Refresh your emotions*). Phrases are rarely complicated by separation. As a means of emotional influence, the figures of rhetorical syntax are used: occasional and query structures, parallelism, inversion, repetitions, parselling, joining constructs, antithesis, etc.: *Do you like? Give it!* (advertising of a jewelry shop); *Your beauty is our work* (advertising of a beauty salon); *Hot delivery of hot dishes* (outdoor restaurant advertising); *Buying - resting, Resting - buying* (advertising of a shopping complex).

In general, the ad text consists of five main elements that are almost always used in advertising: title, subtitle, main text, signatures and comments, slogan [6]. All these components are important, but no promotional message can do without a headline and a slogan. In advertisements for small and medium-sized businesses, they are the most important ones, because they contain the main idea of an enterprise, which seeks to immediately sell its product. And this requires skillful linguistic design of the slogan, which is conditioned by the requirements of brevity, expressiveness and provides its accuracy, aphoristic, elegance. The language of advertising slogans should be fairly simple and designed for immediate perception. Arsenal involved in the compilation of slogans of linguistic means is quite diverse. Essential importance here is the stylistic resources of phonics, vocabulary, graphic means, non-standard morphological forms, expressive syntax. Using these tools makes the slogan interesting and memorable, for example: *MK "Myasnyi" is my choice! Everyone needs dinner and supper!* (restaurant advertising); *Made the body, walk safely!* (sports club advertising). The selection of linguistic means for creating a slogan is an extremely responsible process, since the maximum amount of information important to the consumer must be conveyed with as few words as possible. Each word in the advertising slogan should be expedient, accurate and weighty, to carry the necessary marketing information about the products and their properties, to attract the attention of the potential buyer.

Consequently, the quality of the advertising message of small and medium-sized businesses is ensured by the quality of the algorithm for its creation and the correctness of the choice of linguistic and artistic techniques. Advertising specialists should take into account the role of text in the marketing system, optimizing the impact on the potential consumer. Creating promotional texts, their qualified linguistic design is a creative process that requires knowledge of certain rules and laws. Compliance with these rules, the expedient choice of linguistic means of all levels helps in implementing the principles of successful advertising messages, increases its efficiency, which, in turn, helps to increase the profit of small and medium-sized businesses, their sustainable economic development.

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5. FOREIGN ECONOMIC FACTORS OF BUDGET SECURITY OF UKRAINE

Babets I.G.

The level of budgetary security of Ukraine taking into account the influence of foreign economic factors was assessed. The dynamics of the integral indicator of fiscal security of Ukraine in 2006-2018 was analyzed. The coefficients of sensitivity of the integral indicator of budgetary security to the change of each indicator in other equal conditions were determined. In the short run, the insignificant sensitivity of the integral indicator to the change in indicators, taking into account the level of external debt and the state of foreign trade balance of Ukraine, was revealed. With the help of the linear regression model, direct dependence of the ratio of the state budget deficit to GDP has been established from the change in the ratio of aggregate payments for servicing and repayment of the state debt to the state budget revenues and the ratio of trade balance deficit to the total foreign trade volume of Ukraine for the period 2006-2018.

Problems of formation of budgetary security of Ukraine in conditions of geopolitical transformations

Budgetary security, as the target function of optimizing budget revenues and expenditures, is determined not only by the effectiveness of institutions operating in the middle of the state, but also by relations with international financial organizations and the state of cooperation with countries, strategic partners. Although the need to attract external loans and the state of foreign trade balance are largely due to the aggravation of a number of internal threats (reduction of industrial production, shadowing of the economy, processes of reforming intergovernmental fiscal relations), they are considered as foreign economic factors of budgetary security, since they depend to a large extent on decisions and actions of external actors - governments of countries, international institutions, trade partners.

The formation of budgetary security of Ukraine takes place in conditions of geopolitical changes, which are the result of the aggravation of the rivalry of leading global and regional leaders-states for the redistribution of spheres of influence, in particular, in the post-Soviet countries. Destabilization of the internal economic and political situation due to negative external influences leads to aggravation of the main hybrid threats that cause a significant imbalance of the budget system. In particular, armed conflict and hostilities in the country's east led to an increase in the share of budget expenditures for financing the defense and security sectors and the social security of temporarily displaced persons from temporarily occupied regions to Ukraine's controlled territory, which, in the absence of the state budget of Ukraine and local budgets of Donetsk and Luhansk areas of income of a single social contribution and a large amount of bad tax debt of enterprises in the occupied territory, have become additional factors def. Budget cadence. In connection with this, there is an increase in public debt as the main source of financing the budget deficit. The accumulation of public debt, including external, leads to an increase in budget expenditures for servicing public debt and increases the burden on the expenditure part and the so unbalanced budget in the context of implementing system reforms and conducting a military operation in the East of the country.

At the same time, complex geopolitical conditions generate threats in the sphere of foreign economic activity of our country: the crisis in the supply and transit of energy resources, Russia's support for instability and separatism in our country, the introduction of Russia's embargo and restrictions on trade in goods from Ukraine, reducing the volume of industrial production of export goods, technological backwardness enterprises of the processing industry and lack of funds for their technical modernization. The threats associated with the loss of access of domestic producers of industrial and agricultural products to the Russian market are aggravated by the low competitiveness of high value-added products, in particular high-tech, in the markets of European countries. Despite the effect of the Agreement on a comprehensive and deepened free trade area with the EU, exports to European countries are growing at a low pace and do not compensate for significant losses in trade with Russia, resulting in a deterioration in the state of foreign trade and, accordingly, the balance of payments of Ukraine, which, in turn, leads to an increase in public debt. The above determines the relevance of the study of the impact of foreign economic factors on the level of budgetary security.

Methods of studying the budget security of the state

The method of determining the influence of foreign economic factors on the state of fiscal security of the state is based on the indicative approach to assessing the level of economic security of the state, set forth in the Methodological Recommendations [1; 2], and provides: the justification of the system of budget security indicators taking into account the indicators that characterize the debt burden on the state budget and the state of foreign trade balance; calculation of actual and normalized values of indicators for at least 5 years; calculation of the integral indicator of fiscal security and its coefficients of sensitivity to changes in indicators, in particular those taking into account the external economic component.

Formation of the set (list) of indicators is carried out according to the principles of representativeness, reliability and informational accessibility, taking into account the recommendations of relevant documents [1; 2]. The list of basic indicators of fiscal security may be supplemented, if necessary, by other indicators that detail the impact of relevant phenomena and processes in the context of economic reform, which will allow more accurate assessment of the results of institutional changes and their implications for public finances, budget creation, and redistribution of public goods.

Taking into account the above, for the purpose of studying the state budget security, we use a system of indicators that allow taking into account the main internal and external factors of influence: the level of GDP redistribution through the consolidated budget (excluding the Pension Fund revenues) in%; ratio of deficit (surplus) of the state budget to GDP (%); share of taxes on income, profit and increase of market value in state budget revenues,%; the ratio of aggregate payments for servicing and repayment of the state debt to the state budget revenues (%); amount of transfers from the state budget,% to GDP; the share of local budget revenues (without transfers) in the consolidated budget,%; the level of "shadowing" of the economy,% of GDP; the ratio of the deficit (surplus) of the trade balance to the total volume of foreign trade (%).

The integral indicator of budget security of the state is calculated according to a methodological approach based on the theory of "additive value" and allows us to determine the value of the whole as the sum of the values of its components. If x_{ij} is some actual figures, j = 1, ..., m; i = 1, ..., n, which in aggregate characterize the budgetary sphere, then the integral indicator of fiscal security has the form of linear convolution:

$$I_i = \sum_{J=1}^{m} a_{ij} \; z_{ij} \;, \qquad (1)$$

where a_{ij} – weighting factors that determine the degree of contribution of the j-th indicator to the integral indicator of fiscal security; z_{ij} – normalized values of input indicators x_{ij} [2].

The integral budget security indicator goes to 1 when all xij acquire the "best" or optimal values, and is close to 0, when the values of all indicators are "worst" in terms of compliance with security criteria.

An important stage in the calculations is the transition from absolute to normalized values of indicators that vary from 0 to 1. In this case, in order to ensure the same information orientation of indicators, they are divided into stimulators and stimulants. Accordingly, in order to obtain the normalized values of the actual indicators of budgetary security, we will apply the methodological approach, which was substantiated by A. Sukhorukov and Y. Kharazishvili, in which the maximum value of the indicator for the indicator-stimulants is chosen as the normative value, and for the indicators-disintegrants, the minimum value for the investigated period [3, c. 16].

In order to determine the weighting factors (a_i) according to the Methodology for Assessing the Level of Economic Security of Ukraine [2], a model of the main components is used, in which the connection between the primary features and components is described as a linear combination:

$$Y_i = \sum_{j}^{m} c_{ij} \cdot G_j \,, \tag{2}$$

where Y_i - standardized values of the i-th characteristic with unit variances, the total dispersion is equal to the number of signs *m*; c_{ij} - the contribution of the jth component to the total variance of the set of indices of the i-th sphere.

The components G_j are determined according to the linear dependence:

$$G_j = \sum_{i}^{m} d_{ij} \cdot x_{ij} \,, \tag{3}$$

where d_{ij} - factor load; x_{ij} - input data.

Weight coefficients a_i are calculated by the formula:

$$a_{ij} = \frac{c_{ij} \cdot |d_{ij}|}{\sum_{j}^{m} c_{ij} \cdot |d_{ij}|} . \tag{4}$$

Construction of the model of the main components is carried out using the program "Statistics" (module "Factor Analysis") and provides: calculation of the correlation matrix; the separation of the main components and the calculation of factor loads; identification of the main components.

The assessment of the degree of impact of a separate threat to the integral indicator of fiscal security should be conducted in order to identify the most dangerous of them and to develop measures to eliminate or minimize their impact. Methodology for the study of dynamic processes in the economic system and the determination of the sensitivity of parameters at the output to the change in input parameters of the system, developed by Yu Harazishvili [4, p. 115], involves the use of a sensitivity coefficient, defined as the effect of the deviation of the independent variable Δx_i on the dependent variable *y*:

$$U(t, x_i) = \lim_{\Delta x \to 0} \frac{y(t, x_{i,0} + \Delta x_i) - y(t, x_{i,0})}{\Delta x_i} = \frac{dy(t, x_{i,0})}{dx_{i,0}} \approx \frac{\Delta y(t, x_{i,0})}{\Delta x_{i,0}}. \tag{5}$$

Formula (5) allows us to determine point elasticity as the limiting value of arc elasticity, provided that the growth of the factor x goes to zero. To avoid inaccuracies and increase the probability of the results of calculating the sensitivity of the integral indicator of budgetary security to the impact of each individual threat, it is expedient to use the coefficient of arc elasticity, which determines the percentage change of function under the influence of the percentage change in the argument:

$$E(y_{i,x_i}) = \frac{\Delta y_i}{\Delta x_i} \cdot \frac{x_i}{y_i}. \tag{6}$$

The integral budget security indicator (I_B) over the studied time interval is a function of the set of indicators (x_i):

$$I_B(t, x_i) = f(x_1, x_2, ..., x_i). \tag{7}$$

Using the functional dependence of the integral indicator of budgetary security on the set of indicators, the impact of each of the threats is determined by the coefficient of sensitivity (elasticity) in the year t based on the approach outlined in [5], using the formula:

$$K_ч = \frac{\Delta I_B}{\Delta x_i} \cdot \frac{x_i}{I_B}, \tag{8}$$

where ΔI_B – the difference between the actual value of the integral indicator of budget security and its value after changing the actual indicator value by 1%; Δx_i – the value of the change in the actual value of the indicator in%; x_i – actual (initial) indicator value; I_B - actual (initial) value of integral indicator of budget security.

Results of estimation of influence of foreign economic factors on the state of budgetary security of Ukraine

The dynamics of indicators characterizing external fiscal security factors during the investigated period, except for 2010, reflects a change in the state budget deficit (Figure 1). The unfavorable conjuncture of foreign markets in the conditions of the complication of the geopolitical situation leads to an increase in the negative balance of Ukraine's foreign trade and a deficit of the balance of payments due to the lack of foreign exchange inflows, which necessitates the attraction of external loans, which become burdensome for the state budget. Permanent budget deficits, in turn, become a source of threats, the impact of which is manifested through the unbalance of budget revenues and expenditures, excessive dependence of the economy on external and internal borrowing.

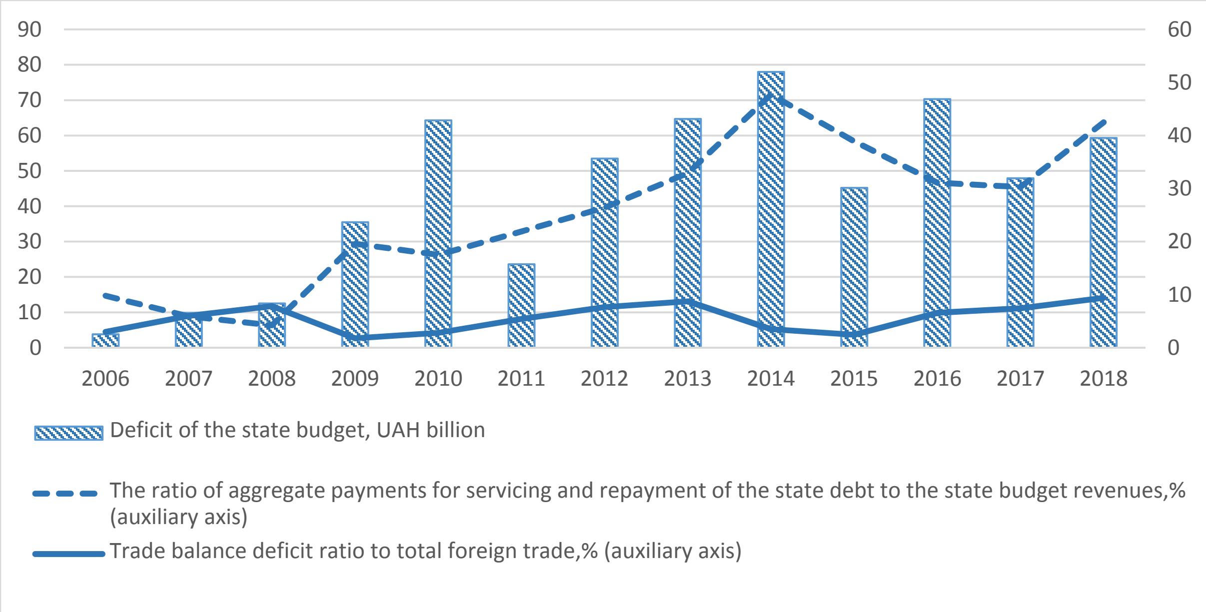

Fig. 1. Deficit of the state budget and indicators taking into account the influence of foreign economic factors on the state budget security of Ukraine

Source: calculated by the author according to the data [6-9].

During 2006-2018, wavy changes in the state budget deficit (Figure 1) are characterized by achievements of peak values in 2010 (UAH 64.3 billion), 2014 (UAH 64.7 billion) and 2016 (70.3 billion UAH). The main sources of financing the state budget deficit were still external borrowing. In 2008, the share of external borrowings in the budget deficit was 49.6%, in 2016 it increased by 37.6 pp. and amounted to 87.2%, and in 2017 it exceeded the amount of the budget deficit by half. From the point of view of strengthening budgetary security, an important task is not only to reduce the budget deficit, but also the transition from external to domestic borrowing as the main source of its financing. However, although external borrowing in 2017 was 3.6 times smaller than domestic borrowing, their volume is growing at a faster pace. Thus, for the period of 2008-2017, external borrowing increased by 16.7 times, while domestic ones by 13.8 times, and in 2017, compared with the previous year, the growth rate of these borrowings amounted to 268.8% and 152.3% respectively %

Measures to reduce the deficit and optimize budget revenues are envisaged in the Medium-Term Strategy for Public Debt Management, which, according to experts [10], will help to reduce debt burden, currency risks, increase the creditworthiness of the state and, consequently, reduce borrowing in the future. In particular, the Strategy defines the task for the Ministry of Finance of Ukraine to reduce the debt-to-GDP ratio to 60% in 2018, 52% in 2019 and 49% in 2020, and sets qualitative targets that will improve the structure of debt and reduce risks [11].

However, the Law of Ukraine "On the State Budget" in 2019 provides a total public debt of our country in the amount of 2,448.73 billion USD [12], which is 12.9% more than in 2018. Accordingly, the growth of public debt at a faster pace, it is impossible to ensure the ratio of public debt to GDP in 2019 at 52% according to the State Debt Management Strategy (according to our estimates, the value of this indicator will be 77.2%). An increase in the amount of public debt will increase payments related to its servicing in future periods, which will limit the expenditures of the state budget to finance socio-economic development.

Analyzing the change in the normalized values of the indicators (Table 1), we can assume that the improvement of the state budget security in 2018 was mainly due to increased compliance with the safety criteria of such indicators as: the share of taxes on income, profits and increase in market value in the income of the state the budget, the amount of transfers from the state budget to GDP, the share of local budget revenues in the consolidated budget, the level of "shadowing" of the economy. At the same time, the deterioration of the values of individual indicators of fiscal security indicates an increase in the corresponding threats. For example, an increase in the level of GDP redistribution through a consolidated budget from 33.1% in 2016 to 34.4% in 2018 is a consequence of an increase in the rate of growth of budget revenues over GDP growth, that is, the growing threat of rising public indebtedness.

The results of calculating the coefficient of sensitivity prove that the integral indicator of fiscal security in Ukraine is most sensitive to changes in the share of local budget revenues (without transfers) in the consolidated budget (Ks = 0,203), the share of taxes on income, profit and increase of market value in the state budget revenues (Ks = 0.194), level of GDP redistribution through consolidated budget (Ks = 0.096).

Consequently, the increase of the level of budgetary security of Ukraine in 2017 was significantly influenced, first of all, by an increase in the share of local budget revenues (without transfers) in the consolidated budget, as the growth of this indicator by 1% contributes to an increase of the integral index by 0.203% on other equal terms. The increase in the share of taxes on income, income, and increase in market value in the state budget revenues from 17.8% to 19.98% contributed to the strengthening of budgetary security in 2018, as the increase in the value of this indicator by 1% leads to an increase of the integral index by 0.194% on other equal terms. At the same time, the improvement of the budget security situation in 2018 was restrained to a certain extent by an increase in the level of GDP redistribution through the state budget, since the growth of this indicator by 1% leads to a decrease of the integral index by 0,096% at the other equal terms.

Table 1 - Indicators of fiscal security of Ukraine in 2006-2018

Year	Redistribution of GDP by consolidated budget, %	The ratio of the state budget deficit to GDP, %	Share of taxes on income, income and increase of market value in state budget revenues, %	The ratio of aggregate payments for servicing and repayment of the state debt to the state budget revenues, %	Volume of transfers from the state budget to GDP, %	Share of local budget revenues (without transfers) in the consolidated budget, %	The level of "shadowing" of the economy, % of GDP	The ratio of the trade deficit to the total foreign trade volume, %	Integrated budget security indicator
2006	1,000	1,000	0,915	0,429	0,963	0,856	0,993	0,597	0,847
2007	0,751	0,500	0,991	0,712	1,000	1,000	1,000	0,296	0,843
2008	0,746	0,538	1,000	1,000	0,839	0,926	0,926	0,226	0,824
2009	0,716	0,179	0,703	0,214	0,881	0,933	0,800	0,998	0,722
2010	0,716	0,125	0,807	0,240	0,788	0,915	0,758	0,634	0,675
2011	0,756	0,389	0,915	0,192	0,684	0,764	0,847	0,327	0,645
2012	0,720	0,184	0,849	0,159	0,591	0,796	0,847	0,231	0,597
2013	0,753	0,159	0,858	0,128	0,650	0,838	0,823	0,203	0,606
2014	0,787	0,143	0,695	0,088	0,627	0,782	0,686	0,508	0,575
2015	0,696	0,304	0,704	0,108	0,598	0,651	0,613	0,731	0,563
2016	0,692	0,241	0,874	0,135	0,634	0,658	0,671	0,270	0,556
2017	0,670	0,438	0,844	0,139	0,570	0,665	0,778	0,239	0,569
2018	0,665	0,422	0,942	0,099	0,619	0,699	0,873	0,188	0,599
Weighting factors	0,086	0,065	0,122	0,127	0,166	0,174	0,167	0,094	-
Sensitivity factor	**0,096**	0,045	**0,194**	0,021	0,017	**0,203**	0,024	0,029	-

Source: calculated by the author according to the data [6-9]

In this case, the low sensitivity of the integral indicator to the change in indicators characterizing the foreign economic component was revealed. Thus, an increase of 1% in the ratio of aggregate payments for servicing and repayment of the state debt to the state budget revenues leads to a decrease of the integral index by 0,021% on other equal terms, and the ratio of trade balance deficit to the total volume of foreign trade turnover - accordingly 0,029%.

The coefficient of sensitivity allows us to determine the effect of the change of each individual indicator on the integral indicator of fiscal security, provided that all other indicators are unchanged. To assess the degree of simultaneous influence of the main factors and the link between the key indicators of fiscal security allows the method of regression analysis. The integral indicator of fiscal security is not appropriate to choose as a dependent variable for constructing a model to avoid the effect of auto-correlation. Therefore, in the study, we use the deficit indicator of the state budget as a dependent variable.

The results of modeling the impact of the key indicators of Ukraine's fiscal security on the change in the ratio of the state budget deficit to GDP in 2006-2018 by linear regression (equation 9) allowed to reveal a direct impact on the ratio of the state budget deficit to GDP (*BD*) of the following indicators: total payments for servicing and repayment of the state debt to the state budget revenues (x_1); the share of local budget revenues (without transfers) in the consolidated budget (x_2); the level of "shadowing" of the economy (x_3); the ratio of the trade deficit to the total volume of foreign trade (x_4):

$$BD = - 32{,}9 + 0{,}81x_1 + 1{,}25\,x_2 + 0{,}93x_3 + 0{,}38x_4. \quad (9)$$

The statistical significance indices (R = 0.96; R^2 = 0.94) confirm the correlation between the independent variables and the dependent variable (*BD*), and Fisher's F criterion confirms the strength of these bonds (F (4.7) = 25, 9). In the context of our study, let us draw attention to the significant positive correlation between the ratio of the state budget deficit to GDP and the indicators characterizing the external economic factors of budgetary security: an increase in the volume of aggregate maintenance payments and repayment of the state debt to the state budget revenues by 1% leads to an increase in the dependent variable on 0.81%, while the increase in the ratio of the trade balance deficit to the total foreign trade by 1% leads to an increase in the dependent variable by 0.93%.

Conclusions.

The degree of manifestation and the influence of foreign economic factors on the state of budgetary security of Ukraine are determined by the geopolitical changes that have taken place in the last five years and have significantly influenced the process of budget formation and the structure of budget expenditures. First of all, it refers to military actions in the territory of the temporarily occupied parts of the Donetsk and Luhansk Regions, the economic consequences of which have been the source of a number of threats to the budget security of our state due to the reduction of budget revenues as a result of the loss of a part of industrial production and increase of budget expenditures on financing of armed forces and social security temporarily displaced persons.

The results of the conducted research allow us to draw conclusions on the improvement of the state budget security of Ukraine in 2017-2018 and the insignificant influence on the value of the integral indicator of changes in the volume of aggregate payments for servicing and repayment of the state debt to the state budget revenues and the ratio of trade balance deficit to the total volume of foreign trade in 2018. Such insignificant influence of the foreign economic component on the level of budgetary security is to a large extent conditioned by constant non-compliance with the safety criteria of two indicators, as evidenced by their low normalized values during 2016-2018.

In spite of the absence of significant influence of external economic factors on the level of fiscal security of Ukraine in the short term, as evidenced by the results of calculating the respective sensitivity factors for 2018, there is a strong direct correlation between the ratio of the state budget deficit to GDP and indicators that characterize the degree of public indebtedness, including external, and the state of the foreign trade balance of Ukraine in the long run, confirming the results of the regression analysis of data for 2006-2018 .

Accordingly, priority measures to counteract the threats posed by the negative impact of foreign economic factors should be directed at reducing external debt and improving the state of foreign trade balance. The instruments for achieving these goals are, first of all, in the institutional sphere, which needs to be improved in terms of ensuring market relations in Ukraine, the creation of favorable conditions for entrepreneurial activity and the implementation of programs for import substitution and increasing the volume of industrial production.

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6. METHOD OF OPTIMAL PLANNING OF INFORMATION SYSTEMS ON THE BASIS OF SOLID DETERMINISTIC MODELS

Pribylnova I.B., Dovgopol N.V., Peresada O.V.

Abstract. The paper describes the method of optimal planning of information systems on the basis of solid deterministic models. Over the past decade, a certain philosophy of management of production enterprises, standard management formats that promote the efficient organization of business is developed. To solve various business tasks, it is necessary to describe processes in detail and visually. That is to build their models. The models are intended for a detailed description of the operations performed consistently in time for a particular technology.

Introduction. The decision to automate is an important step for any enterprise. The basis of automated processes, the customer puts the basis of the management system, rebuilds the logic of business processes, and prepares a tool for analyzing their activities and adopting more balanced management decisions on its basis. This process can totally change the business's performance.

Reengineering is a fundamental rethinking and radical redesign of business processes to achieve significant results in key performance indicators such as cost, quality, service level, and efficiency in today's business.

The variability of the modern business world requires the constant response of enterprises to events around. Today it has to operate in a dynamic environment that is characterized by rapid technological changes, a wide range of products, as well as an instantaneous change in consumer preferences.

Therefore, there is a need to set up such a tool, the use of which will help enterprises to timely choose and implement optimal solutions in the following areas: economy, organization of production, regulation and stimulation of labor.

It should be noted that the actual issues are computerization and automation of accounting. Information systems can increase the productivity of employees, reduce the impact of "human factor", increase the speed of reporting and documentation, provide the possibility of parallel accounting in several standards.

Recent trends in financial affairs have revealed many complex business problems, which require the development of procedures for the efficient management of an enterprise. The purpose of the article is to justify the feasibility of modeling information processes at the enterprise.

1. Grounds of the study. The main goal of any business deriving from its nature is providing long-term commercial results. However, the method of achieving this goal largely depends on the specifics of the environment. Increased competition in the transition to the saturated market and almost unlimited possibilities of modern production and the widespread introduction of new information technologies of the postindustrial era are the main strategic challenges of the XXI century. Under these conditions, the success of a business is largely determined by the speed and accuracy of reaction of the company to changes in the external environment. Effective change management becomes a key factor of competitiveness. This requires the use in the management of new concepts, techniques and tools.

Reengineering of business processes is one of the most controversial areas in management theory. Reengineering is a fundamental rethinking and radical redesign of business processes to achieve significant results in key performance indicators such as cost, quality, service level, and efficiency in today's business.

The purpose of the reengineering project is to move the company from target orientation to the process orientation and the final result of these processes. It is the progressive Adam Smith era of splitting work into separate operations that created the structures and rules of business, which together require huge labor costs, and means of time and time, so that the implementation of a number of individual operations yields the final result of the process.

An information technology plays an important role in the process of reengineering. Most of the changes listed mean a sharp increase in the amount of information processing each employee - from an individual employee to the head of the company. Such growth can be effective only with a significant increase in labor productivity in relation to the processing of information. Moreover, the old business rules that lead to ineffective work are eliminated by new technological solutions, especially in the IT field.

Over the last decades, a certain philosophy of management of production enterprises, standard management formats that promote the efficient organization of business is developed. Such means allow automating the following functions:

- assessment of the feasibility of the production plan for the main resources of the enterprise (raw materials and equipment, workers, electricity, etc.);
- the formation of a resource supply program (procurement of raw materials and materials, hiring of workers, energy supply, etc.);
- formation of a production program (schedules of production of parts, semi-finished products, finished products);

- formation of a sales program (schedule of shipment of finished products, preparation of sales contracts, management of deliveries and shipment to consumers of finished products, etc.);
- adjustment of the production plan and production standards;
- formation of financial and economic reports (operational and financial budgets and reports).

Business process is a stable, focused set of interrelated activities (otherwise - the sequence of works), which, according to a certain technology, converts inputs to outputs that are of value to the consumer.

To solve various business tasks, it is necessary to describe processes in detail and visually. That is to build their models. The models are intended for a detailed description of the operations performed consistently in time for a particular technology.

Currently, interest in generally accepted Western standards of management has increased dramatically in Ukraine.

At the end of the 1990s, when competition appeared on the market to a proper degree, and the profitability of enterprise activity began to fall sharply, managers felt great difficulties when trying to optimize costs so that products remained at the same time profitable and competitive. Just at this moment, it was absolutely clear that it was necessary to have in front of my eyes the model of the company's activity, which would reflect all the mechanisms and principles of the interconnection of different subsystems within a single business.

The concept of "business process modeling" has come to life of most analysts at the same time as the emergence of complex software products on the market for the complex automation of enterprise management. Such systems always understand the conduct of a deep pre-project survey of the company. The result of this survey is an expert opinion, in which separate points are made recommendations for the removal of "bottlenecks" in the management of activities. Based on this conclusion, immediately before the implementation of the automation system, a so-called reorganization of business processes is carried out, sometimes quite serious and painful for the company. Similar company surveys are always complex and significantly different from case to case.

2. Problem statement. The process of setting the task involves the development of an information process model at the enterprise. The enterprise model is based on the description of the main business processes of the enterprise. For each dedicated business process, a quantitative model is constructed, and then, by consolidating information about business processes, an aggregated quantitative description of the enterprise is obtained.

The concept of enterprise modeling on the basis of the main business process description is presented in Figure 1.

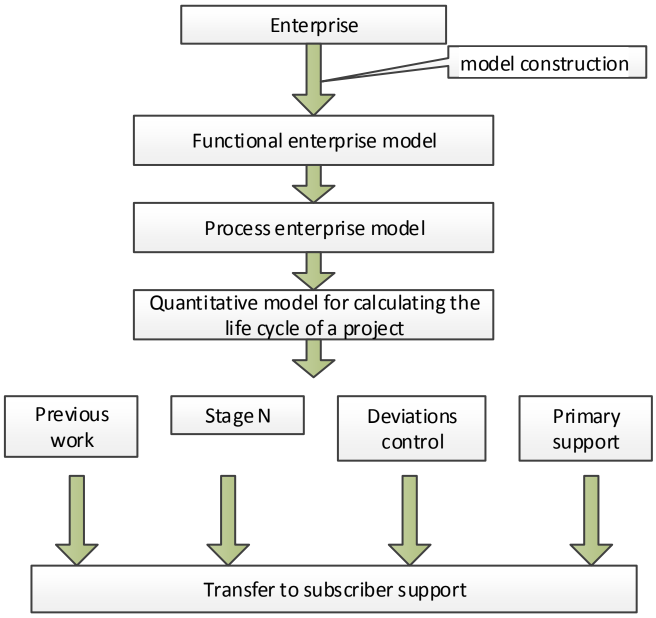

Fig. 1 - The concept of enterprise modeling on the basis of the main business process description

From the scheme clearly follows the logic of consistent detail used in the simulation of business processes of the enterprise. At the first stage, the roughest model of an enterprise is built that is a functional model that gives an idea of the functions of the enterprise and the distribution of responsibility for their implementation. The functional model of an enterprise does not contain information about the interrelation of functions. For this purpose, a process model is under construction. The process model also provides a description of the flows of resources (material, information, etc.) used in the performance of functions, but it does not give them the value of what is needed to calculate the financial plan of the enterprise.

One of the processes of business process management – planning is considered as an optimization problem.

The task looks like this:

- to plan the activity of the enterprise as a whole;

- carry out preliminary works (pre-contract works, initial works under contract, inspection, consulting, and prototyping, initial training of users and revision of the basic project management plan);

- to conduct stage N - the basic block of processes (detailed stage plan, coding, testing, design, commissioning, operational testing, transfer for operation);

- management of deviations (project verification, additional survey);

- primary support;
- transfer to subscriber's support.

The proposed model includes elements of the life cycle of a project (for example, precontracted stage of work) and product (stages of subscriber service and project termination, that is, output of the product from operation).

Feature of the proposed model:

- Inclusion of a particular phase in the life cycle - management of deviations. The need for such a stage on the one hand, the lack of certainty of the initial requirements of the customer and the possibility of changing them during the creation and implementation of the automation system, and on the other hand, the high complexity of the system itself, which usually includes many independent modules (subsystems);
- Iterative approach to creation and introduction of automation system. That is, the system implementation is carried out by a method of successive approaching real needs of the customer (it is especially worth noting that in the course of work these needs not only specify, specify, but also can change a lot).

Stages of the project life cycle cannot follow strictly one after the other, and overlap - a new stage can begin during the performance of the previous one.

Each stage passes through several stages - initiation, planning, execution, monitoring (control), and completion.

In the model, as a criterion of quality, the financial flow of marginal profit, which is formed as the difference between revenues from sales of products and payments for variable costs (costs of raw materials and labor, workers' labor), are taken. Payments for fixed costs are not taken into account; therefore, they do not depend within certain limits on volumes of production and accordingly do not influence decision-making. This task may arise from an enterprise that plans to implement a small investment project a year later, without attracting borrowed funds. For the current year the task is to accumulate the maximum possible amount of money to support the ongoing activities next year and a small investment project.

The paper describes the method of optimal planning of information systems on the basis of three-dimensional deterministic models. There are many methods of planning, including optimal. All of them are characterized by the desire to choose a plan, best aligned with the internal capabilities of the enterprise and with external conditions, and the forecast for both those and others in the planning period is carried out with the help of mathematical models.

The previous work includes a group of processes performed both before the conclusion of the contract and at the initial stage of the contract – at the stages of consulting and initial design of the system. The importance of high-quality performance of these works cannot be overestimated, so in their course laid the Foundation, the basis for future decisions. Part of the previous work is done "free of charge". That is, the client does not pay for them at this stage of interaction (in the future, the cost of these works can be included in the estimate). This applies to pre-contract work related to the creation of the project charter and the project management baseline. To minimize these works, to save on them in any case it is impossible – it works on identification and prevention of many potential risks of the project, that is a kind of insurance for the future, investments in successful completion of the project.

Precontracted work consists in finding a client and selling services to him. At the conclusion of the stage, we obtain the customer's decision on the choice of the project executor, as well as the start of the project.

3. Implementation stages. Primary works under the contract begin after the customer has decided to start automation.

The customer makes his decision in the order of the beginning of the project. This document declares the formal start of the project, defines the organizational structure of the project, the composition of key project officials on the part of the customer, their powers, rights (for example, signing documents) and responsibility and the procedure for interaction of the participants.

This order, as well as a preliminary description of the content of the project, is the necessary documents for signing an agreement of intent.

After signing the agreement, the project team produces additional diagnostics of the project subject area in order to prepare a basic project management plan. The basic project management plan includes an order for the start of the project, a description of the content of the project, the organization of work (based on the life cycle).

After the completion of the primary work we receive:

- agreement of intent;
- order on the project (statute of the project);
- preliminary description of the content of the project;
- basic project management plan;
- contract for the N stage of work;
- project management plan.

Survey is a process of collecting and analyzing information about a client's enterprise for the purpose of designing a system.

The purpose of prototyping (in conjunction with training) is to start preparing users for implementation, familiarize them with the functionality of the model solution, identify inconsistencies (gaps) between business processes in the enterprise and algorithms of the basic solution, teach work with the products of the employees of the project team of the customer, determine the general terminology, etc.

Usually, a typical configuration is considered as the base prototype.

Revision of the baseline project management plan is actually the result of the implementation of the preliminary stage of the work and is allocated at a separate stage in order to increase the attention to the need for careful elaboration of the project management plan. Output data:

- basic project management plan;
- survey report;
- consulting conclusion;
- results of the analysis and construction of the technical architecture;
- results of prototyping and training of users.

Output of the stage is a co-ordinated and approved version of the project management plan.

If necessary, inclusion in the basic plan of amendments (additions) affected (not changing) terms, cost and functional new version of the base plan must be approved by the first persons of the project - sponsor on the part of the customer. If the changes concern the composition, work performed, their sequence, the design team, etc. - approval and confirmation is allowed at the level of project managers on the part of the customer and the executor.

The next phase is designing - stage N.

Stage N is a group of processes that are most common both for the client and for the franchising firm. The feature in the proposed model lies in the fact that the purpose of this stage is not the full realization of all requirements of the customer, but only their parts. The choice of scope and composition of work from which the project begins to run remains with the client and franchise firm. This could be, for example, automation of accounting or personnel accounting (as the most deterministic processes). Or this may be the implementation of one of the subsystems.

Phases of stage N can be repeated several times in order to automate other areas (introduction of other subsystems).

Simultaneously with the expansion of functionality and with the development of automation systems, there may be a need for minor and sometimes serious processing of the results of the previous stages – that is, additional iterations in the automation of these sites.

The process of forming a detailed plan of work for stage N. All works are decomposed to the level of the performer.

The definition of the composition of works, the assessment of the required resources, and the planned staffing of the working team is made on the basis of the decomposition.

This information is a basis for planning the sequence and duration of work and serves as a basis for assessing the cost of the phase.

Preparation of the plan is completed by drafting the budget and developing a schedule of works.

Encoding is not just code writing. The term coding should be understood as the process of creating a configuration. This process is conducted in accordance with the established rules.

Testing is a verification and attestation of the created solution. The verification answers the question whether the system is correctly created and whether the application complies with the specifications. The certification answers the question whether the solution is working correctly.

The "coding and testing" phase ends with the delivery of the created configuration to the customer. The order of delivery is obligatory in detail determined by the project management plan, as well as fixed in the contract (or in the annex to the contract) for the current stage of work.

In general, delivery is a confirmation (demonstration) of the system's performance on a pre-prepared and agreed test case.

At the stage of commissioning, the "launch" of the developed system (subsystem) is carried out. Launch includes:

- deployment of the system for key users;
- entering of initial data, including transfer of data from replaceable accounting systems;
- training (training) personnel to work with the system created;
- detection of inconsistencies in the system;
- work with detected inconsistencies (correction of errors);
- complete deployment of the system, transition to industrial exploitation.

Operating test regulations are defined in the project management plan and may be additionally fixed in the contract, if this phase is allocated in a separate independent stage of work.

In general, operational testing is carried out by the customer on real data. The duration of these works should not exceed one calendar month. This term is explained by the fact that the main business processes at the customer's enterprise have a period of 1 month. Thus, within one month, almost all automating business processes can be screened.

Also, during the operational testing, performance tests can be planned and performed (using a similar database of real data).

Since the iterative principle of creating an automated system is laid down in the lifecycle model, at the stage of operational testing it is necessary to identify the discrepancies between the subsystems (modules) created or modified at various iterative stages.

Management of deviations is the most important block of processes of a model of a life cycle.

The differences of the real created system from the ideal, necessary for the client are understood as deviations. Deviations should be manifested (at the earliest possible stage) and managed, that is, in due time the necessary measures to eliminate deviations should be taken.

Due to the rather high uncertainty in the subject area, it is possible both to change (clarify) the goals that need to be achieved by the client, and not to accurately identify them in the previous stages.

The task of the verification stage is to detect these deviations as early as possible until their amount exceeds the critical value, which would not allow the project to be completed (or it would lose its meaning). The result of the verification stage of the project is the verification protocol.

The protocol contains the following sections:

- list of detected deviations;
- analysis of the causes of deviations;
- possible variants of work for deviations;
- estimation of variants, choice of one or several possible (optimal) variants.

Then, in the event of significant deviations requiring adjustments to the baseline project management plan, the results of the verification are passed to the decision of the senior management of the customer (for example, to a sponsor of the project).

Possible solutions (further work with deviations):

-to make the necessary changes to the project's baseline (issue a new version), adjust the project management plan and continue the work;

- to complete the current project and initiate a new one;
- to complete the current project, go to subscriber support;
- to terminate the contract.

An additional survey is carried out if, at the preliminary stage, it was decided to continue the work of the current project. It is also conducted in the same way as the initial survey. The scope and order of the survey are determined by the results of the verification of the project.

Primary support is a usual maintenance, but is carried out by the forces of the project team, therefore, a fairly significant risk of identifying inconsistencies that require prompt workout. At this stage, preparation for the next exit from the project team is underway and work on subscriber support is underway. Stage should not be tight for duration (it is recommended 2-4 weeks).

The final stage is the transfer to subscriber support. This phase is performed not only at the end of the project as a whole, but also on the fact of the implementation of individual large modules put into operation.

Conclusions. Actual issues are computerization and automation of accounting. Information systems can increase employee productivity, reduce the impact of the "human factor", increase the speed of reporting and documentation, and provide the possibility of parallel accounting in several standards. When used, the customer concludes that the optimization of business processes is an effective, and a promising method for the development of the enterprise, its advantage is the minimum additional investment.

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7. PROBLEM OF FORECASTING AND INNOVATION ECONOMICS CONTROL BASED ON INTEGRATED DYNAMICS MODEL

Ramazanov S.K., Stepanenko O.P., Tishkov B.O., Honcharenko O.G.

Abstract. The problem of forecasting and optimal stochastic control is proposed on the basis of 4 spheres' integration of modern complex systems' of the innovative economy activity and functioning in the phase space and in the space of ONTI (ESTI) - "education - science – technology - innovations". A general conceptual integrated model is proposed, a generalized synergetic model of dynamics is considered including various uncertainties (stochastic and chaotic components).

Introduction. In today's difficult conditions and with the development of a modern economy, there is a need to consider the problems of its forecasting in a new way. This is due to the growing impact of the globalization processes and factors of uncertainty and risk on the economy and the performance of individual countries and regions. Existing methods and forecasting models rely heavily on the use of econometric models. In this paper, we analyze the possibilities of forecasting development based on the approximation of the integral stochastic growth model in the form of recurrent equations, which are formed taking into account the properties of the increments of the Wiener random processes. In this case, only the current or initial state of the economy is taken into account. Only the integration of socio-economic, environmental, cultural-spiritual and other processes modeling methods can ensure the sustainability and viability of the whole system's development**.** [1-7].

The aim of the work. The problem of modeling, forecasting, optimal stochastic control and decision making in socio-ecological and economic systems with humanitarian components, that is, on the basis of the integration of the four fields of activity and the functioning of modern complex systems in the innovative economy (presented in the facsimile space, and in the space of ONTI "education - science - technology - innovations"), but in the modern science as a whole, is the main and actual.

The purpose of this work is to study the methods, principles and models for forecasting and management used in various socioeconomic processes and systems, as well as the introduction of a new class of models for solving the problems of modeling and forecasting of socio-ecological and economic processes. The work is based on the analysis of modern methods of dynamic modeling and forecasting of various processes and systems [12-27]. The development and research of the proposed integral socio-ecological-economic stochastic nonlinear dynamics model is also focused on man-made systems, objects and processes for forecasting and optimal stochastic management in an innovative economy.

Presenting of the main material. The development of models of dynamic systems and the solution of the tasks of optimal control of such systems remains an actual direction of research in modern mathematics with applications to various fields. A characteristic feature of complex dynamic systems is their inherent problems of temporary failure of used administrative principles and structural disproportion. Examples of dynamic systems with such a structure are systems of sustainable development of regions.

The concept of sustainable and safe development of the state as a whole and in separate regions allows ensuring stable and balanced development of the four sectors of life-activity: economic, ecological, social and spiritual and moral unity on the basis of innovative socio-humanitarian technologies, combining the principles of economic efficiency into an integrated system, social security and environmental safety.

The general scheme of the integration model of sustainable safe ecological-economic and social-humanitarian development of the system can be presented as an integrator:

$$S = E_n \oplus E_c \oplus S_o \oplus H_u \oplus ESTI ,$$

that is, as an integral "4-une" system, with E_c the economic subsystem (production), E_n - the ecosphere, S_o- the social sphere, H_u - the humanitarian sphere, $ESTI$ - education, science, technology, innovation (ONTI) or, in particular, R&D (Figure 1).

So, the system (model, concept) of sustainable and safe development is the integration of 1 + 2 + 3 + 4, in space (, t), that is, NMSSD is a noosphere model of sustainable and safe development and is defined as a subset of sets / subsets: (1.4-1.2), (1.2-2.3), (2.3-3.4), (1.4-3.4) (see figure) describing a system with integral and synergetic powers. Note also that sub-systems are presented here: 1-E_c; 2-E_n; 3-S_o; 4-H_u.

Recently, the systematic approach to the simulation of nonlinear dynamic systems has become increasingly widespread in various fields. This is due to an increase in requirements for the operation of systems of various natures, increasing their complexity, with the growth of volumes of information flows, reducing the time for making managerial decisions, etc.

In such conditions, management based on only heuristic rules, accumulated experience or expert judgment often turns out to be ineffective. In addition, the dependence of the perception of complex systems on the subject of research leads to a significant fragmentation of the very methods of analysis and synthesis for systems of different nature, which, in turn, does not always allow to develop effective control procedures that satisfy the system-oriented tasks.

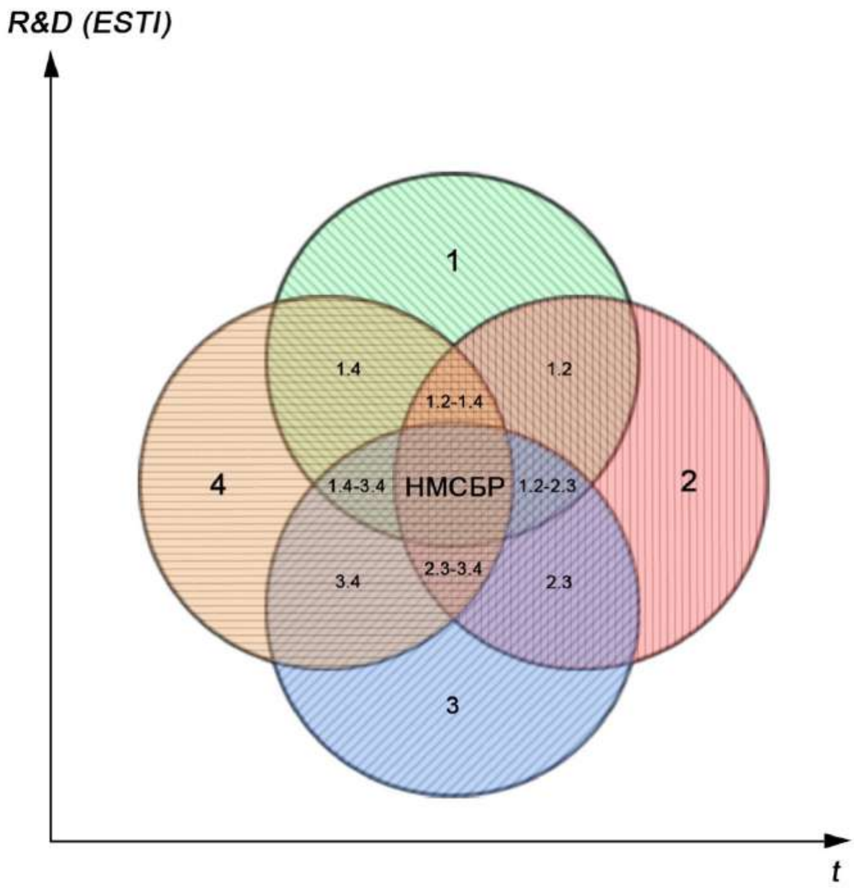

Fig.1 Noospheric model of sustainable and safe development in space ($ESTI$, t)

Therefore, there is a need for the development and application of such models, methods and approaches, which, from the common methodological approaches, would allow to analyze the behavior of the modern system, to construct a model of its development, to predict its state and to form a controlling influence on the basis of received data, in order to achieve the desired goals with the given restrictions and criteria.

Therefore, it is important to systematize, analyze and develop new analytical models, methods and approaches to the assessment of the state and behavior management of complex non-linear stochastic dynamic systems, as well as to demonstrate the possibilities of their use to solve the problems of management of systems of different nature, including social, economic, environmental, political, etc. functioning in conditions of uncertainty.

1. Stochastic model of system dynamics. The principle of system dynamics of stochastic processes or the method of system dynamics in the presence of exogenous and endogenous stochastic influences can be represented as a stochastic differential equation

(SDS) [2-4]: $\dot{X}_j = F(X_j^+, X_j^-, W_{jt})$, where $\alpha_j, \beta_j > 0$, W_{j_t}, is the standard Brownian motion; $\sigma_j(X_j, t)$ - volatility factor. In particular, the equation of stochastic dynamics of the j agent can be represented as:

$$\dot{X}_j = \alpha_j X_j^+ - \beta_j X_j^- + \sigma_j(X_j, t) dW_{jt}. \tag{1}$$

When adopting the concept of white noise with continuous time, the stochastic dynamics equations can be represented as:

$$\dot{x} = F(x,t) + \sigma(x,t) \tag{2}$$

where $\{e(t), t \in T\}$- white noise with continuous time. To represent a stochastic model of system dynamics in a discrete case, we can use the difference equation in the form:

$$x(t+1) = f(x(t),t) + w(x(t),t), \quad t \in T, \tag{3}$$

where f - the conditional mean from $x(t+1)$ for a given $x(t)$, and w - a random variable with zero mean. If the conditional distribution $w(t)$ for a given $x(t)$ is a normal law, then the model can be rewritten as:

$$x(t+1) = f(x(t),t) + \sigma(x(t),t)e(t), \quad t \in T, \tag{3*}$$

where $\{e(t), t \in T\}$ - a sequence of independent equally distributed random variables with parameters (0,1).

2. *A stochastic logistic model for the development of an economic agent is*

$$\dot{X}_j = A_j X_j \left(X_j^0 - X_j\right) / X_j^0 + \sigma_j(X_j, t) e_j(t), \quad j = \overline{1,k}, \tag{4}$$

where X_j^0, X_j - *respectively, the maximum (boundary) possible and the current* value of the investigated magnitude, and X_j^0 does not depend on time, and $\{e_j(t), t \in T\}$ is white noise with a continuous time, $\sigma_j(X_j, t)$ - the volatility coefficient.

3. *The conceptual model of the forecasting and management of ecological-economic processes (EEP) of a technogenic economic object* in the presence of "NO- and MULTIPLE-factors" can be represented in the form of a theoretical-plural model as a tuple: $\langle X, Y, F, H, R, E, \Omega, T, G, K_u, K_p, P, U \rangle$ where X is a set of possible states of technogenic economic object; $Y = \langle Y^{ecn}, Y^{ecl} \rangle$ - the total output of the technogenic economic object, and Y^{ecn} is the productive set (that is, the "useful output"), and Y^{ecl} - the set of pollution (that is, "harmful output"); $F = \langle F^{екн}, F^{екл} \rangle$ - model display of the feasibility study; $H = \langle H^{ecn}, H^{ecl} \rangle$ - general operator of observations (measurements); R - resource set (ie, the main controlled input of the feasibility study); E - a set of uncertain factors (both external and internal, that is, both additive and multiplicative), in particular, this set of stochastic, fuzzy, multiple or

mixed uncertainty; Ω - a set of restrictions; $T=[t_0,t_k]$ - time interval of operation and development of the feasibility study; G - target set; K_m - generalized ecological-economic criterion of management (EEC); K_p - generalized forecasting optimization criterion (FOC); P - operator of ecological and economic forecasting (predictor); $U=\langle U^{ecn},U^{ecl}\rangle$ - vector of ecological and economic management (EEM). The designation "ecn" and "ecl" correspond to economic and ecological variables.

Then the task of optimal ecological and economic forecasting, that is, the estimation of the predictor, for both internal and external processes, can be formulated as follows: to determine the estimation $\hat{x}(t_k+\delta),\delta=\delta_0,\delta_1,...$ of the state vector $x(t_k+\delta)$ at a given step of the forecast δ on the basis of the set of ecological and economic observations $\{y(t),t\in[t_0,t_k]\}$ and according to the given FOC K_p.

The task of the EEM is now to determine the effective integrated control vector $U=\langle U^{екн},U^{екл}\rangle$ based on the estimates $\hat{x}(t_k+\delta),\delta=\delta_0,\delta_1,...$ and nonlinear dynamics of the ecological-economic model of the feasibility study, which ensures the achievement of the goal G for a given generalized ecological-economic criteria K_u and constraints Ω, taking into account the conditions of uncertainty and risks.

A multiplicative-additive stochastic model with chaotic dynamics in the general form can be represented as vector equations:

$$\dot{x}=A(t)x(t)[X^0-x(t)]+D(t),\ A(t)=a(t)\lambda(t)\zeta(t),\ D(t)=d(t)\xi(t) \tag{5}$$

or, multiplicative-additive stochastic model with chaotic dynamics and management, that is, taking into account the leaders of the action:

$$\begin{gathered}\dot{x}=A(t)x(t)[X^0-x(t)]+D(t)+P(t),\ A(t)=a(t)\lambda(t)\zeta(t),\\ D(t)=d(t)\xi(t),P(t)=p(t)\psi(t)u(t).\end{gathered} \tag{6}$$

The observation model is represented as:

$$y(t)=H(t)x(t)+\eta(t). \tag{7}$$

The following notations are used here: $\xi((t),\ \zeta(t),\ \eta(t)$ - stochastic components in models (5) - (7), and $\lambda(t)$ - chaotic component in the system model (5). Other designations are given above. Remember that the matrix $H(t)$ can also be stochastic, that is, equation (7) will be a model of a multiplicative-additive mixture of random processes, the study of which provided the author of the article.

4. Integral socio-ecological and economic dynamic model with variables of spiritual and moral behavior. The model of sustainable and safe development of societies and the world in general should be based on the integral paradigm of socio-ecological and economic and spiritual and moral unity and on the basis of innovative socio-humanitarian technologies. The object of research of system analysis, synthesis, innovative technologies of modeling and management in this case is the system: *"Creator - Man - Environment (spiritual and socio-humanitarian, ecological and economic environment)"*. At the same time, the global goal to ensure the safe existence and sustainable development of the entire world civilization is to study and develop integral models of the whole system with the following oriented structure [2].

Integral socio-ecological and economic dynamic model with variables of spiritual and moral behavior can be conceptually represented in the general (block-like) form:

$$\begin{cases} \dot{X}_1 = f_1(X_1, X_2, X_3, X_4; P_1, \xi_1), \\ \dot{X}_2 = f_2(X_1, X_2, X_3, X_4; P_2, \xi_2), \\ \dot{X}_3 = f_3(X_1, X_2, X_3, X_4; P_3, \xi_3), \\ \dot{X}_4 = f_4(X_1, X_2, X_3, X_4; P_4, \xi_4), \end{cases} \tag{8}$$

where $X = (X_1, X_2, X_3, X_4)$ - combined vector of behavioral variables and states of the socio-ecological-economic system taking into account the variable level of spirituality X_4 - (SEESD), with $X_1 = X_1(t)$ - vector of economic variables; $X_2 = X_2(t)$ - vector of environmental variables (pollution); $X_3 = X_3(t)$ - vector of social variables; $P = (P_1, P_2, P_3, P_4)$ - the total parameter vector of SEESD (internal and external environment); $\Xi = (\xi_1, \xi_2, \xi_3, \xi_4) -$ vector of external random and indeterminate variables. For example, for technogenic production systems (TPS) [1-4]: $X_1 = \langle K_1, L_1, I, \tau, C \rangle$,a $C = (C_1, C_2, C_3, C_4)$ - vector of some parameters of consumption (expenses), and C_1 - the value of social consumption (that is, the salary, etc.), $C_2 = C_Э$ - consumption on ecology, $C_3 = C_s$ - consumption on safety, $C_4 = C_i$ - volume of investments on innovative, informational and humanitarian technologies.

An option of a generalized scheme of an integrated hierarchical object- and subjective-oriented management and decision-making system is presented in [2, 3]. Subjective-oriented management and decision-making is presented in the block "The subject of management and DM", where together with the variables (mods) k, e, r it is also important to include a variable level of spirituality, here k - cognitive variables, e - emotionally - psychological variables, r - variable reflections, which together determine the dynamics of the behavior of the decision maker (BDM) [2].

Model of dynamics of cognitive-emotional and spiritual and moral behavior of BDM. Subject or BDM as an organism and person is an open system, which is self-organizing and self-evolving, and which is characterized by the presence of non-linear and unpredictable behavioral behaviors. Therefore, the formal-mathematical methods of nonlinear science, taking into account the du-cognitive-moral component, will allow adequately describe, analyze and simulate the processes of decision-making [3].

Consider one of the options for a partial description of the dynamics of BDM behavior in the process of making effective decisions. It is important to consider in the first place not only the cognitive component of the DM process, but it is important to take into account both its emotional and spiritual components. Let's notice that in the human psyche and rather highly developed animals, environmental models are formed. This fact is a common place in the modern science of behavior-dink. At different times and by different authors, these models were called cognitive schemes (C. Levin) or cognitive maps (E. Tolman). But, even with an adequate model, the process of adopting an optimal solution and object management can be quite complicated. Therefore, in the human psyche there is a simplified mechanism for assessing the situation and decaying decisions, which is called emotions. Emotions estimate the situation not on all parameters, which can be quite a lot, but only on several of the most important for the carrier of the psyche (that is, mods). Accordingly, emotions can trigger not that behavior, which is optimal in this situation, and some other, which, on average, has well "proven" itself in the process of evolution in similar situations. Based on these considerations, under the emotions we will refer to the psychic (cybernetic) management mechanism of the behavior of BDM, which evaluates the situation on a certain set of parameters (its set for each specific emotion) and launches the appropriate behavior program (it's for each type of emotion). It is important to note that the emotional dynamics of BDM may have a significant impact on the level of spiritual-moral and moral-ethical status.

The dynamics of the processes of interreaction and interaction (ie, the dynamics of synergetic processes) of the cognitive or emotional modes (a group of essential parameters or variables) among themselves and the emotional and cognitive modes with each other can be described by a system of equations of the type Lotka-Voltaire.

In a generalized form, this model has the form [3]:

$$\dot{x}_i(t)=\lambda_i^s x_i\left[\mu_i(R)-\sum_{j=1}^{n}\beta_{ij}(R)x_j(t)\right]+\eta_i(t)x_i(t),\ i=1,\ldots,n,$$

where $x_i \geq 0 -$ characterizes the activity of *i*-th mod (this is the number of *i*-th population in ecology); n - number of interacting mods (number of populations); $\mu_i(R)$ - increment of *i*-th mod; R - a set of resource variables, for example, available information and other available types of resources; $\beta_{ij}(R)$ - elements of the matrix of interaction; $\mu_i(t)$ - multiplicative noise present in the system for the *j*-th mod; λ_i - characteristic time, which determines the process (speed of installation); s = - 1, 0, 1, 2. Depending on the ratio of parameters, this model de-monitors an exceptional variety of behavior. With more or less symmetric connections, that is $\beta_{ij} = \beta_{ji}$, the phenomenon of multistability is manifested, that is, in the system two or more stable states are possible at the same time. The realization of one of them is determined by the initial conditions. With asymmetric bonds there are heteroclinic and close to them boundary cycles, stable heteroclinical channels and dynamic chaos [3].

Cognitive and emotional modes are closely linked. However, it is natural to assume that the mods of one family are more closely linked to one another than with mods from another family. In this case one can assume that one family only modulates the dynamics of another, without destroying it. In particular, cognitive mods maintain an emotional balance, and emotions induce or (if they are negative) inhibit intellectual activity. With this in mind, it is natural to describe the interaction of emotions and cognitive activity through the help of related subsystems of equations. Given the dynamics of resources for which cognitive and emotional modes are struggling, there must be three such subsystems: fashion emotions, cognitive modes and resources (attention, memory, energy). The emotional and cognitive processes of the brain BDM may differ significantly in their dynamic properties. Cognitive activity in most cases can be regarded as a transition-based process dependent on the goal. The dynamics of emotions can be much more diverse.

5. Synergetic model of dynamics of nonlinear stochastic system with chaotic behavior:

$$\dot{x}_i = \left[\lambda_i \xi_i(t) x_i(t) \left[\Sigma_X^0 \pm \sum_{j=1}^{n} a_{ij}(t) \prod_{k=1}^{j} x_k(t) \right] + \sum_{l=1}^{3} d_{il} \frac{\partial^2 x_i}{\partial r_l^2} + w_i \right] + b_i u_i(t),\ i = \overline{1, n},\ \overline{x}_i(0) = x_{i0} \quad , \tag{9}$$

where $\langle \xi_i, w_i \rangle$ - stochastic outrageous components of the model; $\{a_{ij}(t)\}$- non-stationary components of the model; $\{d_{il}\}$ - diffusion coefficients that determine the level of distribution of the state variables; Σ^0_X - total maximum (maximum permissible) vector value X; $\{\lambda_i\}$ - set of parameters that lead to chaos.

In particular, this model can be represented as a system of equations:

$$\partial X_i / \partial t = A_i[\xi_i\,(r_i X_i - \sum_{j\neq i} b_{ij} X_i X_j - a_i X_i^{\,2}) + D_i(x,y)\Delta X_i] + \varsigma_i + u_i \quad , \tag{10}$$

where X_i - coordinates of the system vector state, and $X_i \equiv X_i(t,x,y)$; i, j =1,2,…,n; r_i - reproduction rate (reproduction, growth, development, etc.); a_i - saturation parameter restricting growth (reproduction); b_{ij} - parameter of interaction between subsystems (subjects of economic activity); $D_i(x,y)$ - diffusion coefficient of the i - th subsystem (subject of economy) at the point (x,y); $\xi_i \equiv \xi_i(t,x,y)$ i $\varsigma_i \equiv \varsigma_i\,(t,x,y)$ - stochastic multiplicative and additive components of the model, respectively; $u_i \equiv u_i(t,x,y)$ - coordinates of control vector, that is, management decisions; A_i - scaling factor Δ - Laplacian, i.e. $\Delta(*)= \partial^2(*)/\partial x^2 + \partial^2(*)/\partial y^2$, and $t \in$ [0, T] - time of operation and development of the system.

Such models describe and cover a rather broad class of complex processes and systems, which include NMDS [1].

The system has a synergistic (or cybernetic) description if the operator D is effectively constructed such that the state of the system at any time $t \in (t_0, T(t_0))$ can be constructed according to the values of the vector $x(\tau)$, $\tau \in (t_1, t_0)$, provided that all the external actions that control are fixed [10]:

$$x(t) = D(x(\tau), \varepsilon, \eta, u),\ t \in (t_0, T(t_0)),\ \tau \in (t_1, t_0), \tag{11}$$

where $\varepsilon(t,r)$ - random action with known probabilistic characteristics $\eta(t,r) \in G_\eta$ action, given by the measure of uncertainty G_η, $u \in R^k$ - managing actions, r - spatial variable (vector).

6. Integral model of dynamics of the system. As a result of complex formalization, we obtain one of the variants of the socio-ecological-economic and innovation model of di-tinting in the form of the following system of equations [4-6, 13-27]:

$$\frac{d}{dt}[K(t)] + \alpha K(t) = I(t) - C(t) - D(t) - B(t) - \alpha K(t) W_K(t), \tag{12}$$

or

$$\frac{d}{dt}[K(t)] + \alpha K(t) = e^{\omega t} F(K(t), L(t), R(t)) - C(t) - D(t) - B(t) + \sigma_k(K,t)e_k(t), K(0) = K_0,$$

$$Y = F(K, L, R, e_Y(t)) = \left[\beta_1 K^{\frac{\delta-1}{\delta}} + \beta_2 L^{\frac{\delta-1}{\delta}} + \beta_3 R^{\frac{\delta-1}{\delta}}\right]^{\frac{\delta}{\delta-1}} + \sigma_Y(Y,t)e_Y(t) \qquad (13)$$

or $$Y(t) = A\tau(t)\left[(1-\alpha_K^1(t)-\alpha_K^2(t)-\alpha_K^3(t))K(t)\right]^{\alpha_1}\left[(1-\alpha_{L_2}^1(t)-\alpha_{L_2}^2(t))L_2(t)\right]^{\alpha_2} + \sigma_Y(Y,t)e_Y(t),$$

$$\frac{d}{dt}[L(t)] - \gamma L(t) = -\gamma_Z Z(t) + \gamma_C C(t) + \sigma_L(L,t)e_L(t),\ L(0) = L_0, \qquad (14)$$

$$\frac{d}{dt}[R(t)] - \gamma_R R(t) = \gamma_K K(t) - Y(t) - \gamma_L L(t) + \sigma_R(R,t)e_R(t),\ R(0) = R_0 \qquad (15)$$

or $$\frac{d}{dt}[R(t)] - d(K(t), L(t), R(t)) = \gamma_K K(t) - \gamma_L L(t) - Y(t) + \sigma_R(R,t)e_R(t),$$

$$\frac{d}{dt}[Z(t)] + g(Z(t)) = f^*(c, K, L, R)(1-\eta c) + \sigma_Z(Z,t)e_Z(t),\ Z(0) = Z_0, \qquad (16)$$

$$\frac{d}{dt}[\dot{\phi}(t)] - \delta_\phi \phi(t) = G[\phi(t)]^{\gamma_1} \cdot \left[\alpha_\sigma^1(t)\sigma(t)\right]^{\gamma_2} \cdot \left[\alpha_K^1(t)K(t)\right]^{\gamma_3} \cdot [s(t)]^{\gamma_4} + \sigma_\phi(\phi,t)e_\phi(t), \qquad (17)$$

$$\frac{d}{dt}[L_1(t)] - \delta_{L_1} L_1(t) = D[\phi(t)]^{\eta_1} \cdot \left[\alpha_{L_1}^2(t)L_1(t)\right]^{\eta_2} + \sigma_{L_1}(L_1,t)e_{L_1}(t), \qquad (18)$$

$$\frac{d}{dt}[s(t)] - \delta_s s(t) = H[\phi(t)]^{\upsilon_1} \cdot \left[\varepsilon_L^1(t)L(t)\right]^{\upsilon_2} \cdot \left[\varepsilon_K^2(t)K(t)\right]^{\upsilon_3} \cdot \left[\varepsilon_z^3(t)z(t)\right]^{\upsilon_4} + \sigma_s(s,t)e_s(t), \qquad (19)$$

$$\frac{d}{dt}[\tau(t)] + \delta_\tau \tau(t) = B\left[\dot{\phi}(t) + \delta_\phi \phi(t)\right]^{\beta_1}\left[\dot{\sigma}(t) + \delta_\sigma \sigma(t)\right]^{\beta_2}\left[\dot{s}(t) + \delta_s s(t)\right]^{\beta_3}\left[\dot{z}(t) + \delta_z z(t)\right]^{\beta_4}, \qquad (20)$$

$$\left\{\dot{K} = -\mu K + I_h(t) - C(t) - D(t),\ K(0) = K_0, \dot{I}_h = -rI_h + h_0 I_0,\ I_h(t_0) = h_0 I(t_0).\right. \qquad (21)$$

$$dC(t) = A(t)K(t)dt - (1-\alpha)K(t)dt + A(t)K(t)W_C(t).$$

(22)

where *Y(t)* - the volume of "useful" output, *K(t)* - capital, *L(t)* - number of employees, $C(t)$ - volume of consumption, *Z(t)* - volume of pollutants ("harmful" output), *I(t)* - investments, *R(t)* – other resources, *D(t)* - costs for pollution abatement and monitoring, $B(t)$ - security and sustainable development costs. Here $d(K(t), L(t), R(t))$ - some function that determines the total amount of expenditures for exploration of natural resources depending on spent capital *K(t)*and attracted labor $L(t)$.

The problem of optimal management of the development of innovation economy on the basis of an integrated stochastic model of dynamics. On the analytical methods used in the formation of control actions on complex dynamic system, it is possible to make some observations, conclusions and recommendations: analytical methods, based on modern mathematical tools and methods, enabling to some extent take into account the characteristics of complex systems - high degree of uncertainty, unsteadiness of the object and the environment of its operation, the nonlinearity of the behavior, multifunction structure and elements, as well as multicriteria, that is, in the presence of "NO - and MULIPLE factors" [1]. It allows using analytical methods in solving the tasks of modeling, forecasting and control of complex systems, including social, economic and political. The complexity of the mathematical apparatus, and often the lack of appropriate knowledge and skills is not a reason for separation of the tasks of sociology, Economics, political systems and living organisms by their teaching and management analytical methods of control theory; strong mathematical methods of analysis, in most cases, allow us to model and control complex dynamical systems defined modes of operation. If the conditions of operation of the system are defined correctly, the mathematical methods of control theory can provide a high-quality managed process; the presence of features of goal-setting in the system is not a problem in the management of complex objects.

Modern methods of management theory allow optimizing processes, including, in contradictory conditions; strict mathematical methods should be applied more intensively with a deeper study of objects. In the first stages, it is enough verbal description of processes, classifications and qualitative recommendations. However, as we will see below, the most well-known are methods that use different mathematical tools. In particular, the humanities have widespread graphs and tables, on the basis of which an effective analysis of static systems is carried out. In this case, the analysis of the presence of connections, without taking into account their quantitative characteristics, can lead to qualitatively incorrect conclusions about the behavior of complex dynamic systems.

Criteria for stochastic optimal control. For exogenous (externally) given parameters $s(t), \alpha_K^1(t),\ \alpha_K^2(t), \alpha_K^3(t), \alpha_L^1(t), \alpha_L^2(t), \alpha_\sigma^1(t), \alpha_\sigma^2(t)$ and the initial values of the variables $K(0),\ L(0),\ \sigma(0),\ \varphi(0),\ \theta(0),\ r(0),\ \psi(0)$ system (12) - (22) - is a system of ordinary stochastic differential equations that satisfies the conditions of the existence and uniqueness theorem for solving the Cauchy problem.

If we consider the historically determined initial values of phase variables and functions $s(t), \alpha_K^1(t), \alpha_K^2(t), \alpha_K^3(t), \alpha_L^1(t), \alpha_L^2(t), \alpha_\sigma^1(t), \alpha_\sigma^2(t)$ to consider administrations, then there is a problem of choosing the best solution.

By adding in this sense the system (12) - (22) by the criterion of optimality, we obtain the objective of optimal control. Possible task of terminal values of phase-type (endogenous) variables $K(T), \sigma(T), \varphi(T), \theta(T), r(T), \psi(T)$. This is for the task of terminal management. So here: $K(t), L(t), \sigma(t), \phi(t), \theta(t), r(t), \psi(t)$ - variable states (phase variables), that is, the coordinates of the state vector $x(t)$; and a set of parameters: $s(t)$, $\alpha_K^1(t)$, $\alpha_K^2(t)$, $\alpha_K^3(t)$, $\alpha_L^1(t)$, $\alpha_L^2(t)$, $\alpha_\sigma^1(t)$, $\alpha_\sigma^2(t)$ - variable control, that is, the coordinates of the control vector $u(t)$.

The criterion for choosing an ecological and economic development strategy [1, 3-4]*:*

$$E\left[\Phi(C,Y,D,B)\right] \to \max, \tag{23}$$

where $\Phi(C,Y,D,B)$ - welfare function, and E - a symbol of a mathematical hope, that is, we obtain a hierarchical multicriteria optimization model of the system in the form:

$$\begin{cases} \mathrm{E}\{Z\} \to \min,\ \mathrm{E}\{K\} \to \max, \\ \dot{Z} = \chi(Z,K,L,R,c), \\ \dot{K} = \phi(K,L,R,c). \end{cases}$$

In the case of a "small" integral management model, the utility function (UF) is a function of parameters/variables $\tilde{u}(\alpha_1,\alpha_2,\alpha_3,\alpha_4)$, where $\{\alpha_k(t), k=1,...,4\}$ - the share of expenses on non-productive, environmental costs, R & D, on safety, innovative and informational technologies, etc., and the criterion of optimality then is the ratio:

$$\Lambda(c,k,z,L,\tau,S) = \int_{t_0}^{T} \tilde{u}(\alpha_1,\alpha_2,\alpha_3,\alpha_4)\exp(-\theta t)dt \to \max_{\{\alpha_i\}\in\tilde{\Omega}} \cdot$$

To solve the problems of EEM on the basis of the reduced stochastic and deterministic models, one can use the well-known classical methods of optimal management with constraints [1-4, 8, 9].

In general, the optimization criterion can be presented as

$$\Lambda(\vec{a}) = \int_{t_0}^{T} \tilde{u}(\alpha_1,\alpha_2,\alpha_3,\alpha_4,...)\exp(-\theta t)\, dt \to \max_{\{\alpha_i\}\in\tilde{\Omega}}.$$

There is a need for even greater integration of models and criteria (and limitations) of optimization of management and DM.

It is also important to consider models and criteria of random (stochastic) factors of multiplicative and additive influence. That is,

$$\Lambda(\vec{a}) = E\int_{t_0}^{T} \tilde{u}(\alpha_1,\alpha_2,\alpha_3,\alpha_4,...)\exp(-\theta t)\, dt \to \max_{\{\alpha_i\}\in\tilde{\Omega}}\ . \tag{24}$$

As a criterion in tasks similar to those considered, usually the target functionality of maximizing the average per capita consumption of a worker in a time interval $[0,T]$:

$$\int_0^T \frac{C(t)}{L_1(t)+L_2(t)} \exp(-\theta t)dt \to \max, \tag{25}$$

where $\theta > 0$ - discount rate, reflecting the degree of preference over real consumption of the future.

Note that criterion (25) is only a private (economic) criterion. Therefore, we need also socio-ecological, innovation and other criteria of optimality!

7. Problems of control synthesis in stochastic systems. Let's consider the problem of analytical synthesis of optimal control in stochastic linear systems [7, 8].

8. Under the phase state of the system we will understand the vector $x=(x_1,x_2,...,x_n)$, where $x_i, i=1,...,n$ – a set of data characterizing the *i*-th sector of the system. Let's assume that all sectors are equipped with some control levers: $u=(u_1,u_2,...,u_n)$

Each of the listed parameters, in its turn, is a vector compiled from the numerical values of the indicators of various characteristics of the dynamics of the system. Let [t_0, t_k] is the period of development of the system. We denote ξ the vector of some additional parameters that are determined by prediction using statistical data of the system, or they are constants.

Thus, the dependence of each variable $x_i, i=1,...,n$ on the controlling variables u_i of the system and the parameter vector ξ is studied.

In particular, the linearized model of the system has the form

$$\begin{gathered}\dot{x}(\xi,t)=A(\xi)x(\xi,t)+B(\xi)u(\xi,t),\\ x(\xi,t)\in R^n,\ u(\xi,t)\in R^m,\ A(\xi)\in R^{n\times m},\ B(\xi)\in R^{n\times m};\end{gathered} \tag{26}$$

where $A(\xi)=\lfloor A_{ij}(\xi)\rfloor$, $B(\xi)=\lfloor B_{ij}(\xi)\rfloor$ - matrices with parametric uncertainty; $x(\xi,t)=\lfloor x_i(\xi,t)\rfloor$- system state vector; $u(\xi,t)=\lfloor u_i(\xi,t)\rfloor$ - control vector; ξ - stochastic processes vector.

The task of synthesis of optimal control of a stochastic dynamic system is as follows: to find the law of optimal control in the form [7-9]:

$$u(\xi,t)=-L\hat{x}(\xi,t), \tag{27}$$

and the target functionality for optimization (minimization) is given in the form:

$$J=\int_\Omega\left\{\int_0^{t_k}(x^T(\xi,t)\Theta x(\xi,t)+u^T(\xi,t)Ru(\xi,t))dt\right\}p(\xi)d\xi. \tag{28}$$

That is, after the averaging we have the criterion for optimal control as

$$\bar{J}(u) = E\left[\int_0^{t_k} (x^T(\xi,t)\Theta x(\xi,t) + u^T(\xi,t)Ru(\xi,t))dt\right] \Rightarrow \min . \qquad (29)$$

In the simple case, we can use the linear observation equation in the form: $y(t) = H(t)x(t) + \eta(t)$. In this observation equation $H(t)$ there is a stochastic matrix of observation [7], which can be asked for practical reasons, and $\eta(t)$ is a process of "white noise" type, which can be asked according to statistics. In this case, on the principle of separation, we must solve two separate tasks [8-10].

In the early works of one of the authors of the problem of optimal estimation (filtering) and identification in multiplicative-additive mixtures solved using the integrated description of the filter [7]. However, the task of filtration is possible and convenient to solve using the Kalman filter for the linear case and filter Stratonovich, nonlinear right side of the equations of dynamics [7-10]. Assessment located as a conditional average with the construction and solution of nonlinear dispersion equations of the Ricatti type. The filter gives the solution to the stochastic differential equation. It can be implemented in the form of a known feedback system with respect to density distribution of the initial conditions. The resulting assessment $\widehat{x}(t)$ is used in the solution of the second problem optimal control $\hat{u}(t) = -L(t)\hat{x}(t)$. As already noted, the problem of optimal control is usually placed on the basis of the Bellman or the maximum principle [7-10]. The criterion can be applied in various cost functional and the vector of functional.

Conclusions. Based on the use of modern approaches, methods, models, information and innovation technologies for the purpose of forecasting and managing the state of nonlinear dynamics of ecological-economic and social-humanitarian systems, integrated stochastic models of objects and processes suitable for system conditions crises The aspect of integration of many spheres and sectors of activity of modern complex systems that are functioning and developing under difficult conditions of instability and nonlinearity is considered. As a result of the complex formalization, one of the variants of the integral socio-ecological-economic and innovation non-linear model of dynamics was obtained in the form of a system of hundred-hasty differential and functional equations. The task of forecasting the state of a complex system in the innovation economy is presented on the basis of an integral model in the phase space with observation equations, the development of filters and algorithms of optimal control. The prospect of further research is to conduct computer experiments on real data.

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8. INFORMATION COMPUTER TECHNOLOGY OF ENTERPRISE DEVELOPMENT STRATEGY FORMATION ON THE BASIS OF BENCHMARKING METHODS

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Annotation

Currently, a significant part of enterprises work without a pre-defined strategy of their development, mostly because there is no technology for the practical implementation of such a strategy. The information computer technology on the basis of benchmarking methods for use in the activities of business entities in any subject area to find, evaluate and make effective management decisions – the formation of the development strategy of the enterprise. In accordance with the wishes of users can be developed as a short-term and long-term strategy.

Introduction

Research of the domestic enterprises activities has shown that a significant part of them operates without a predetermined strategy of their development, which leads to the lack of target guidelines in making industrial, marketing, financial and other management decisions. The absence of a well-defined strategy weakens the position of the company in competition, especially in the case of an enterprise entering the external markets.

Modern business conditions determine for enterprises their rules of conduct in a competitive market. Market practice demonstrates new, up-to-date methods, tools and approaches to managing organizations, and in the future allow them to form advantages among competitors and increase their competitiveness. In world practice, one of these methods is special management tools for benchmarking and best practices.

Benchmarking is a management technology focused on identifying and using the best experience in a particular field. Benchmarking is based on the concept of continuous improvement of activities, which envisages a continuous cycle of planning, coordination, motivation and evaluation of actions in order to permanently improve the work of the organization. [1].

The relevance of benchmarking is not only that there is no need to "invent a bicycle", but that by studying the achievements and mistakes of other companies, you can develop your own most effective business model.

Analysis of recent research and publications

Foreign scientists such as D. Aaker, N. Voevodina, I. Danilov, D. Maslov, G. Raider, T. Pilcher and others are studying the theoretical aspects of benchmarking. In Ukraine, this approach to defining and improving the competitiveness of the enterprise began to be studied in the Soviet era, but today benchmarking theory is practically little developed. Some aspects of benchmarking are considered in their scientific works by such domestic scientists and economists as M. Bublik, N. Gabruk, L. Dovgan, M. Kasatkina, Yu. Karakay, M. Lyutikova, O. Makarchuk, K. Redchenko and others.

When comparing two business models, you need to have a good understanding of both, otherwise you will not get a clear idea of the big picture. So first you need to analyze the production processes in your company, and only then start benchmarking.

Thus, H.J. Harrington and J.S. Harrington believe that benchmarking is an endless process that studies, evaluates, and discovers all the best qualities in other businesses to use their knowledge in their own business. [2].

The benchmarking method is not limited to business processes or products. In fact, over the years, companies have shown great ingenuity in selecting the elements of business that have been considered in benchmarking.

At the same time, it is important to remember that for successful benchmarking, you need to identify the root causes of high performance. Starting by collecting general information about what other companies are doing, the ultimate goal is to identify how they work. The term "implementation tool" refers to benchmarking as a key factor in achieving high efficiency in a company, such as in production, business processes, or resource utilization. [3].

The benchmarks are compared in the benchmarking process:

1) products and services;

2) financial indicators;

3) business processes;

4) strategies;

5) functions, groups and organizations.

Benchmarking aims to identify not only what other companies are doing, but also how they manage to do it. Therefore, the study of the structure and organization of work in the company is one of the common topics when conducting benchmarking. Business can go on any aspect of the organization of work of the company: approved functions or established groups, divisions and business units, the number of employees in them, etc. Part of the benchmarking of an organization can even be the compilation of characteristics on individuals.

The use of social media resources, such as websites to establish professional contacts, has become a new reliable source of information for benchmarking of this type. This method helps to reduce the cost of specialist travel and expensive primary research, and with relatively little effort allows you to discover a large amount of valuable information.

Depending on the parameters of comparison, benchmarking of indicators, processes, and strategic benchmarking are distinguished.

There are the following types of benchmarking:

1) Internal benchmarking.

Based on the name it is clear that this type of research is carried out exclusively within the company. For comparison, the processes, goods or services closest in parameters are taken. The advantage of the method is that the analysis can be carried out without much effort, since there are no difficulties in collecting data. Disadvantage - very limited opportunities to research, resulting in possible bias of the results.

2) Competitive benchmarking.

The analysis is based on a comparison of the products and services of the firm with the products and services of a direct competitor company, with the latter being able to work both locally and regionally or internationally. This type of benchmarking will be more useful if you choose an international organization for comparison.

3) Functional benchmarking.

Such a study compares the processes of one's own company with those of another. Unlike other types of benchmarking, the company selected as a benchmark operates in a completely different field. Advantages of this method in the less expense of efforts for obtaining objective data, and with absolutely ethical and legal methods.

4) Generalized benchmarking.

The companies that have the best performance in processes and approaches are selected for analysis. Moreover, information about the work of these organizations is openly available. For example, there are many publications on production systems at Toyota or Motorola. The processes and approaches that are most appropriate for the company are analyzed and, after appropriate adaptation, implemented [4].

According to F. Kotler, test comparison, i.e. benchmarking, carried out in seven steps: selection of the functions that you want to compare; determining control variables and search for the most successful companies; finding the values of the control variables; evaluation of the company's activities; identification of programs and actions that lead to success of the target company; implementing in the "model" of company activities; study of the results obtained.

Benchmarking is not an equation that is solved in a strictly defined way. There is no single system here; each company uses its own designs. The steps of F. Kotler's benchmarking can be supplemented and modified somewhat:

1) to select a benchmarking object, analyze and detail it. It may be some process, service or product produced by the enterprise. Here it is important to decide the following points: what resources a firm can afford to allocate to this research; a one-time action is planned or similar practices will become regular;

2) to determine the characteristics to be analyzed. The object of analysis can be the process parameters, consumer properties of the product or service;

3) to appoint specialists to carry out benchmarking. It is advisable to take people from different departments. This will give you the opportunity to look more broadly at the subject of research both in your company and in the partner company for benchmarking;

4) to choose partners. These can be serious enterprises whose successes in the implementation of characteristics are of interest to you, undeniable (you have defined the characteristics yourself in the second stage). Partners can be taken as one firm or several. At internal benchmarking of the organization the partners will act as adjacent divisions of the company, the processes within the enterprise or products will be analyzed, manufactured;

5) to collect and to analyze the data needed for further comparison. Most often, the information received must be processed. The fact is that different companies may share the same product specifications in different ways. Everything will need to be brought to a common denominator;

6) to evaluate the capabilities of the company to catch up with the leading organization on the required characteristics. Assessment methods may be different, for example, by GAP analysis;

7) to determine what changes are needed in the operation of the enterprise to achieve a specific result. The overall picture should be based on the results of the adaptation of the acquired knowledge to the conditions of one's own firm;

8) to develop strategic goals and to make plans to achieve them. Much here depends on the magnitude of the intended change. The plans may relate to production organization, management systems and other aspects of the company;

9) to implement previously approved plans. And for these processes constant control is required. If necessary, plans in the course of implementation are adjusted;

10) make a decision on re-benchmarking to solve new problems if, of course, the past ones have been successfully implemented.

If we refer to the publications on the enterprise development strategy, the analysis of the results obtained by other domestic and foreign scientists shows that they focus their theoretical and methodological aspects on the formation of the enterprise development strategy, factors that influence the effectiveness of the chosen strategy, but without proposing specific technologies to obtain practical results. Examples of such publications: [5]–[10].

The purpose of the work

The purpose of the work is to develop information computer technology to formulate an enterprise development strategy based on benchmarking methods in any subject area for use in the activity of business entities to find, evaluate and make effective management decisions.

To achieve this goal, it is necessary to complete the following tasks:

1) To choose the basic model;

2) to develop a model of formation of enterprise development strategy based on benchmarking methods;

3) to develop information computer technology (ICT) on the basis of the obtained model;

Description of work results.

Despite the wide spread of mathematical methods for solving problems of enterprise management, it cannot be assumed that formal methods of modern mathematics will be the universal means of solving all problems arising in this area. Due to the limited application possibilities in management and marketing, economic-mathematical methods, lack in many cases of statistical and other information as well as reliable methods to determine compliance of economic-mathematical models of real objects, the expert assessment is the only means of solving many tasks. The advantages of expert ratings include ease of use to predict almost designer situations, including in the conditions of incomplete information [11].

That is why the work is based on the method of verbal analysis "ORCLASS" (ordinary classification of alternatives) [12] from a set of methods of verbal analysis of solutions (VAS), developed under the guidance of Academician O.I. Larichev.

The basic principles of VAS are as follows:

– using the description of the problem of definitions and wording of the assessments of the solutions in the form natural to the decision maker, their advisors and active groups, without any conversion of these verbal formulations in quantitative values. One of the important characteristic features of the VAS is the use of verbal ratings on ordinal scales of the criteria as the main language for the description of the problem;

– building of decision rules based on logical, verbal transformations of variables subject to psychological and mathematical correctness of these transfor-mations. In accordance with this principle in VAR methods to identify the preferences are only operations of comparing and classification.

The ORCLASS method has at its core three concepts - an alternative, a criterion (and its values), and a class that have the following meanings:

1) alternatives – sets of data (research results). To develop the model are sets of values describing the current state of the enterprise;

2) criteria – a set of characteristics that distinguish alternatives each second. For the developed model is a set of indicators describing the leaders of the business industry;

3) value criteria – the set of all possible values of all criteria, with each criterion they are ordered from best to worst. To develop the model are the values of indicators defining current status of the enterprise;

4) classes – has its own unique characteristics, in order (from best to worst) part of a General list of all possible alternatives (for example, diagnoses, causes of failure, rating or valuation categories, or something or someone, etc.). For the developed model is a set of values that describe the current state of the enterprises that belong to a certain period of the life cycle of the enterprise.

The ORCLASS method allows:

– For any set of criteria and their values, rank (sort by predefined classes) on the principle of "better - worse" any number of alternatives, ie. build a so-called "decisive rule";

– Using a decisive rule, to uniquely determine which of the classes is any of the alternatives in the form of a criterion for describing the current state of the enterprise.

The decisive rule is a table containing all possible alternatives, arranged lexicographically from the best (having the best values of all indicators describing the current state of the enterprise) to the worst (having the worst values of all indicators) alternatives, each of which is matched the class to which it belongs.

The model of the ORCLASS method for the benchmarking case is presented in Fig. 1.

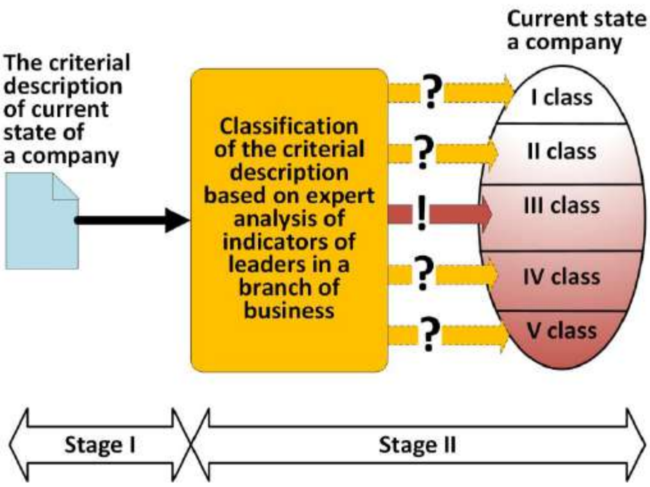

Fig. 1 - Model of the ORCLASS method for the benchmarking case.

Shown at Fig. 1 model is the basis for creating a model for the formation of enterprise development strategy. In fact, another element of the model being developed is the algorithm of finding the optimal path (strategy) from a specific alternative (current state of the enterprise) to an alternative that is guaranteed to belong to either the next best class - a short-term strategy, or the best class - a long-term strategy [13]. The search is conducted on a complete lexicographic set of alternatives. The optimality of the path (strategy) can be both in terms of time and cost of achieving the goal.

Model of formation of enterprise development strategy based on benchmarking methods is shown at Fig. 2.

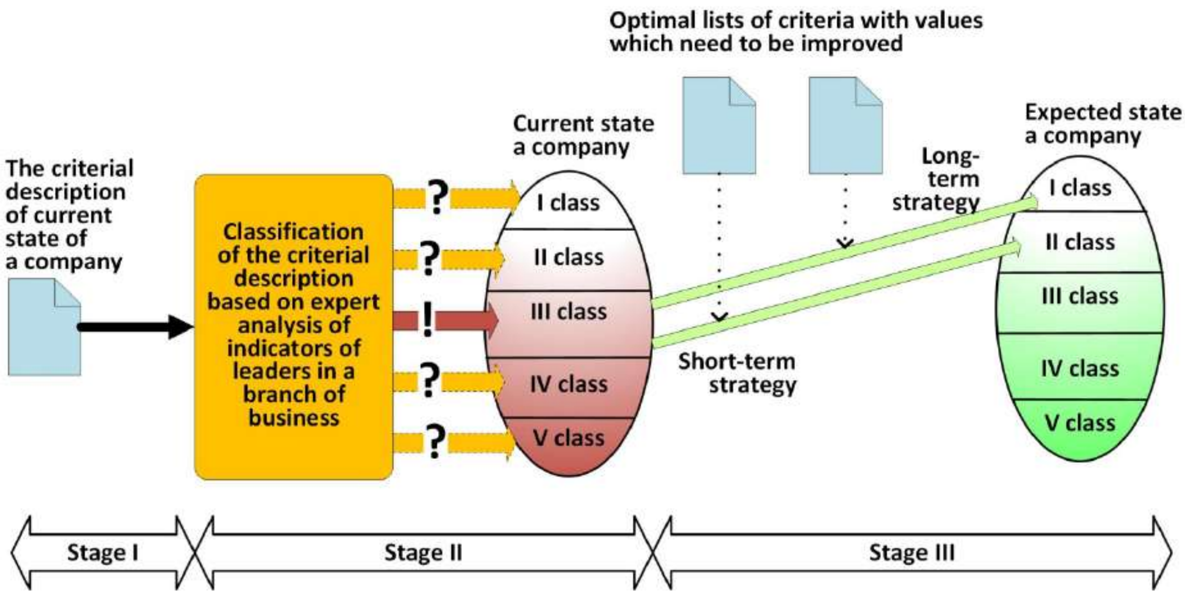

Fig. 2. - Model of formation of enterprise development strategy based on benchmarking methods.

Strategy formation consists of 3 stages:

– Stage I: Information preparation for the evaluation of the activity of the enterprise. The current state of the enterprise is defined as a set of values of criteria, which describes the activity of leaders of a given branch of business after conducting benchmarking.

– Stage II: Classification of the current state of the enterprise in relation to the indicators of leaders of a given branch of business.

– Stage III: Determining Enterprise Development Strategies. Optimal changes (strategy) are automatically determined, the implementation of which will improve the current state of the enterprise. The strategy can be both short-term (moving to the next "best" class) and long-term (moving to the "best" class).

ICT is created on the basis of the developed model of formation of enterprise development strategy. As a product, ICT is a web-based application by which a group of experts with sufficient expertise in a formalized subject area:

1) carries out information preparation for the evaluation of the activity of the enterprise, for which:

- after analyzing the activity of the leaders of this branch of business, criteria describing their status are determined. For example, a description of management, policies and strategies, HR, partnerships and resources, process statuses, consumer attitudes, public attitudes, key performance outcomes, etc. Each criterion is assigned several qualitative values. The name of the criteria and their values are entered into the system;

- all possible states of the enterprise are broken into classes. A certain condition of the enterprise belongs to a certain class from the best (I class) to the worst. Each class has its own set of criteria values. According to the practice, there are enough divisions into 5 classes, for example: "Stable development"; "Trends in development"; “Balance”; "Stagnation trend"; Stagnation. Certain class names are entered into the system;

2) after introducing the values of all criteria in the dialog mode (describing the current state of the enterprise), it receives recommendations as to what values of what criteria and to what extent it is necessary to improve in order for the enterprise to "move" to the next best class - short-term strategy, or the best class - long-term strategy development of the enterprise;

3) after realization of changes of strategy formation it is repeated with the necessary periodicity to achievement of goals of the enterprise.

The monetization of ICT as a product can be implemented as follows: introduction of criteria, their values, class names, construction of the decisive rule and definition (classification) of the current state of the enterprise - free of charge, and strategy formation - for payment

Conclusions.

According to the consulting company Bain & Co, benchmarking is among the three most common business management practices in large international corporations. Benchmarking has become one of the effective and recognized tools for business improvement. So back in 1994, 88% of European and 76% of US companies in one form or another had already used benchmarking.

In 1993, the benchmarking centers of the UK, USA, Germany, Sweden and Italy decided to join forces to develop a benchmarking method in the world. And in 1994, the Global Benchmarking Network (GBN) was founded as a community of independent benchmarking centers. Today it unites such centers from 20 countries of the world and continues to expand.

Benchmarking is not just a copying of the systems used by successful companies. This approach cannot produce the desired results due to differences in business structures. The main thing is the adaptation of these principles for internal application. This is why the benchmarking system can be effective not only with direct competitors in the market, but also with firms whose target audience is completely different. You can even analyze the work of enterprises from a completely different field of activity. Competent benchmarking of the company will be able to radically improve its functioning, but only if there is an understanding of their own processes.

The model of formation of the enterprise development strategy in an arbitrary subject area is developed and the ICT created on its basis are close to the human way of evaluation; knowledge-based; give a clear result; issue expert recommendations for the construction of short-term and long-term strategies; quite simple to implement.

Web-based applications built on the ICT presented are easy to operate and can be used in the activities of business entities to find, evaluate and make effective management decisions.

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9. MANAGING TEAM PROJECTS IN TERMS OF ADAPTATION TO CHANGE REQUIREMENTS OF PROJECT STAKEHOLDERS

Husieva Yu. Yu., Chumachenko I. V.

Annotation

Successful implementation of projects, project portfolios and programs can be ensured, in particular, through the development of decision support information systems for the formation and management of responsive project teams. Based on the analysis of existing developments, we can conclude that the known methods of human resources management are oriented, for the most part, to the psychological compatibility of project team members, without taking into account the issues of competence management and resource allocation. At the same time, the project management methods of the team do not provide sufficient adaptability. With this in mind, the challenge of improving project performance through informed decision making while managing adaptive teams is relevant.

The tools of decision support for project management in the conditions of adaptation to changes in requirements of project stakeholders are offered. Thus, the required method enables monitoring of the project stakeholders' requirements, which in turn allows the project team to adapt to the likely changes in stakeholder requirements. The transition to value monitoring provides an opportunity to take into account the intangible requirements of the project team and other stakeholders. To distribute values, the project team proposes to use a balance model with recommendations for adhering to an equivalent exchange.

Introduction

In today's dynamic environment, one of the urgent tasks of project management is to adapt to changes, in particular, in the field of human resource management of projects and programs. Unstable economic environment reduced investment in project implementation in Ukraine and in the world, increased risks of late execution of projects with budget overruns, necessitates the use of modern project management tools. Human resource management is known to have a direct impact on the overall effectiveness of project management. Therefore, now that both staff mobility due to political changes and the level of human-related risks have increased significantly, developing a project management team with a view to its adaptability is becoming an urgent task.

The adaptability of the project to change is ensured by a variety of tools in traditional and flexible project management. Traditional project management [1] considers change management through an integrated change control process - a process that lasts throughout the project and is to reject or approve requests for change, which are typically generated as outputs of monitoring and control processes. In fact, it is about documenting, not justifying change; control, not control. Therefore, the experience of traditional project management in managing change in managing an adaptive project team is inadequate. In addition, the complexity and cost of implementing change in the traditional approach has increased rapidly since the beginning of the project.

Flexible project management methodologies have a greater degree of adaptability due to their iterative nature, but are mostly used in the field of IT projects [2-4]. A characteristic feature of flexible methodologies is the fixation of project resources, that is, project adaptability to change is ensured by changes in project content (in traditional methodologies, content is fixed). Because the project team refers to its resources, therefore, it is fixed, its adaptability for the most part, manifests itself in the distribution of tasks between team members. For complex projects with various resource constraints, the possibilities of this approach are insufficient.

Common methods of forming and managing a project team in both traditional and flexible methodologies are methods of general theory of personnel management and its development in the form of human resource management - organizational management, management psychology, leadership, motivation, combination of personnel management strategy with the strategy of the company [5, 6]. The disadvantage of this approach is its focus on operational rather than project activity.

Competent approach in project management (in particular, ICB 4.0) defines the competencies that the project manager should possess, but does not make recommendations for the formation of the project team. It should be noted that domestic studies are carried out in similar directions. Adaptation of a competent approach to the modern realities of national project management [7] and development in the field of value project management, which propose to form a project team taking into account the comparison of values of members of the project team and the project, should be mentioned separately. [8].

Therefore, there is a need to develop methods for forming and managing an adaptive project team that combine the features of traditional and flexible methodologies, given the limited resources of the project.

Based on the analysis of the state of the existing developments, it can be concluded that the known methods of human resources management are focused on the psychological compatibility of the project team members, without taking into account the issues of competence management and resource allocation by function. At the same time, the project management methods of the team do not provide sufficient adaptability.

As human resources in the project may change, there is a need for a reallocation of project resources at the operational stage. Existing resource allocation methods are mainly aimed at allocating homogeneous (by function) resources and taking into account the speed of function execution. The application of these methods to heterogeneous projects is inappropriate. With this in mind, the challenge of improving project performance through informed decision making while managing adaptive teams is relevant.

Adaptability as a specific feature of modern project management. Means to adapt the team to changes in stakeholder requirements

Any projects are accompanied by changes in both the internal and external environment. Adequate and timely response to such changes is the key to "surviving" the project.

Today, the most adaptable to adaptation are the so-called "flexible" project management methodologies. In 2001, Agile Manifesto declared such values: «Individuals and interactions over processes and tools. Working software over comprehensive documentation. Customer collaboration over contract negotiation. Responding to change over following a plan. That is, while there is value in the items on the right, we value the items on the left more. ».

Agile is best suited to non-deterministic projects for which the final configuration of the product or service being developed is not known at the start of the project and is formed as a result of successive iterations. Examples of such projects may be research or IT projects. Agile is proven to work well for small projects. However, implementing of Agile for large projects is more problematic [9].

The need to take into account the adaptability factor is also recognized by a representative of traditional project management as PMI (Project Management Institute), which in September 2017 issues the sixth edition of the Project Management Body of Knowledge (PMBOK® Guide), each area of knowledge containing a section called Approaches for Agile, Iterative and Adaptive Environments, which describes how these practices are integrated into project management processes. At the same time, a standard in the related industry - A Guide to The Business Analysis Body of Knowledge - received this addition in 2013.

Taken into account that standards such as the PMBOK® Guide only provide guidance on the use of certain methods, without detailing them and specifying how to adapt to a particular industry, it can be argued that the task of integrating adaptive management practices into traditional project management is relevant, but to date it has no clear practical implication.

Adaptation is a fundamental property of matter, organization and man. Adaptation provides an intelligent approach to problem solving, emphasizing the need for development through interaction, response, adjustment, feedback, and recognition of the complexity and uncertainty of the environment.

Adaptation is considered in several areas:

– biology (adaptation of the organism to external conditions in the process of evolution, including morphophysiological and behavioral components);

– sociology (the process of interaction of an individual or group with the social environment, when an individual assimilates social norms and traditions of subcultural values of a certain group);

– control theory (uses the concept of an adaptive system as a control system that has the ability to change the parameters of the regulator or the structure of the regulator depending on changes in the parameters of the control object or external changes), in particular, in such its applications as education management, enterprise and coordination of its operational and project activities.

APM (Association for Project Management) specialists consider adaptation within three interrelated streams [10]:

– elasticity – recovery, ability to absorb changes and breakdowns, deal with unexpected future;

– flexibility-a variety of potential solutions and options, the ability to respond quickly and change the strategy in response to emerging trends and events;

– evolution is the process of interaction with the environment, relevant changes and responses; potential for innovation; emphasis on continuous improvement.

From a systemic approach point of view, adaptation is the process of changing the parameters and structure of a system, in particular, the control effects, based on current information, with the aim of achieving a certain, usually optimal, state of the system at initial uncertainty in the operating conditions [11].

A system that can adapt to changes in internal and external conditions is considered adaptive.

The project team must adapt in a timely manner to changes in project stakeholders' requirements. In [12-14], an approach is proposed that allows monitoring and controlling the implementation of project stakeholders. The results of relevant research are a tool to support decisions on managing an adaptive team. Thus, the indicators of the method of the developed volume of requirements of project stakeholders were determined:

PR – the planned volume of requirements (in monetary form), which according to the plan must be completed at the time of the report on the volume of development;

ER – the actual volume of requirements (in monetary form) that is really executed at the time of the report on the mastered volume;

AC – the actual amount of resources (in monetary form) that is spent on the implementation of the project at the time of the report on the volume of development;

SR – deviations in the compliance schedule:

$$SR = ER - PR.$$

CR – deviations in meeting cost requirements:

$$CR = ER - AC.$$

SPIR – index of meeting the requirements of stakeholders according to the schedule:

$$SPIR = \frac{ER}{PR}.$$

CPIR – index of fulfillment of stakeholders ' requirements by cost:

$$CPIR = \frac{ER}{AC}.$$

Thus, there are several areas within which the project can be carried out at the time of the report on the completed volume:

- fulfillment of requirements is carried out in accordance with the plan by terms and budget. Ideal condition in which the variance in terms of time and cost is zero and the corresponding indices are in units;

- one of the planned indicators - either the budget or the deadline, is executed according to the plan, the corresponding deviation is zero, the index is one;

- the implementation of the project on both indicators (budget and timing) is not planned, but the deviation for one of them is positive, i.e. there is a budget saving or ahead of requirements.

- the implementation of the project on both indicators (budget and timing) is not planned, deviation for both - positive, i.e. there is a budget savings and ahead of requirements.

- the implementation of the project on both indicators (budget and timing) is not planned, deviation for both - negative, that is, there is an excess of budget and lag in the fulfillment of requirements.

There are two ways to forecast stakeholder compliance in the future. The first method is non-adaptive, though it allows you to change the original duration and cost estimates included in the baseline plans if new information indicates that the initial estimates are incorrect:

$$EAC(R) = \frac{BAC}{CPIR},$$

where EAC (R) - estimate requirements at completion, estimate of project budget completed on the basis of data known at the time of the report on the volume completed; BAC - the budget on completion, the cost of meeting all project requirements. The EAC (R), calculated at each time point, shows what the final cost of the project will be if the project stakeholders still continue to meet the same level of performance as before, i.e.,

$$EAC(R) = AC + residual\frac{PR}{CPIR}.$$

This is a pessimistic assessment; because it is based on the assumption that further implementation of the project (during the implementation of stakeholder requirements) will make mistakes that have already occurred in the part of the project that has already been implemented.

In a more optimistic (adaptive) approach, if it is assumed that from the date of the report on the completed project requirements the work of the team will be adjusted and the project will be implemented in accordance with the plan, the value of EAC (R) is calculated as the AC up to the current date (actual costs at the current date) that can no longer be modified, plus the amount of work that needs to be done based on the basic requirements plan. That is,

$$EAC(R) = AC + residualPR,$$

$$EAC(R) = AC + BAC - ER.$$

An even more optimistic view can be offered, which provides an opportunity to not only improve project compliance from now on, but also to offset budget overruns by the time the project is completed. Adjustments of this nature make sense to use in small projects.

Balance of value in adaptive project management

A more general approach to monitoring project stakeholder compliance may involve tracking not just the list of requirements but achieving some value for each stakeholder.

Thus, the EVM Scoped Method allows you to track the progress of a project in terms of completing its work on time and within budget; the ERM Requirements Method combines specific requirements with project work and enables monitoring of compliance with requirements, which in turn allows the project team to adapt to likely changes in stakeholder requirements. The transition to value monitoring provides an opportunity to take into account intangible requirements, which is especially important for managing a project team that has its own requirements, but the project clearly only includes a "technical" component that is directly related to the execution of project robots and is relevant, for example, to the required hardware, software, communications, etc.

The theoretical basis for such an approach (in determining value) may be, for example, the P2M standard (in terms of which a project is a mission-based value creation exercise within an agreed upon time frame and constraints in the form of resources and external circumstances) or the GPM Global P5 Sustainable Project Standard (which provides a list of design characteristics to evaluate in terms of sustainability, Figure 1). The latter standard has a unit for evaluating, in particular, project management policies regarding personnel practices, recruitment and staffing procedures, employee attitudes and well-being, which may be useful in this study.

The achievement of the project's planned value is tracked through a series of indicators:

PVal – the planned project value to be achieved at the time of the report;

EVal – the actual value of the project actually achieved at the time of the report;

SVal – deviation in the achievement of the scheduled value:

$$SVal = EVal - PVal\,.$$

SPIVal – the index of achievement values on schedule:

$$SPIVal = \frac{EVal}{PVal}\,.$$

If the value of the project as a whole (or for the individual stakeholder) can be determined in monetary terms, then the deviation and the value achievement index can be calculated.

It should be noted that for the effective work of the team the achieved team value should not be reduced during the execution of a specific project. In this case, the redistribution of values within the team can be modeled on the balance sheet.

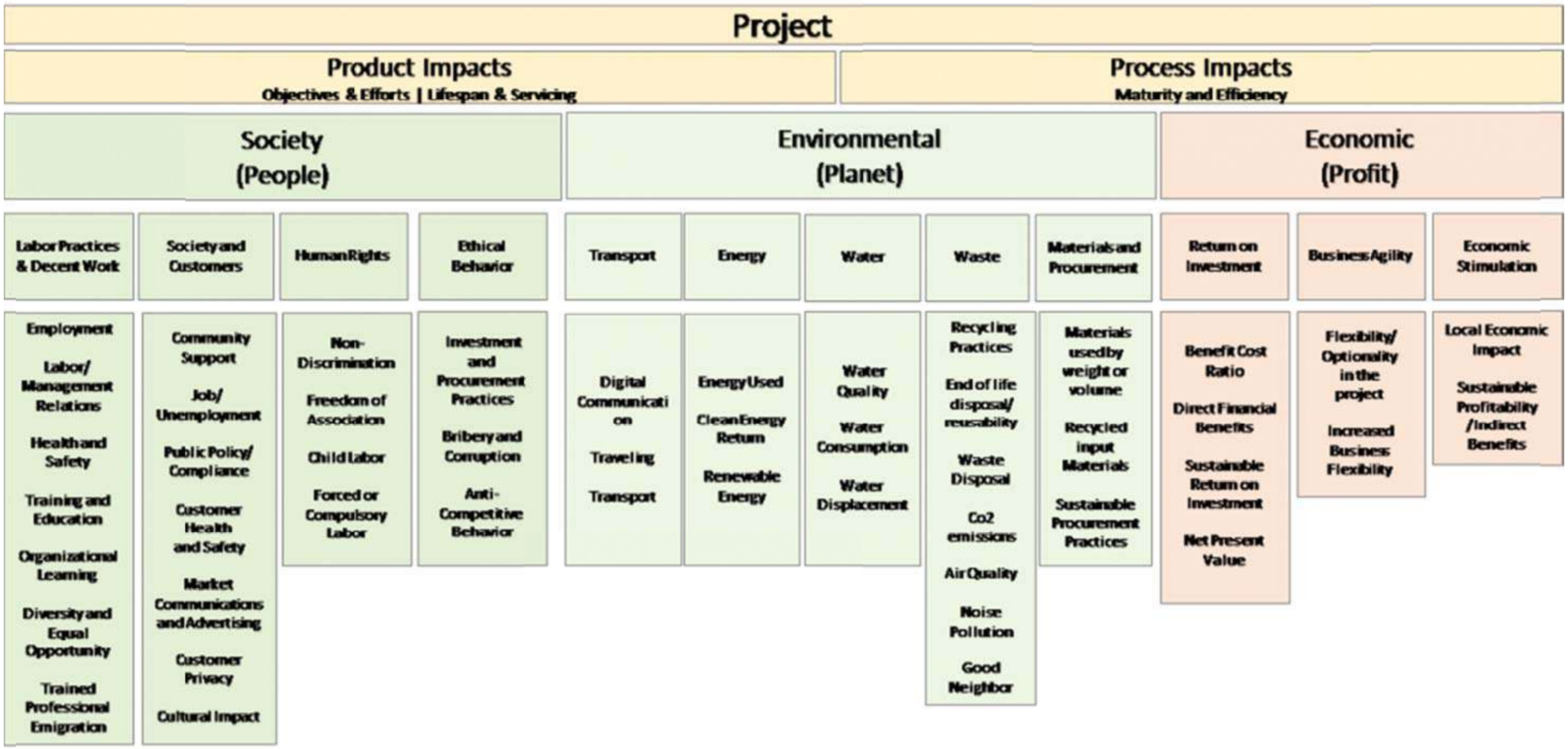

Fig. 1. Matrix GPM P5

The model of balance relations proceeds from [15-17] that the project stakeholders (in particular, the team) enter into relations with each other solely for the purpose of resource exchange. Relationships between objects can be of three types: asymmetric (in favor of the target element or to the detriment of the target element) and equivalent (Fig. 2, Table 1). An equivalent exchange is a state that the system seeks. It provides a balance of the system which, in the absence of external influences, is stable. In this case, asymmetry in favor of the target element can be considered as a positive phenomenon only in the short term. In the long run, the counterparty will seek to strike a balance or break the relationship.

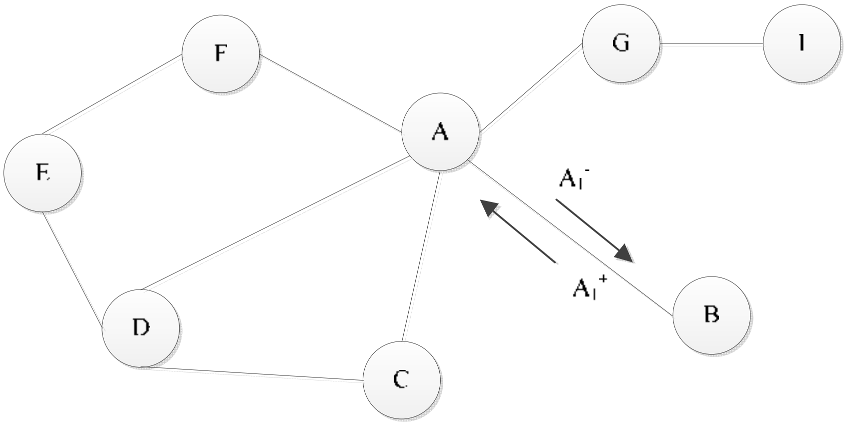

Fig. 2 – Balance sheet model of stakeholder relationships

Table 1 – Description of the stakeholder relationship system using the balance sheet model

Characteristics of the target element	Characteristics of the non-target element	Relationships description	Balance equation
The target element has a relationship with other elements	Non-target elements are unrelated (direct or through other elements)	The network is divided into separate subnets, which consist of two elements, one of which is the target.	$\sum\limits_i A_i^+ \geq \sum\limits_i A_i^-$
	Non-target elements have links with each other	There is a possibility of compensated imbalance, when unbalanced relations between some elements are compensated by unbalance with other elements	

The opposite is possible only when the resource estimates are different for different stakeholders. That is, the asymmetry in favor of the target element can be positive for its counterparty. The balance equation for bilateral relations is formulated as follows: $A^+ \geq A^-$

Therefore, the distribution of values within a team over the long term should be equivalent and taking into account individual estimates of resources different for different team members.

Conclusions

In order to maintain the competitiveness and investment attractiveness of projects and programs in the current economic environment of Ukraine, it is advisable to improve the methods of personnel management as a universal resource inherent in projects and programs in all sectors. It is important both to improve the known concepts, theories, methods and approaches, and to develop new methods to support change management decision-making when forming an adaptive project team.

It is advisable to carry out the corresponding developments with the combination of traditional project management means and "flexible" methodologies, which will allow implementing the advantages of both methodologies and methods of classical human resource management.

The instruments of decision support for project management in the conditions of adaptation to changes in requirements of project stakeholders are offered. Thus, the required method enables monitoring of the project stakeholders' requirements, which in turn allows the project team to adapt to the likely changes in stakeholder requirements. The transition to value monitoring provides an opportunity to take into account the intangible requirements of the project team and other stakeholders. To distribute values, the project team proposes to use a balance model with recommendations for adhering to an equivalent exchange.

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10. FEATURES OF STAKEHOLDER MANAGEMENT IN PROJECT ENVIRONMENT

Malanchiy S.O., Hutsa O.M., Kyriy V.V.

Abstract

The management of external and internal forces in the environment of projects is a pressing issue. It is well known that the best results are achieved by those projects and organizations that fully take into account the influence of stakeholders and competently build their relationships with all stakeholders, which creates value for all parties, not just for project owners. The systematization of the entire stakeholder management task is proposed, which is presented as a single process of sequential related actions, which allows the manager to see and control the whole process as a whole.

Introduction

To date, project management research and publications have placed particular emphasis on planning and management techniques whereby a manager can control timeframes, costs, resources and quality. The project environment, including stakeholders, remains to be explored so far and does not have the sufficiently clear and accepted management practices.

At the same time, experience shows that many of the problems associated with the implementation of the project lie in the field of the environment, and the success of the project manager in achieving his goals depends to a large extent on his communication skills. Therefore, the quality and ability of the project manager to communicate with people is much more important than his technical knowledge [1]. In any case, this is why he is forced to devote a large part (80 ÷ 90%) of his working time.

An actual task is to summarize, analyze and form an idea of the possible existing approaches to managing the project environment.

Analysis of recent research and publications

A review of foreign and domestic sources shows that the theory of stakeholders was actively discussed and developed not only by specialists in the field of management, but also by philosophers, lawyers and, what may be most interesting, by political scientists.

The founder of the theory of stakeholders is considered to be Robert Edward Freeman, who published in 1984 the work on strategic management, based on managing the stakeholders. Central to this approach is the notion of stakeholders, which over time was undergoing famous changes and clarifications. Scientific publications also use the terms stakeholders, interest groups, pressure groups, members of the coalition, but they are not completely identical in meaning to the term stakeholder. Stakeholder theory is a relatively young in a number of management theories, the first and still the most concise definition was proposed by Freeman in 1984: "Stakeholders are groups of people without whom the organization could cease to exist" [2]. Further this concept was somewhat expanded and fleshed out by Freeman: "a Stakeholder may be an individual or group support (providing) activities of the organization in the same way as does the holder of the shares" [3].

Subsequently, Freeman's ideas were expanded by other researchers with a focus on a number of special areas of management theory and economics. Further researchers proposed new definitions, focusing on the interest or influence of stakeholders on organizations. Thus, in 1996, Lockwood identified stakeholders as people "really interested in the results of the organization's activities," and the same year Ryan proposed his own interpretation of the term: "a person or group of people who can influence the organization or are affected by the organization". In the British manual (part of the BS6079 1996 standard) on project management, a more detailed definition is given: "Persons or groups of people who are vitally interested in the success of the organization (project) and the environment within which there is an organization (project)" [4].

Some experts believe that dominating the definition is ownership of a part of a company, while other researchers find it more important to indicate "power or influence". At the same time, in both cases, the central to determine the stakeholder is the existence of a relationship. Some researchers and practitioners claim that the stakeholders that have relationships, but do not bear the risks of the company, are not the owners of a part of the company. Some authors point out a desire to take on risk, expressing loyalty to the company or adding value, striving to participate in organizational benefits or gaining the right to vote in management decisions or management through representatives. Out of many definitions, the most recognized dichotomous view ultimately stood out: a stakeholder is any group or individual who can influence and is affected by the achievement of organizational goals. [5].

Most researchers of the concept of stakeholders believe that a special important stage in its development is associated with the appearance in 2002 of the book by Post J., Preston L., Sachs S. "Rethinking a corporation: stakeholder management and organization wealth" [6].

Many authors have noted that the classification of stakeholders is difficult because of the existence of significantly different narrow (legal) and broad (managerial) definitions. The legal aspect proceeds from the relations that are fixed in the contracts: the stakeholders have rights, and the firms have obligations and obligations; or stakeholders are those persons without which a firm cannot exist.

The managerial approach, based on theories of organization and sociology, is more pragmatic: it is based on aspects of the relationship between stakeholders and the company; however, this approach has ambiguity, since those whom the company can influence are not always able to influence it. This broad management approach leads to the need to pay attention to all stakeholders that are worth taking into account, to take care of them and respect them. The narrow legal approach leads to the selection as stakeholders of a much more limited group, which is associated with the company under consideration contractual relations, the intensity of which can be assessed. These approaches are not mutually exclusive: stakeholders who influence or which a given firm can influence can have a contractual relationship with it, and stakeholders who do not have a contractual relationship can also influence or influence the activity of the firm.

However, many authors point out that when using a narrow approach, competitors should be excluded from the composition of the stakeholders, although they should be integrated into the stakeholder system on the basis of a broad approach, as they can damage or provide benefits to the company, i.e. they should be considered in a strategic perspective. Managerial interpretations involve multiple relationships with wide variations in intensity and intensity of impact. However, this approach leads to a very significant increase in the number of stakeholders. Thanks to globalization and technological development with improved communication and information systems, virtually everyone is connected to everyone, and everyone influences everyone and is influenced in their activities.

Thus, like any young theory, the stakeholder theory is somewhat ambiguous, and many practical situations cannot be explained and predicted on its basis. One of the reasons for these difficulties is the ambiguity and variability in time of the identification of the stakeholder and its influence on the organization. Another reason is that today practically any company operating in developed markets is, in a certain sense, a stakeholder firm, i.e. each market entity is a stakeholder for others. In other words, determining the number, analysis and making informed decisions on all stakeholders in this situation become almost impossible.

At the same time, the need to manage relations with stakeholders objectively exists and is recognized. Resolving the problem requires the development of a holistic methodology, the basis of which is the definition and classification of stakeholders.

The conclusion is that the processes of managing relationships with interest groups and the mechanisms for evaluating the effectiveness of this management have not yet received a corresponding systemic development, either in theory or in practice. Such mechanisms would clearly indicate the role and contribution of each of the participants in the relationship and, accordingly, build effective communications, set specific tasks for management and monitor their implementation.

Aim of the study

The aim is to summarize and systematize the existing approaches to the definition and interaction of interested groups of persons in projects.

Description of the work results

To understand what environmental factors affect the project, the manager should consider the organization implementing the project as a subsystem operating within a larger system (environment) and interacting with other subsystems. To the environment refers (Dict.) - "a set of things, conditions and influences" [7]. Thus, the environment includes almost everything outside the scope of the project, including:

- factors of the internal environment:
- company owners, management, heads of functional departments, coordinators of other projects, temporary project personnel and personnel transferred on a permanent basis;
- as well as factors and actors in the external environment:
- state institutions and public organizations;
- legislation and regulations;
- politics, economy, ecology, security, culture, morality, religion;
- technologies;
- other project participants represented by the customer, suppliers, consumers, competitors, contractors, financial institutions, land owners, real estate, etc.

The main conclusion is that the project is connected with other subsystems or organizations in the environment surrounding the project. This creates a bilateral relationship of interdependence. That is, to achieve success, the manager should not be limited to the scope of the project as such. He must study and try to control, or appropriately adapt external forces, on which effectiveness and results depend. But the fact is that all these factors belong to the general environment of the project and lie outside the direct control of the project manager. The manager does not have traditional power over key figures and factors in the project environment. The only exceptions are permanent members of the team who are directly subordinate to him.

Power is built in the form of influence and means the ability to force someone to act in accordance with someone's wishes [7]. The basic rule concerning the distribution of power and influence is that “persons who are not subordinate directly to this manager have the right not to follow his instructions at all” [1]. In order to get the support of important (influential) people inside and outside the organization, the ability to build interpersonal relations is extremely important to the manager. In fact, managers have to become diplomats in order to achieve a certain influence and understanding in order to provide the necessary control over the environment and the effective completion of the project. The process of analyzing the project environment (see Fig. 1) begins with an examination of all the actors and factors that have or those that may affect the success of the project.

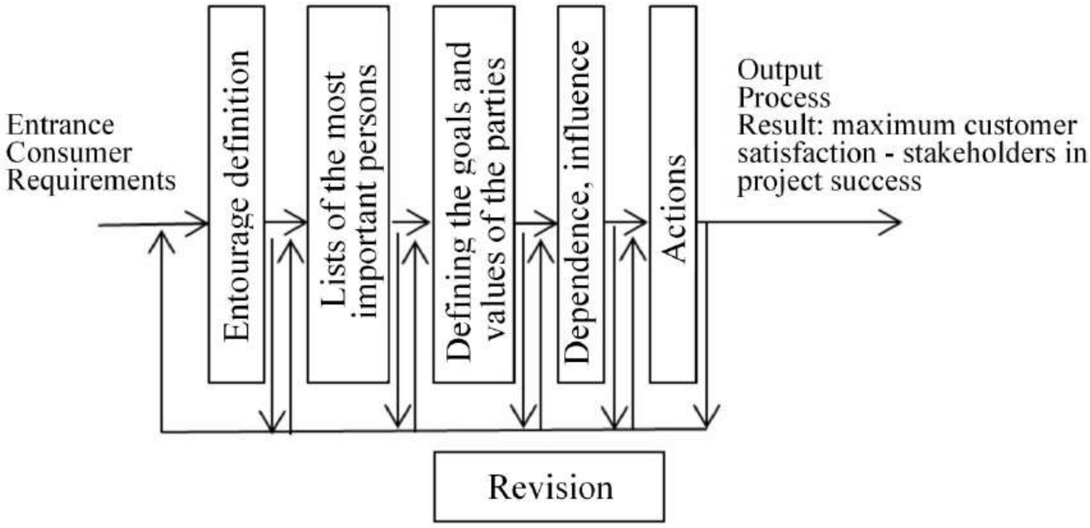

Fig. 1. The process of managing the project environment

The definition of the main actors is sometimes called the “mapping of persons” [7] who is interested in the project, i.e. identifying individuals or parties interested in a project’s success or failure.

Parties can be considered both in terms of possible assistance from them, and resistance to project implementation. After identifying the main driving and restraining forces, a “force field pattern” is built [8]. This can be done by conducting and discussing with the participants of the “working session” [7], which includes key members of the project team and already well-known important stakeholders from among the customer, key performers, and product developers.

To help members of the working group to “identify” stakeholders, you can use certain “categories” or “classifications” of standard types of stakeholders [8] and, knowing how these groups (categories) affect the content and progress of the project, more clearly outline their future roles.

The second step is to identify the most important actors; assessment of potential problems, the probability of their occurrence and the power of influence.

You can identify problems in the categories of "high degree of dependence", "high risk", "insufficient effect" [7]. After identifying problems, you can cross out the least important ones.

Juhani Silvasti suggested using the SSWO-analysis [9] to determine potential opportunities and dangers. As a result of the SSWO analysis, a list of strengths and weaknesses of each interested party is obtained, as well as a list of their capabilities and hazards for the project. The manager should concentrate on those opportunities and dangers that are most important for the successful implementation of the project. The degree of importance depends on how influential the stakeholder is in general and how strong it is in an area where there are opportunities or dangers. You can decide which features to use and which dangers to prevent.

The next step to define the goals and values of the stakeholders is to collect information about the most important stakeholders. In order to influence the key figures and factors in the project environment, the manager needs to understand the nature of the business (activity) of each group of participants and, accordingly, their possible interests in the project, the understanding of their incentives and behavior in different circumstances, the guidelines.

In order to come to an agreement on goals, norms, to build a comfortable level of mutual relations and mutual obligations, S. Bushuyev believes [1] that it is necessary to understand the goals and values of all stakeholders:

- What are their stated goals?
- What are their hidden goals?
- How are they organized?
- How do they coordinate their actions, carry out general management?
- What are their orienting values?

The answer to these questions allows us to understand how we can serve “their” orienting values, through whom personally, through what sequence of actions and what could be an alternative to these actions.

Another important direction of the manager’s thinking should be to consider the project from the point of view of the authority he has over external actors and factors. It is useful, according to Robert Youker [7], to divide power into three levels: control, influence and understanding. Control means the ability to give orders and expect these orders to be executed.

An influence means less power than control. Although the actions of an individual influence the achievement of the goal, the complete achievement of this goal also requires appropriate actions by other persons over which the project manager has no direct control.

An understanding means the absence of power or influence, but only implies knowledge or awareness of the potential impact (assessment) of the actor or factor. For example: a project manager can control his employee and exert a certain influence on the heads of other services (often acting through top management), but can only assess his dependence (degree) on representatives of various public institutions and organizations.

Opportunities for influencing and controlling the main environmental factors include both organizational forms and development strategies.

Organizational forms are:

- formal organizations;
- coordination groups (teams);
- communications managers;
- consulting centers.

Process changings include:

- management plans (relationships);
- reports;
- team building (involvement, expansion of the circle of stakeholders committed to the project).

To build organizational forms of communication, you need to have clear ideas:

- what stakeholders and what of their actions to control;
- forms, methods of their work, norms, procedures;
- forms of incoming and produced documents;
- form of communication to be maintained.

This information is the "key" to the further development of a formal organization that engages in interactions (its functions, roles, positions, competencies, areas of responsibility, instructions, forms and methods of work).

Interactions must be carefully planned. The development of an action plan - a plan for managing relationships and stakeholders, will require an answer to questions in relation to each group of persons [9]:

- How to use the capabilities of a stakeholder?
- How to prevent the dangers caused by the interested party?
- How are the project capabilities for the stakeholder taken into account?
- How are the project hazards for the stakeholder taken into account?

The plan determines what will be done, why and how, who will do it and when, and what will be received as a result of the event.

To manage stakeholders means to maintain communication and inform about the results achieved and plans for further actions so that they are convinced that the basic agreements are being implemented and that their interests are respected.

The indicators in the progress reports should be consistent with the views of stakeholders on how success will look from their point of view.

A formal presentation of the criteria for project success, taking into account the views of key stakeholders, can be the matrix for determining success [8]. It can be used as a separate document describing the content of the project. At this stage, we use the roles of stakeholders already defined in the process of analyzing the project environment to build a vertical matrix field. The horizontal field of the matrix contains the main success factors that stakeholders have identified as indicative for assessing the success of the project.

Next, for each of the success factors, we determine a specific meter (indicator) that can be used after the project is completed to determine whether this project was really successful and how much from the point of view of its stakeholders. This indicator can be monitored during the project and reflected in progress reports.

One of the roles of the diplomatic efforts of the project manager is to expand the circle of people who consider themselves members of the team. A well-established method of team building is to conduct a seminar on the start of the project. Involving all interested parties at the initial stage of planning allows taking into account their interests and how they will affect the anatomy of the project. It can be longer meetings with members of the working group, or both.

The project has a clearly defined goal (mission). The desire to ensure the achievement of the main goal of the project is also one of the important sources of power and obliges all participants to constructive work.

The obvious way to achieve influence is to establish personal relationships. The project manager needs to try to establish appropriate relationships in order to increase the degree of control and influence. What can a project manager do to increase influence or control? The key to success lies in understanding the goals and interests of the main actors and people interested in the project. Persons interested in the project act in accordance with their own interests.

The project manager will be able to increase his influence if he can understand their main interests and link them with the expected results of the project. One should skillfully appeal to the interests of actors, using the main sources of power over people: power through remuneration; power through coercion; the power of charisma; power of an expert (standard, example); legal authority (official, appointed).

But few managers understand that even for subordinates, the power in the organization is based more on spiritual leadership, rather than position and position [7]. Effectively acting managers know the sources of their power and use them to achieve the goals of the project, always occupying a leading position.

Conclusions

1) Many of the problems associated with the implementation of the project lie in the field of the environment, and the success of the project manager in achieving his goals depends to a large extent on his ability to communicate.

2) The project environment, including stakeholders, is still less studied and does not have enough clear and accepted management methods.

3) In order to understand what environmental factors influence the project, the manager should consider the organization implementing the project as a system operating within the framework of a larger system (environment) and interacting with other subsystems.

4) To achieve success, the manager should study and try to manage, or in a certain way adapt external forces, on which efficiency and result depend.

5) An important direction of the manager's thinking should be to consider the project from the point of view of the power that it has over external actors and factors.

6) The project manager will be able to increase his influence if he can understand their main interests and link them with the expected results of the project.

7) The management strategy for the main environmental factors includes both organizational forms and measures aimed at developing the process.

8) To build organizational forms of communication, the manager needs to have clear ideas: what stakeholders and what actions (functions) to monitor, and in what form to maintain communication. This information is key to the further development of a formal

organization that supports relationships: its functions, distribution of roles, competencies, and areas of responsibility, instructions, forms and methods of work.

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11. AUTOMATION OF PROCESSES IN SOCIO-ECONOMIC SYSTEMS BASED ON SITUATIONAL MANAGEMENT

Hutsa O.M., Yelchaninov D.B., Peresada O.V., Dovgopol N.V.

Annotation

Existing systems of situational management in socio-economic systems are based on mathematical models in which inaccuracies are at least based on computational errors and require human participation, which is not always possible. A model of situational process control systems based on qualitative methods has been developed. The model will allow, firstly, to automate processes in socio-economic systems, and secondly to create automatic process control systems. Moreover, the proposed model is devoid of the shortcomings of mathematical models and is close to the human way of expressing knowledge.

Introduction

Situational management, as a method of automation of management processes, based on psychological analysis and the study of operator's thinking, was proposed by Yu.I. Klykov [1] and D.A. Pospelov [2]. The method is based on the assumption that all the necessary information about managing an object that people managed poorly or not very poorly before creating a control system can be obtained from direct observation of their work or from their verbal explanations. Moreover, the object management model can be obtained on the basis of special processing of texts in natural language, which describes a fairly large experience of people [3].

The essence of the concept of situational management boils down to the following [4]: each type of specific situation should have its own control procedure (scenario) with its own criteria and decision-making methods. The situational control method is used when the complexity of the control object and the particularities of the problem being solved do not allow constructing a mathematical model and setting a traditional problem, as well as when control is carried out mainly in conditions of uncertainty and poor structure of the problem. In this case, it becomes necessary to use heuristic procedures and use high-quality information.

Actually, the situational management system (SMS) has all the signs and relates to intelligent control systems (ICS) [5]. ICSs use Intelligent control algorithms, which imply the rejection of the need to obtain an accurate mathematical model of an object, orientation to the use of "hard" (simple, usually linear) algorithms for generating control actions, and the desire to use synthesis methods known to the developer at any cost, previously positively recommended for other, simpler classes of objects. Moreover, the theory of intelligent control is still far from complete. Among other important open questions remain such as synthesis of control algorithms, coordination and planning of targeted behavior of ICS; testing (verification) of synthesized control algorithms in the face of possible changes in the external environment and control objectives. Obtaining answers, in particular to these questions, will give the key to formalizing the design procedure for highly efficient ICSs and, as a result, SMS.

The situational management method is one of the most relevant and promising methods that allow for a wide class of systems to solve the search problem (in the process of adaptation) of control system operation algorithms.

Analysis of recent research and publications

The relevance of the problem raised is confirmed by a sufficient number of publications.

So, in [6], the issue of constructing a situational management strategy, relevant for managing complex objects in uncertain environments, when the lack of a strategy is associated with the possibility of default of operational (reactive) decisions, is considered. A method is proposed for constructing a strategy in situational management systems, which opens up the possibility of implementing algorithms such as "situation – strategy – decision". But the construction of a strategy for transferring an object from the current situation to the target is carried out according to a mathematical model in the form of a situational network in which the degree of preference for a solution is determined by some objective, expert-defined function that has a quantitative expression.

In [7], a situational approach to the management of organizational and technical systems (OTS) was considered during the planning of operations (military operations). A variant of the functional model of the situational approach to the management of OTS is developed. To classify the signs of problem situations (technological relationships), the authors use the declarative knowledge of experts in the form of an oblique matrix, but then, when modeling problem situations, they use an efficiency criterion that has a quantitative expression. The proposed model, in essence, is automated only in the part of modeling problem situations - a description of the current situation prevailing at the control object is submitted to the OTS by the decision-maker (DM).

The review article [8] considers theoretical aspects related to the formation of effective management of the behavior of complex socio-economic objects in an unstable environment. It is noted that situational management of complex objects and fuzzy control algorithms, the organization of which is based on the application of accumulated experience and data obtained by interviewing highly qualified specialists in a given area, can most fully satisfy these requirements. The formation of decision support systems (DSS) on a situational basis and using fuzzy control algorithms is proposed as a promising form of management organization. The result of the work of such a DSS is a lot of output rules (products) for managers, providing various fuzzy (qualitatively expressed) values of the controlled parameters.

The article [9] talks about the differences in the application of Business process management (BPM) and Situational Process Management (SPM). BPM software is designed for the flow-oriented processes - there is a predefined sequence of actions that must be followed, and coordination of the flow of actions is as automated as possible. SPM is focused on supporting business activities, which are: maximally human; has high variability; easily structured; occurs in the face of frequent changes. Unlike structured processes, where applications (BPM software) can replace people, in the case of SPM, software can only increase the capabilities of people performing unstructured work.

In [10], it is stated that the general task of situational management of complex objects is decomposed into the following tasks: decision management when detecting or predicting a problem situation in the process of managing objects and planning management of objects based on the decision made. The scheme of solving these problems is presented: determining the target situation corresponding to the mode of functioning of the managed object in the form of a decision-making task; the choice of a way to achieve the target situation in the form of a task of the direct control of an object. However, it is proposed to use mathematical models of Mayer, Lagrange or Bolza from the classical control theory as a DSS.

There are a number of publications suggesting the use of SMSs in project management to change the approach "One Size fits all approach". So, for example, in [11] a context-dependent method for implementing BPM systems was proposed, consisting of implementation fragments that are based on critical success factors for implementing BPM and situational factors specific to the organization. Depending on the set of situational factors, the project manager decides on the use of one of the previously developed action scenarios for the implementation of the BPM system. And in [12] a method for situational project management (the original author's name is SitPM) is described, similar to the previous method, but intended for projects in the field of software development.

At the same time in [13] it is emphasized that despite the widespread of mathematical methods in the solution of management tasks, it cannot be assumed that formal methods of modern mathematics will be the universal means of solving all problems arising in this area.

Mathematical (quantitative) methods have several drawbacks related, on the one hand, with the necessity of high qualification of developers of such control systems, and on the other hand, errors induced by mathematical models, which have been used. In connection with the limited possibilities of application in management mathematical methods, lack in many cases of statistical and other information as well as reliable methods for the determination of conformity of mathematical models of real office objects, expert (qualitative) assessment is the only means of solving many tasks. The advantages of expert ratings include ease of use to predict almost any situation, including in the conditions of incomplete information.

A review of the publications suggests that:

– the vast majority of the proposed solutions is based on mathematical models (quantitative methods), with their inherent errors;

– such systems are automated only in terms of modeling the control object; decision-making or entering a description of the situation requires decision-making;

– the main source for creating object management models for SMSs is the knowledge of experts who use terminology in their subject area, i.e. overwhelmingly qualitative data.

Purpose of the study

To develop a model of an automated system for situational process control in socio-economic systems, which:

- is close to the human way of expressing knowledge;
- is based on expert knowledge in an arbitrary subject area;
- gives an unambiguous result;
- involves human participation only in the creation/modification of models;
- is easy to implement.

Description of the work results

In the general case [5], the structure of the control system consists of the following blocks (see Fig. 1):

– **the analyzer** carries out a preliminary analysis of the current situation taking into account earlier management decisions;

– **the classifier** checks whether the current situation belongs to one of the predefined classes;

– **the knowledge base** contains a description of the classes of situations;

– **the solver** selects the required control actions supplied to the control object;

– **the simulator** provides a forecast of the development of the situation several steps forward, using the model of the control object for this. The presence of this unit allows you to adjust control actions in time, without waiting for the object to get into dangerous situations.

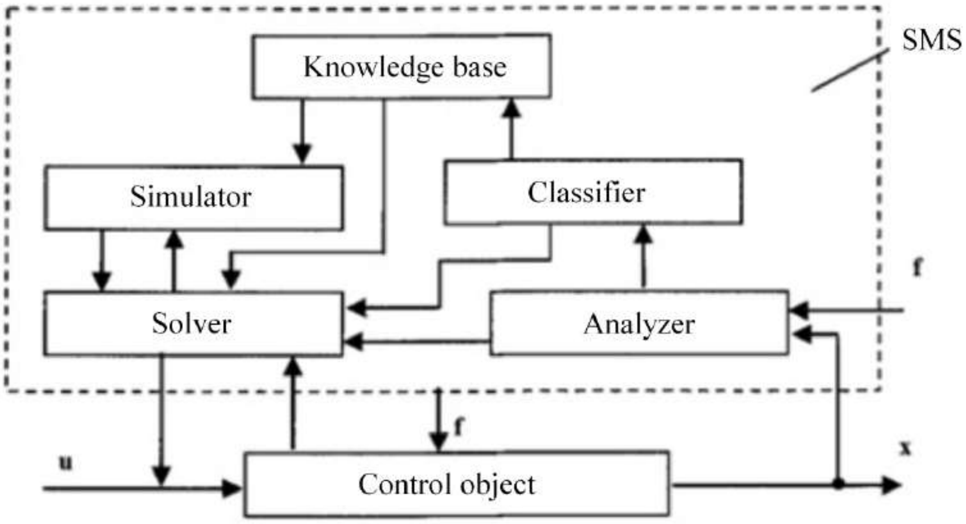

Fig. 1. The structure of a system of situational management:
u – management; **x** – current state of an object; **f** – external environment

Presented in fig. 1 structure (which can be called a structural model) reflects the current state of the SMS organization - the knowledge base is expert knowledge, the control object is described by a mathematical model, and the solver selects the required control actions in accordance with the values of the membership function set by experts within any scale.

In quantitative methods, an implicit assumption is made that a person once measures a certain quantitative parameter, and the obtained value is the only one reflecting the preference of the DM. However, studies by psychologists [14], as well as the practical experience of using these methods, allow one to doubt the correctness of this assumption.

As it is known, the DM is not an accurate measuring device that does not allow errors in quantitative measurements [15]. Psychophysics gives quantitative confirmation of a person's inaccuracy in measuring physical parameters (weight, length, and so on). As a result, the direct assignment of quantitative criteria weights is always carried out with errors [16]. The need to take errors into account in quantitative measurements is rightly pointed out in [17]. In psychological experiments [14], it was shown that human "heuristics and biases" lead to significant errors in the information received (for example, when quantifying events probabilities).

Therefore, the development of the proposed model is based on the use of quality information - expert knowledge obtained from experts in terms of their subject area.

The most complete process of self-organization of automation in support and support of the real-time decision-making process is reflected in the OODA cycle [18] - a model also known as the “Boyd's loop” developed in the USA by adapting the so-called five-membered Warsaw cyber cycle (codenamed “Red Star”) [19].

The OODA model has 4 processes in its structure: **O**bserve, **O**rient, **D**ecide, **A**ct and involves repeated repetition of the action loop: the feedback principle is implemented. With regard to process management, OODA is closely linked to the planning cycle. Observation is the result of monitoring the results, and orientation is the result of evaluating the results. The decision is the result of the planning process, and the action is the implementation of the decision.

At the same time, the most adequate model for constructing and improving the process is the so-called Schuhart improvement cycle [20], better known as the Deming cycle or PDCA cycle.

The OODA and PDCA models complement each other (see Fig. 2).

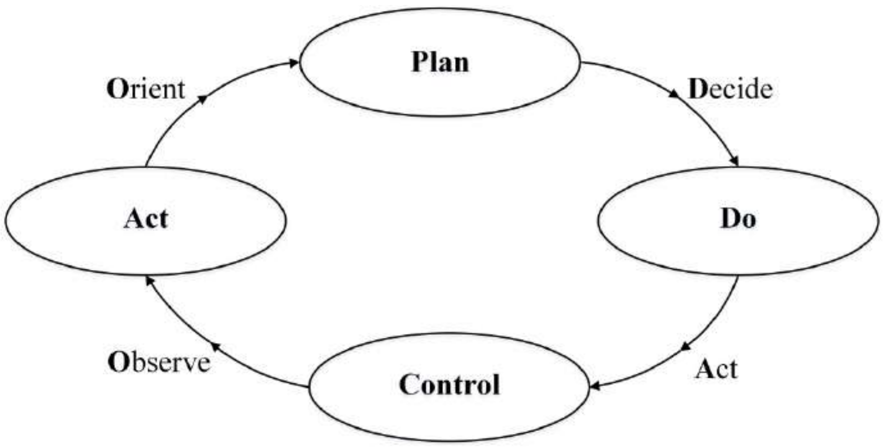

Fig. 2. Integration model OODA and PDCA

If we talk about expert knowledge, then they can be conditionally divided into two types [21]. One of them - facts, information, theories, problems, etc., is called **declarative knowledge** and is most often displayed in tabular form. They answer the question "What is this?" with their help, you can evaluate the results obtained in the course of any activity (process). Another type is the human ability to solve problems, compose music, treat patients, find faults in cars and devices, etc. called skill or **procedural knowledge**, displayed in the form of process diagrams. This knowledge answers the question "How to do this?" And with their help you can get the required results.

The interaction of expertise with the integrated OODA and PDCA model is shown in Fig. 3.

Let us consider in more detail the presentation forms and the content of expert knowledge most suitable for the requirements of the developed model.

Declarative knowledge in fig. 4 combined models are the knowledge base for DSS.

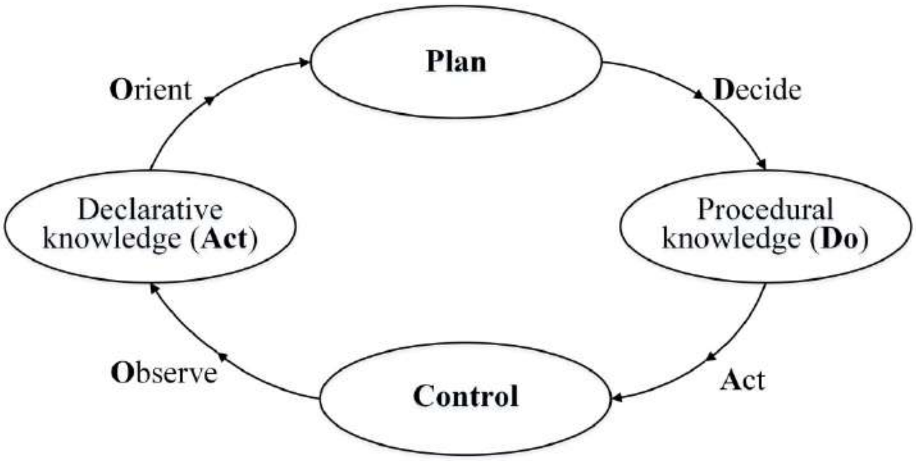

Fig. 3. Interaction expert knowledge and the integration model

It is possible to build such a DSS using the "ORCLASS" method (ordinary classification of alternatives) [15] from a set of verbal decision analysis methods developed under the guidance of academician O. Larichev The basic principles of verbal decision analysis (VDA) are formulated as follows:

– *use to describe the problem of definitions and wordings of estimates of decision options in the form that is natural for the DM, his advisers and active groups, without any conversion of such verbal formulations into quantitative meanings*;

– *building a decision rule based on logical, qualitative transformations of verbal variables, while observing the psychological and mathematical correctness of these transformations*.

The “ORCLASS” method is based on three concepts - an **alternative**, a **criterion** (and its values) and a **class** having the following semantic meaning:

– **alternatives** – data sets (research results). For the model under development, these are sets of process indicator values;

– **criteria -** a set of characteristics that distinguish alternatives from each other. For the model under development, this is a set of process indicators;

– **criteria values -** a set of all possible values of all criteria, while for each criterion they are ordered from best to worst. For the developed model, these are the values of the process indicators;

– **classes -** having their own unique characteristics, ordered (from best to worst) parts of the general list of all possible alternatives (for example, diagnoses, causes of malfunctions, rating or rating categories of something or someone, etc.).

The ORKLASS method allows:

– for any set of process indicators and their values, rank (sort by predefined classes) according to the principle “better - worse” any number of sets of process indicator values, i.e. build a **decision rule**;

– using the **decision rule** to unambiguously determine which of the classes belongs to any of the sets of values of process indicators received at the DSS input.

The decision rule is a table containing all possible alternatives, arranged in lexicographic order from the best (having the best values of all process indicators) to the worst (having the worst values of all process indicators) alternatives, each of which is assigned a class, to which it belongs.

Procedural knowledge of the combined model presented in fig. 4 is the knowledge base for the process executors and the software and hardware complex (SHC) necessary for the full implementation of the process control goals. Expert knowledge is displayed using one of the process modeling methods, namely BPMN (Business Process Model and Notation) [22]. BPMN is a specification of the language of graphic elements for displaying processes in modeling workflows occurring in the system under study. The resulting process model is a network of graphical objects that depict actions (tasks, subprocesses) associated with control flows.

Actually, the full specification of the language is difficult enough for non-specialists to understand and redundant to display most processes. Therefore, in the developed model, it is proposed to use the so-called DSL (Domain Specific language - object-oriented language), namely, a set of graphic elements of the language of visual modeling of regulations (LVMR) [23]. This language is developed on the basis of BPMN and currently contains only 14 graphic elements (of which 2 are most often used), corresponding to BPMN elements, but having either more limited or modified functionality, which is determined by the specifics of the display of process regulations. The minimum set of elements and their specific properties allow LVMR:

– to be a formal **metamodel** of knowledge representation about process regulations in any subject area in the form of logic circuits;

– automatically check received circuits not only for syntax but also for semantics;

LVMR, as well as BPMN, is intuitive - as practice shows, the experts with whom we had to work almost immediately begin to "read the diagram" despite the age and degree of technical education.

Analyzing the structure and content of the described forms of knowledge representation, we can draw the following conclusions:

– declarative knowledge with the implementation mechanism represents the level of decision-making - the choice of strategy, including monitoring (*Observe*) and evaluation of process indicators, as well as the choice of a process execution scheme corresponding to the current set of process indicators (*Orient*);

– procedural knowledge is an action plan in the form of a process diagram (*Act*), including the adoption of operative (tactical) decisions "stitched" in a diagram in situations corresponding to the current set of process indicators (*Decide*).

The separation of the stages of the combined model by management levels is shown in Fig. 4.

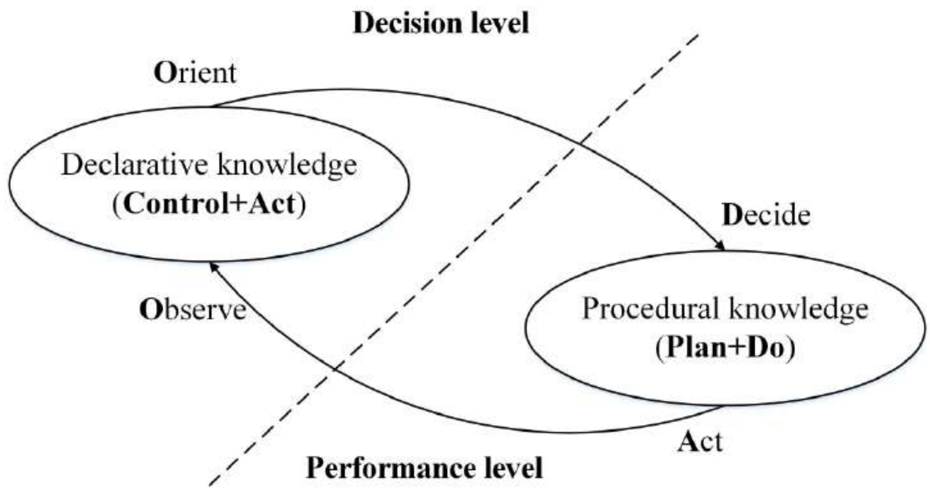

Fig. 4. Separation of stages of the integration model by the level of management

Presented in fig. 5, the model determines the structure of an automated control system based on qualitative methods, including the following elements (see Fig. 5):

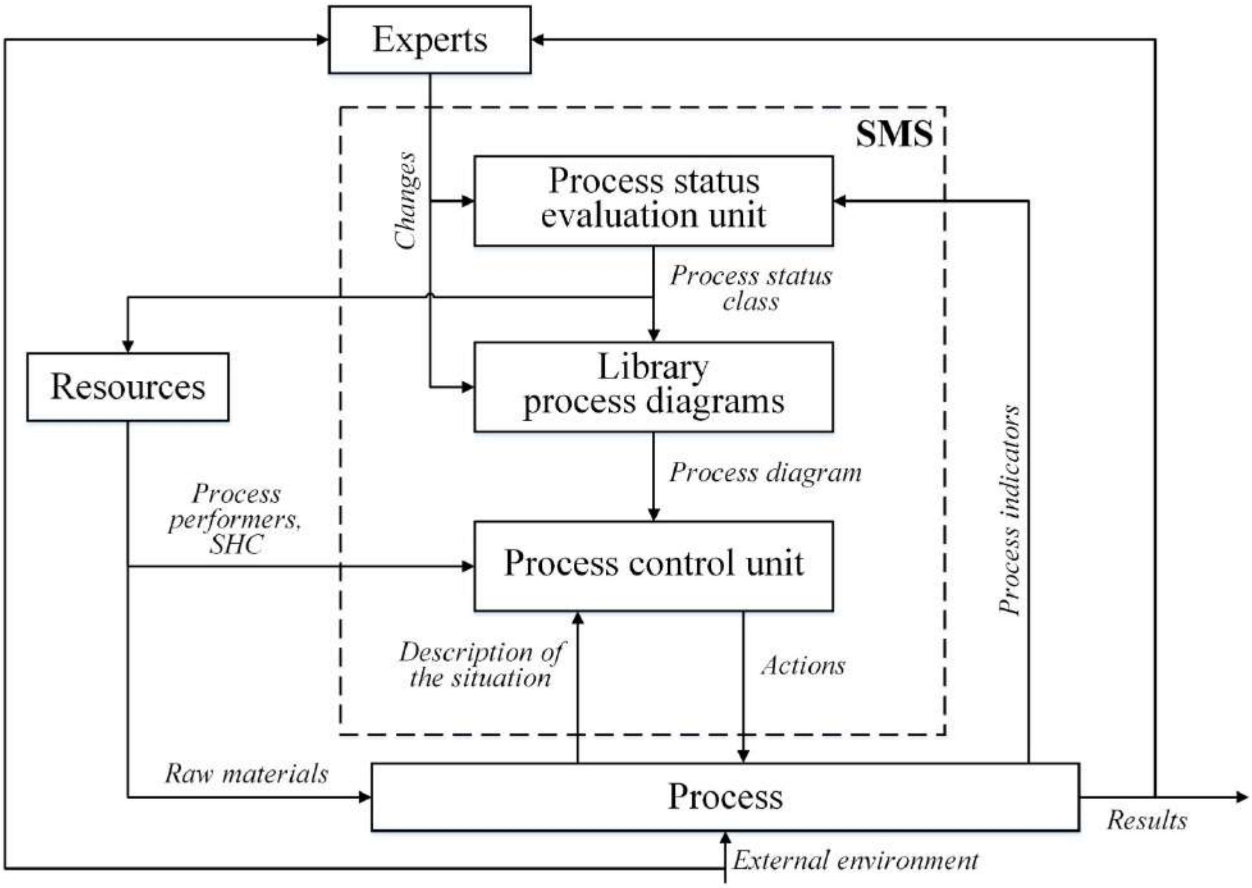

Fig. 5. The Structure of an automated system of situational management based on qualitative methods

– **Process status evaluation unit -** DSS, which determines to which class the set of values of the process indicators received at the input belongs. DSS is built on the basis of a decision rule developed using the ORKLASS method of verbal analysis;

– **Library process diagrams -** process diagrams containing descriptions of actions in situations and related to classes that are defined in DSS. Schemes developed by LVMR;

– **Process control unit -** executors of the process and SHC, operating in accordance with the selected process scheme;

– **Experts -** make changes to the decision rule and process schemes in case of deviation of the process result from the expected ones or to compensate for the environmental impact;

– **Resources -** a set of resources (process executors, SHC, raw materials and components) supplied to the inputs of the process control unit and the process depending on the class to which the current set of process indicator values belongs.

Conclusions

A model of an automated system for situational process control in socio-economic systems has been developed, which has the following features:

– based on expert knowledge in an arbitrary subject area, expressed in a qualitative way;

– produces an unambiguous (not approximate/rounded) result;

– involves the participation of an expert only in creating/modifying models;

– includes resource management (which is not found in any of the existing models);

– allows you to create both automated and automatic management systems;

After creating the appropriate software, it is possible to make the similar systems by users who do not have programming and knowledge management skills.

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12. FORMALIZATION OF DEVELOPMENT PROCESSES AT CHANGES IN BUSINESS - MODELS OF THE COMPANY

Danshyna S. Yu.

The development management process aims to change the existing processes of the company's business model. The rules for their transformation are determined by the development procedure. The paper proposes a formalized presentation of the company's development process. It is based on a descriptive multi-level model of interaction between approaches and uses the IDEF 0 methodology. Its advantage is the ability to combine verbal and graphic modeling. To verify the model, we analyzed the results of the implementation of some development projects in the UC “Gorelektrotransservis”, Kharkov. The verification results confirmed the possibility of its application for solving problems of managing the development procedure through projects.

Introduction

The competitiveness of companies depends on the ability to respond and adapt to changes in the external environment. At the same time, growing competition, the changing demand of consumers requiring more complex products, the rapid change in the environment in which companies operate, require the introduction of innovative business models [1], [2]. According to a survey conducted by the Economist Intelligence Unit, more than 4 thousand executives and top managers of companies believe that "... companies should respond more quickly to environmental changes by introducing business models that are relevant to these changes," while "... business models should regularly reviewed (more often than products and services provided by the company)” [1].

Currently, in the managerial environment, changes in the business model affect not only the issues of improving classical (functional) management, but also actively apply the principles of project management. The positive global experience shows that most of the various tasks, regardless of complexity and scale, can be successfully solved through projects [3]. Therefore, the project orientation of solving problems and development issues, aimed at optimizing individual elements of the business model of companies, as well as for the implementation of individual projects, has become widespread in the world [3], [4].

The complexity of projects is constantly growing, requiring innovative changes in the management structure from managers that can affect finances, competitiveness, profitability and efficiency [3], [5]. Moreover, an analysis of publications shows that significant advantages can be achieved by introducing an integrated project management methodology as the main condition for the success of the process of implementation of changes and development [2], [3], [5], [6].

Multilevel model of interaction of approaches as a tool for formalization of company development processes

A specific feature of innovation processes are changes – the transition to a qualitatively new level of development of the organization, allowing to expand the understanding of competitive advantages and rethink the potential of individual employees and divisions of the company to reach a new position on the market of products/services, greatly enriching the corporate culture and philosophy. Variability has become one of the main factors of competitiveness of companies; in order to achieve desired goals and effects, every change must be managed. This control requires the processing of large volume of information leads to the need of systematization and formalization of the process [2], [7], [8]. This model will be part of the process control system modifications.

Any company, being an open system, combines two target settings - the desire to survive and the desire to develop. Therefore, one of the goals of the change process is development [9], which can be defined by the following transformation:

$$f : P_1 \to P_2, \quad (1)$$

where P_1 – processes of an existing business model; P_2 – processes of the changed business model of the company, and the display rules are determined by the company's development procedure.

To formalize the company's development procedure, we will use a descriptive multilevel model for the interaction of approaches (the “nested doll” model) proposed in [10] for solving goal-achievement tasks in project management (Fig. 1).

Analysis of development mechanisms is based on a systematic approach to the study of the current business model (developing object) in order to find objective criteria that allow a quantitative study of development processes based on a balanced scorecard. As a result, the most complete, systematic view of the modeling area is formed, the boundaries and relationships of the modeling object with the environment are determined [9], [10].

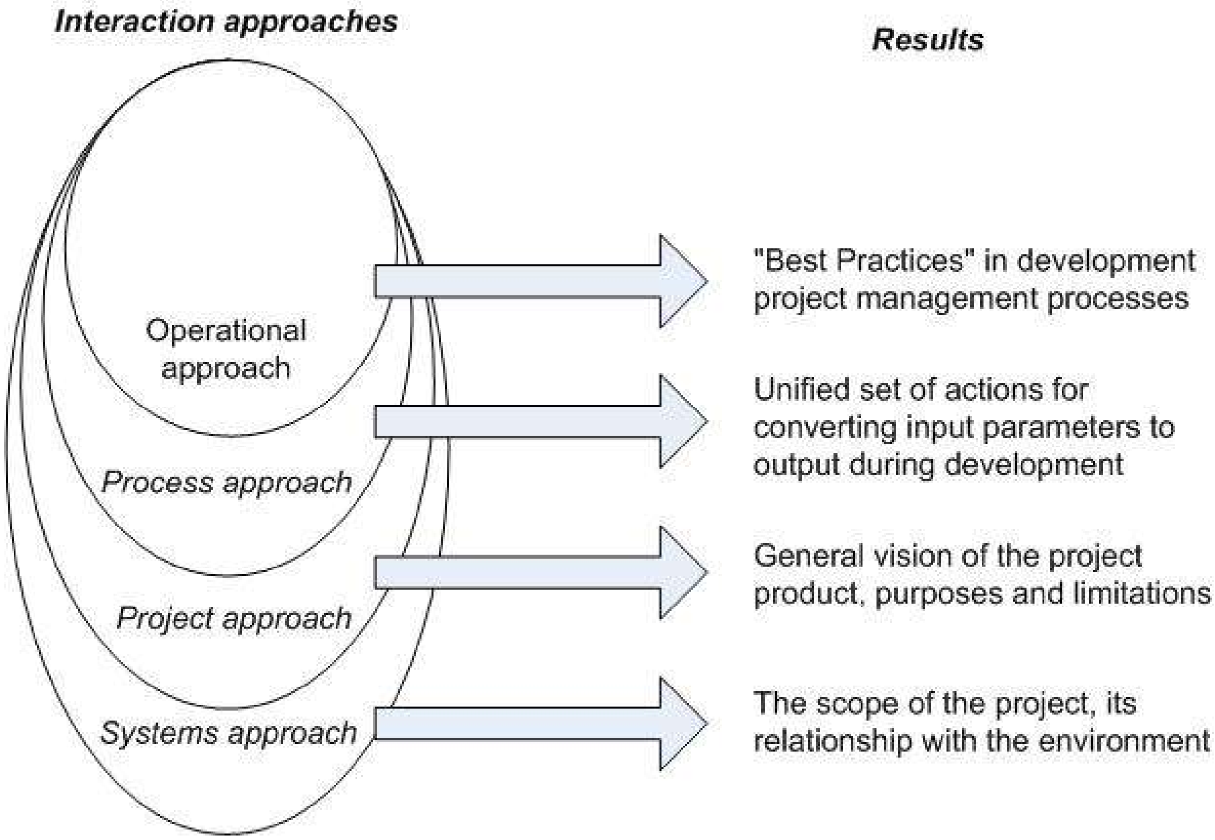


Fig. 1. A multi-level model of interaction of approaches for formalizing the company's development procedure

The general idea of developing a company in accordance with a systematic approach can be presented in the form of a context diagram indicating ICOM codes, obtained using the IDEF 0 methodology, which defines the syntax and semantics of the modeling language and presents the modeling results in graphical form (Fig. 2).

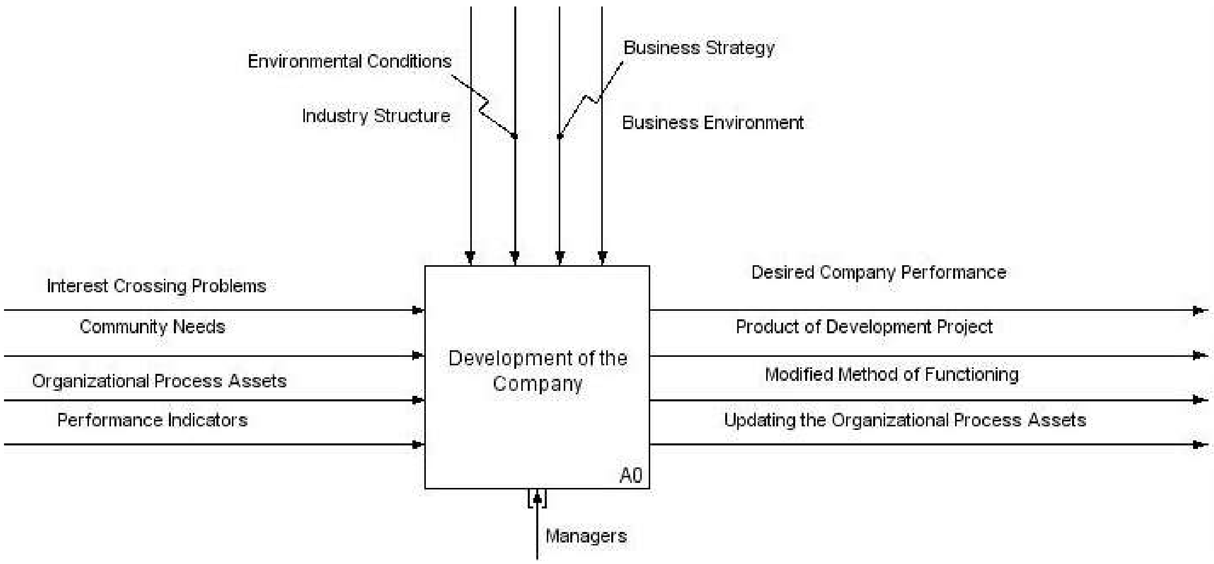


Fig. 2. The context diagram obtained as a result of applying a systematic approach to formalizing the company's development process

To obtain a relevant description, the development procedure is considered from the perspective of the project approach. The essence of the processes occurring in the external environment of the company is analyzed, those innovations are selected that will reduce the entire variety of external and internal influences to a single line of development, increasing (maintaining) the effectiveness of the activity. The choice of management tools takes into account the uniqueness of development projects and ensuring the achievement of goals in a given system of criteria [9], [10].

The process approach allows you to select and implement a specific development project by carrying out regulated and unified actions [2], while the operational approach allows the integration of project results into the company's operations and the transfer of “the best practices” to various development project management processes [10].

Summarizing the abovementioned, the company development procedure (expression (1)) based on a multi-level model of interaction of approaches can be represented as a functional model of project-oriented development management (Fig. 3).

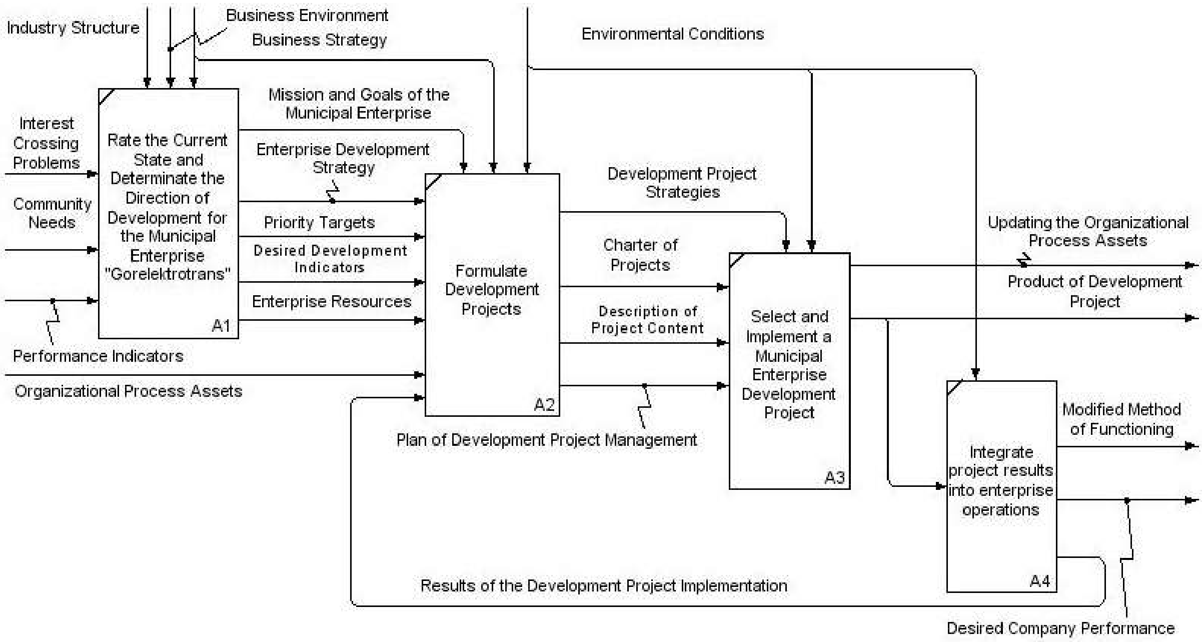


Fig. 3. The functional model of the project-oriented management that defines the procedure for the development of the company

Thus, we obtain a formalized representation of the company’s development procedure for implementing the mapping rules in transformation (1), which, unlike the descriptive multi-level model of interaction of approaches, based on the IDEF 0 methodology, determines the functions and information flows during development, which increases the ease and simplicity of perceiving connections between the analyzed data.

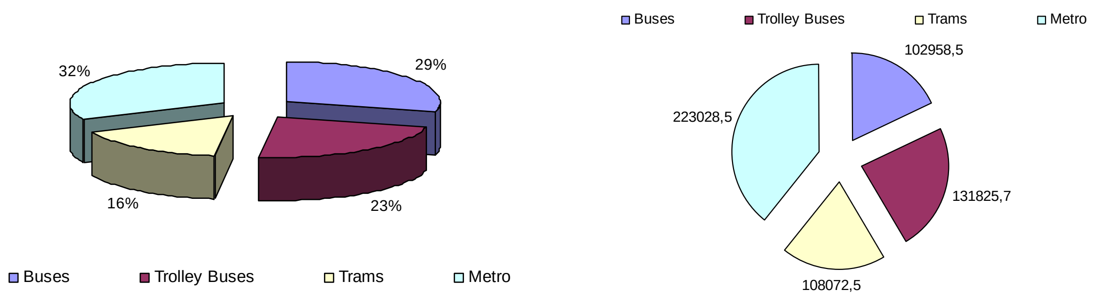
Verification of the functional model of the project-oriented management of the company's development

As it is known, a sufficient condition for model verification is the coincidence of the research results with known facts [11].

To verify the functional model of project-oriented management, we will consider how directions are selected and development projects are implemented in the UC “Gorelektrotransservis”, Kharkov.

At the initial stage, the choice of development directions is based on a systematic analysis of the input data (input arrows of the context diagram (Fig. 2)). These data include:

1. The efficiency of the UC, characterized by passenger turnover (in total for urban electric transport), the value of which in 2018 reached 71% of the total passenger turnover, and the number of passengers carried (in thousand), the number of which over the same period amounted to 462926.7 (Fig. 4).



а) б)

Fig. 4. Urban passenger traffic performance indicators
(according to the website kh.ukrstat.gov.ua): a - passenger traffic of urban transport;
b - the number of passengers carried, thousands.

2. The problem of overlapping interests is related to competition with road transport (buses in the fixed-route taxi mode) in the transportation market, whose passenger turnover in 2018 amounted to 29% of the total urban passenger turnover, as well as the presence of a large number of personal vehicles.

3. The needs of society are aimed at increasing the mobility of the population by ensuring quality transportation, improving communication between the districts of Kharkov, as well as expanding access to transport services for people with disabilities and other low-mobility groups.

4. The assets of the organizational process are determined by the existing infrastructure of urban electric transport and the current standards and norms for the transportation of population.

Moreover, the choice of development directions is regulated (upper arrows of the context diagram (Fig. 2)):

1. The UC business strategy, which is formed in accordance with the National Transport Strategy of Ukraine for the period until 2030 (Decree of the Cabinet of Ministers of Ukraine of 05.30.2018 No. 430-r), which defines the priorities for the comprehensive formation of the transport policy, the main directions of development of the transport sector and stimulating introduction of the most environmentally friendly modes of transport.

2. The existing structure of urban electric transport, consisting of 3 metro lines, 23 trolleybuses and 13 tram routes (Fig. 5).

3. Business environment, consisting of a network of 150 city public bus routes (Fig. 5).

4. Environmental conditions that depend on the political and economic situation, geographical location, etc.

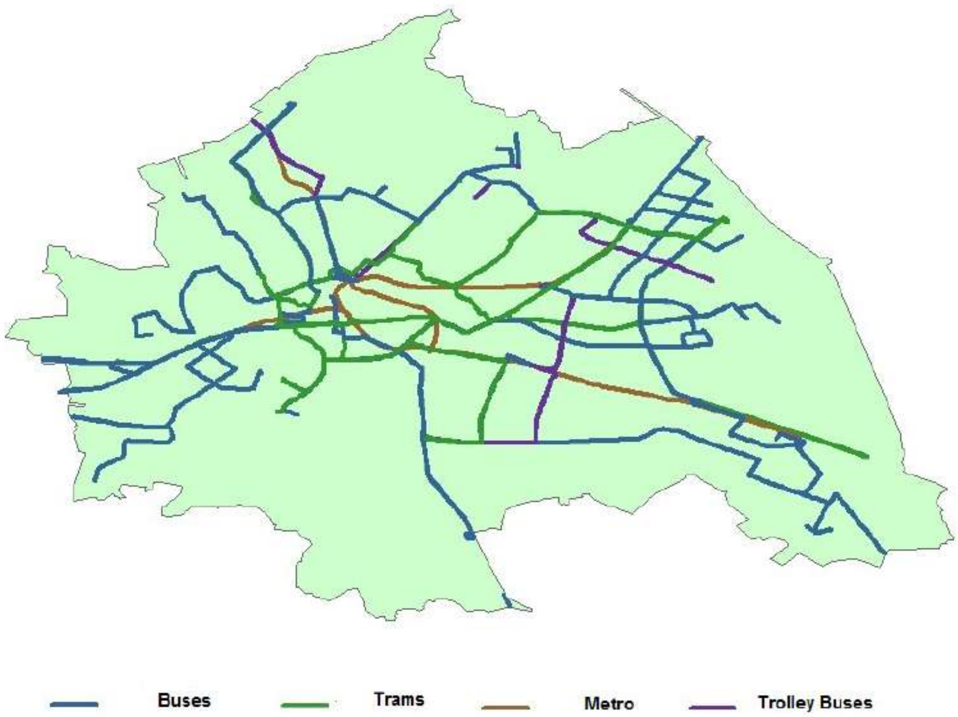


Fig. 5. Geoinformation model of the structure of urban transport in Kharkov (according to 2GIS service)*

As a result, at the stage of assessing the current state of the UC and determining its main directions of development on the basis of a systematic approach, the mission of the enterprise was formed: "Ensuring the harmonious development of the city and its regions through the development of an environmentally friendly transport system." The mission

*Analysis of the model shows that about 10% of the existing routes of city electric transport completely duplicate the routes of city buses, and about 6% of the routes coincide with bus routes by 50%.

allows you to define an enterprise development strategy aimed at improving passenger services while reducing the financial burden on the city budget, and formulate priority goals of the business model that affect:

- UC position in the transportation market (the goal is to increase market share);
- innovations (the goal is to apply new technologies in the transportation process);
- production (the goal is to improve the quality of transportation);
- marketing (the goal is to improve passenger service);
- personnel management (the goal is to preserve jobs with an acceptable level of remuneration, improve working conditions and motivation);
- finance (the goal is to maintain and maintain financial resources at the required level and ensure their rational use), etc.

As world experience shows, the implementation of strategies, regardless of their complexity and scale, is more effective through projects [6]. Therefore, the project orientation of solving problems and development issues has become widespread in Kharkov. To date, UC "Gorelektrotransservis" selected and implemented a number of development projects. he main characteristics of some of them are presented in Table 1.

Table 1 - Generalized features of the development projects of UC "Gorelectrotranssservice" (based on analysis of site publications https://www.city.kharkov.ua)

Development Project Direction	Solved problem	Project Results (to date)
Improving the efficiency of transportation management	Non-compliance with the schedule of urban passenger transport, long waiting time for vehicles and, as a result, transfer of passengers to taxis due to the presence of duplicate routes (Fig. 4)	*Desired performance indicators:* - improvement of passenger service due to compliance with the schedule and speed; - adjusted passenger flow; - prompt response to an emergency, etc. *Project Product:* - Dispatch system based on GPS navigation. *Modified way of functioning:* - reduction in the interval of traffic by 10%.

Fin. Table 1

Development Project Direction	Solved problem	Project Results
		Organizational process asset renewal: - priority on compliance with traffic schedules.
Improving the route network based on the existing electric transport system	Imperfect existing route network (Fig. 6) and low operational properties of transport infrastructure facilities	*Desired performance indicators:* - increase in passenger traffic through the use of new trolleybuses of increased capacity; - involving people with disabilities in the passenger flow. *Project Product:* - updated trolleybus fleet; - an equipped, updated network of stops for electric vehicles. *Modified way of functioning:* - routes agreed upon with applicable standards. *Organizational process asset renewal:* - compliance with the standards B.2.3-218-550: 2010.
Development of an existing route network	Low reach due to the lack of urban transport routes between separate areas of the city of Kharkov (Fig. 6).	*Desired performance indicators:* - increase in annual passenger traffic by 25 thousand people; - Improved passenger service by reducing access to the metro. *Project Product:* - two metro stations extending the Alekseevskaya line; - trolleybus line connecting the metro station "Heroiv Truda" and st. N. Uzhviy. *Modified way of functioning:* - New routes for electric vehicles.

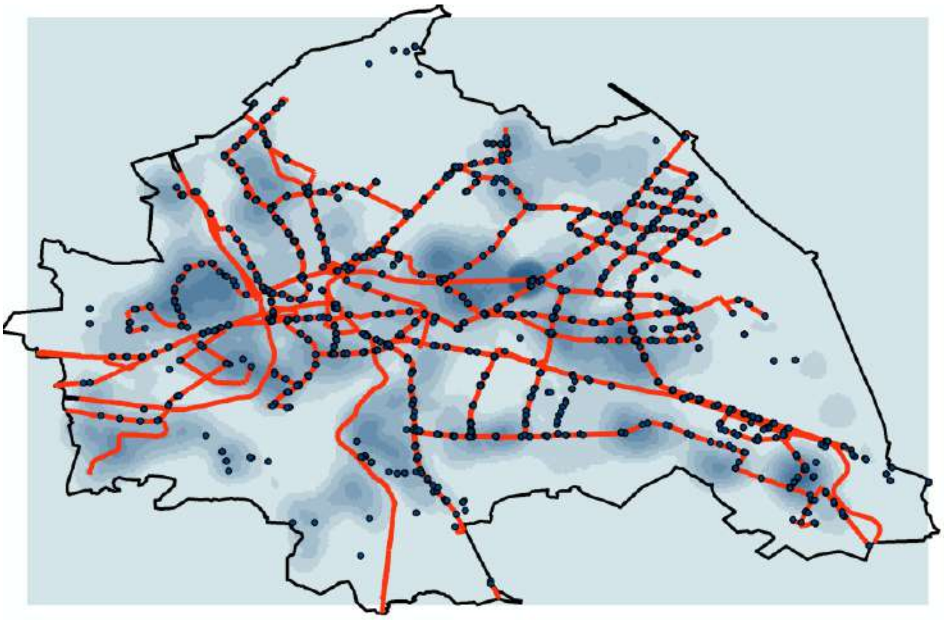


Fig. 6. A model of urban transport routes indicating the existing (according to the Department of Infrastructure) and necessary stops on the density map of urban development in Kharkov *

In the future, the results of projects are successfully implemented in the operational activities of the UC, contributing to the achievement of strategic development goals by structuring information, increasing the accuracy of analysis and, as a result, reducing time for planning and organization.

Conclusion

The determining factor for a company's success is its ability to respond to environmental changes, coordinating with them its desire to survive or the desire for development. At the same time, the global trends confirm that the tasks associated with the development of companies can be successfully solved through projects.

The development management process is aimed at changing the existing processes of the company's business model, and the rules for their transformation are determined by the development procedure, which requires generalization and formalization.

The paper proposed a formalized representation of the procedure for the development of the company, which is based on multilevel descriptive model of interaction approaches. To improve efficiency and productivity through the use of standard models focused on application in specific subject areas, use the IDEF 0 methodology. Its advantage is the ability to combine verbal and graphic simulation, which increases the ease and simplicity of perception of the linkages between the analyzed data. To verify the model, we analyzed the results of the implementation of some development projects in UC "Gorelectrotrans", city of

* The points on the model show the existing and necessary stops, the location of which is calculated according to B.2.3-218-550: 2010 “Bus stops” taking into account the city’s building density.

Kharkov. The verification results confirmed the possibility of its application for solving problems of management procedure development through projects.

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13. ELECTRICITY POWER CONSUMPTION MANAGEMENT IN HYBRID POWER GRID WITH RENEWABLE ENERGY SOURCES

Shendryk S.O., Tymchuk S.O., Shendryk V.V., Telizhenko O. M.

In this paper is considering a power consumption forecasting problem as a part of decision making process at choosing energy system optimum mode in uncertainty conditions. The power consumption models, which forecasting both for a long period of time and short term are proposed. Our study focused on the selection of the most appropriate power consumption forecasting methods in distributed hybrid power grids. The model can be used as the tool for making decision at the stage of the hybrid power grid operational management.

Introduction. The innovative development of modern world energetics is characterized by increased demands for efficient use of available energy resources. Today energetics has a tendency to develop in two directions: in the direction of increase the efficiency and reliability of renewable energy sources, and in the direction of energy saving. All this requires a restructuring of the electricity generation infrastructure, storage, distribution and electricity power consumption.

Therefore, economically and environmentally feasible is the introduction of distributed energy generation from diverse renewable energy sources [1, 2]. This approach to energy production has several advantages. The using of hybrid grids with renewable energy sources (RES) allows to reduce electricity losses during electricity transmission, to produce energy for their own needs and send the surplus into a common network [3]. To generating can be used the local renewable energy sources whose potential has a sufficient level in all regions of Ukraine [4]. Distributed energy production is also characterized by low environmental pollution. The combination of different energy sources provides stability as the advantages of each type of renewable energy complement each other.

A number of organizationally issues and hybrid grid management issues should also be considered. As changing weather conditions, seasons, network capacity, electricity consumption, etc. are significantly affected on renewable energy sources, to optimal management of the hybrid grid on their core, it is necessary to process a huge amount of information in real-time, especially to predicting the generation rate and electricity consumption rate. Traditional deterministic approaches cannot be used in modeling, forecasting, decision-making on hybrid grid management.

Literature Review. Problems of electricity consumption estimation on the basis of intelligent systems are studied in [5]. In particular, the dependence of energy consumption on socio-economic factors is substantiated, approaches to decision-making regarding the planning of the energy enterprise development strategy are proposed, as well as for the creation of a national energy policy. In [6], the necessary and sufficient conditions for the application of models for predicting electricity consumption, namely SVR, η-SVR and ε-SVR models, are studied.

Complex ecological and economic problems of forecasting energy consumption and greenhouse gas emissions during its production are studied in [7]. The author substantiates the using of ARIMA models. It is proved that the using of such models will improve the accuracy of forecasting indicators to achieve best environmental quality management practices.

Scientific works [8, 9] are devoted to the energy consumption forecasting modeling for planning and energy optimization of buildings and campuses. The benefits for households and operators of power grids from forecasting electricity consumption in homes was proved.

In [10] describes the possibility of constructing power consumption models using databases of existing information systems. However, the paper does not propose a system that takes into account the multifactorial influence on current electricity consumption and its forecasting.

Domestic scientists are actively using fuzzy models and neural networks in predicting financial, economic, technological and other processes [11]. Further development of the methodology for managing the modes of power consumption of industrial facilities is devoted to work [12, 13]. The methods of short-term forecasting and operational control of power modes are substantiated in [12]. In [13], an analysis of the existing system of alignment of the schedule of electric load of industrial enterprises was carried out.

The basic principles of the theory of modeling systems at efficiency management and electricity forecasting use by consumers should be based on regularities of internal (technical, economic, structural, regime) and external (meteorological, ecological, fuel and energy, macroeconomic) factors that characterize the system «generation – climatic conditions – energy consumption” [14]. The dynamics of these factors are characterized by poor predictability. However, despite their poor predictability, there is an interconnection (co-integration) that leads to some common, interconnected change [15].

Decision-making process. The decision-making problem when managing a hybrid grid can be described in formal as a tuple

$$TDM = \langle A, E, S, T \rangle,$$

where A – a set of available alternatives to power grid conditions, E – the task environment, S – advantages of the person who makes decisions (PMD), T – actions over a set of alternatives.

System advantages of a PMD is determined by technical and economic indicators of each process in the hybrid grids operation. Based on these feasibility indicators, it is possible to define optimization criteria for each phase of the alternative states of the hybrid power grid.

The decision-making process at the stage of effective management of the generation is affected by information about weather conditions and the current technical condition of the energy source. The decision-making process at the stage of ensuring effective management of electricity use is affected by information about the current technical condition of the power source, the current technical condition of the power banks, and the current level of consumption.

In fact, the main selection criteria of alternative modes of operation of the hybrid grid are: the quality and quantity of electricity from renewable sources, reliability of power supply, the maximum profit [16]. Each of these criteria has its own weight depending on the preferences of the PMD, and also changes your weight depending on changes in the situation. The set formation of alternatives available states of the hybrid grid may be performed using information about its current state and forecasts of generation and consumption. Using a large amount of data necessary to provide PMD information system (DSS), this helped to shape the decision. The main functions of this system are shown in Figure 1.

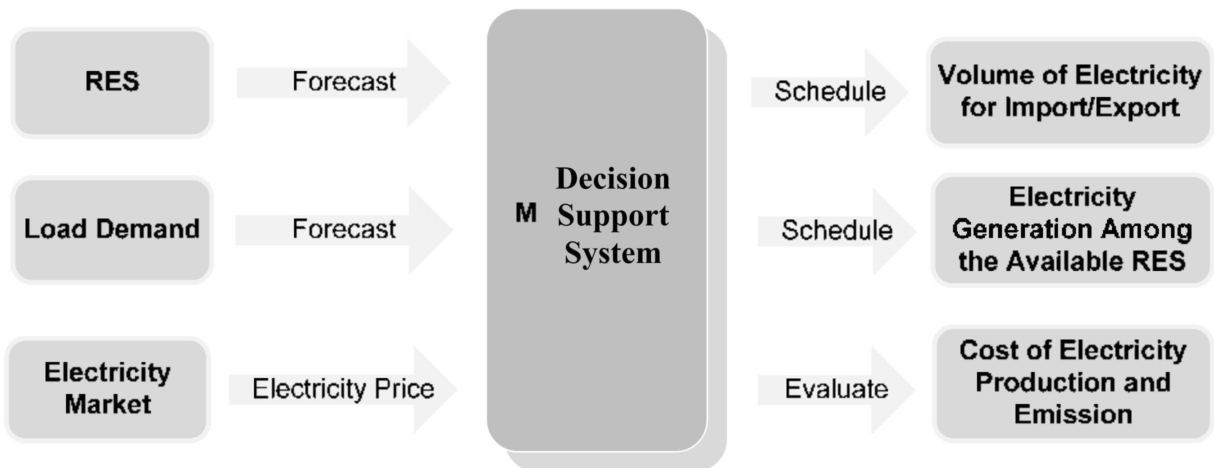

Fig. 1. Inputs and outputs of the decision-making system

The main functions of DSS at the stage of effective generation management are to evaluate the metrological characteristics that affect the power of renewable energy sources, determine the power of renewable energy sources, depending on physical, technical and economic factors. This functionality is ensured by: monitoring of weather data; collecting information about the technical characteristics and current functioning of the hybrid grid facilities, transferring the collected data to the system server, processing and storing them. The hybrid grid performance indicators should be presented as reports to the user.

In general, the input data for DSS are the forecast values of electricity demand (forecast level of electricity consumption), the need for the generation of electricity from renewable energy sources for some future period (hour, day, week) and the market price for electricity. The main functions of the DSS are to manage the decision-making process, to determine the power of the sources and load for creation the energy production schedule and estimate the cost of energy production. Long-term energy management in a hybrid distributed power grid includes a control of dependence on energy sources from the level electric energy, the impact on the environment and the cost of production of electricity, management of controlled loads to ensure an appropriate level of reserve capacity in respective to the electricity market and the load.

Implementation of organizational and technical measures for efficient using of electricity at individual consumer is impossible without energy consumption monitoring in real-time (as subsystems of the decision-making support system), short-term energy consumption forecasting depending on the specific impact the external factors is based on objective information, which comes to the system. The proposed system is a tool of direct and indirect actions regarding the determination of real economic effect from the introduction and support of energy saving measures. In turn, rationing of power consumption for elements and areas of consumption enables an objective comparison of expenses for certain periods of time and is a prerequisite for the formation of specified applications for purchase/sale of electric energy on the energy market [17].

Short-term energy management in a hybrid distributed system is used for balancing power and includes voltage regulation and energy dispatching in real time among renewable energy sources [18]. Approach to energy management in hybrid networks with renewable energy differs from energy management of traditional power systems, which are aimed at managing uncertainty of demand on load by controlling the supply. The main objective of energy management of hybrid networks is to achieve energy balance through the introduction of direct and indirect mechanisms for managing demand response and load. However, uncertainty on the supply side in such a system also needs to be managed [19]. Electricity management technic from the hybrid grid should be presented on the side of consumers, and is called the demand management. It is designed to control the level of energy consumption by the consumer, to benefit the overall work of the grid, avoiding the formation of high peak loads. Demand management is aimed at ensuring the supply-demand balance in real time. It also provides for the development of a distributed grid of electricity production and to improve system reliability and reduce capital costs associated with electricity transmission [20, 21, 22].

The entire decision-making process for power planning can be divided into two steps. The pre-decision stage for the possibility of generating electricity, which performs an objective evaluation of the collected and pre-processed information and the decision stage at which the information is structured and refined, is supplemented by additional consumption information to obtain a final decision.

The forecasting of power consumption. Power consumption is a cyclical process in which the characteristics of each cycle are dependent on a number of external and internal factors. The internal factors include: the number of units of load, schedule weekends and holidays, etc. To the external refer such as seasonality, climatic features, etc. There are also a number of factors associated with emergencies that are usually carried out beyond the forecasting task. Cycles can be divided by the duration on an hourly, daily, weekly, monthly, and annual. Depending on the purpose of forecasting, the model should describe any of these cycles. The consideration degree of external and internal factors depends of the forecast cycle, for which is developed model [23]. The longer the cycle, the more factors must be considered. Based on the preliminary studies can also be concluded that the increase in the duration of the forecast cycle leads to the growth of forecast error. The model developed to forecast for the year, account for the largest number of factors, but has a maximum error for the daily forecast. However, the model developed for the daily forecast has the minimum error in the forecast for the day, but has the excessively large number of errors at the forecast on month or year in advance, because the number of factors considered in it is limited.

The proposed approach to forecasting models is an attempt to take advantage of long-term forecasting models for short- and medium-term forecasts. The advantage of a long-term model is the maximum consideration of all factors affecting electricity consumption. This means that this model qualitatively correctly describes the process of electricity consumption within the covered cycle, but quantitatively the given forecast may be unsatisfactory. If the long-term forecast model is adjusted to take into account operational information, then, while maintaining a qualitative description of the process, it will acquire the necessary precision for the short-term forecast. This is the basic idea of our research. The type of forecast dependence is determined on the basis of the analysis of the initial data. It should be noted that the process of determining the optimal type of regression function is not formalized. Traditionally, a polynomial approach justified in interpolation problems that does not satisfy the prediction task is used.

Analyzing the daily schedules of electricity consumption, we can conclude that the electricity consumption during the day is uneven. In general, daytime electricity consumption can be divided into morning, evening and background periods. Since the graphs of power consumption show clearly expressed peaks during the day, it is rational to construct the predictive function not in the form of a polynomial, but in the form of a superposition of the Gaussian curves for consumption peaks and direct for background consumption.

The process of electricity consumption has some uncertainty, so the forecast model is fuzzy. It should be noted that weekly and especially annual cycles are more related to seasonal external oscillations, which are nonlinear in nature. However, based on the preliminary analysis, it is determined that the second-degree polynomial models are optimal in this case. The regression coefficients are determined as a result of applying a fuzzy regression analysis to the yearly power consumption data set. ASCAE registers the experimental data, as a rule, with a period of 30 minutes, so when looking for regression coefficients time is discretized with the specified step.

The coarsening algorithm for short term prediction consists of two parts: algorithm of correction of long-term forecasting models and the actual prediction algorithm. In the early stages of entering of initial data necessary for the formation of corrective sample and introduce the matrix of coefficients of the long-term forecast models. The operations of matrix multiplication to obtain the prediction of power consumption are performed. Then searches for the optimal solution, calculates the forecast of power consumption on a given date. Also, is calculated the indicators of forecast quality – degree match, degree of uncertainty and the connection with the traditional evaluation of forecast quality – mean module relative error. For fuzzy model mean module relative error is not a reliable indicator of quality because is designed to evaluate the discrepancies of numbers, not sets.

Conclusions. In order to study the effectiveness of the developed method of short-term forecasting, a calculated study was conducted. The implementation of the electricity efficiency management system, in our estimation, can lead to an average of 3% savings in electricity consumption. The expected economic effect (in annual terms) was calculated using the example of Sumy State University. Savings of 3% of electricity consumption, i.e. 119725 kWh, will provide an economic effect of UAH 206 thousand in annual terms only for one university [24].

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14. FUZZY LOGIC FOR ANALYSIS OF PROJECT QUALITY

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Annotation. Project management is a modern business strategy. However, little attention has been paid to the assessment of the actual implementation of design decisions in modern literature. Each project is unique in its own way. At the same time, typical errors occur from project to project. It is proposed to use a fuzzy logic tool for analysis and further accounting of project deviations. The accumulated experience will allow to improve approaches to the creation of the project. Fuzzy logic is an excellent tool for accounting for qualitative indicators expressed in linguistic language. This article discusses the construction of a hierarchical fuzzy linguistic model. The main plus of hierarchical models is getting rid of the "curse" of dimension. The following input linguistic variables are considered in this article: "designer experience", "designer versatility", "percentage of designer errors", "project complexity", "source data quality", "development time". Each indicator is described by the particular values. By collecting expert information, a rule base is created both for building membership functions by particular values, and for making an assessment decision. The output linguistic variable is "the project quality". As a defuzzification method, the best compromise method is used to obtain the final value of the input variables. The software implementation is implemented in the environment of fuzzyTECH 5.54 d Professional Edition. A 5.4% reduction in specification errors results in significant cash savings.

Introduction. The globalization of business, production, energy, space exploration, information technology, service industries and many other areas of human activity is a powerful driving force for the development of common approaches to planning and execution of projects in various sectors of the economy and around the world, without taking into account national borders. Project management has become the preferred business strategy. The number of books, print and electronic magazines, seminars, forums, articles on project management continue to grow [1]. Tom Peters calls the project manager job number one in the 21st century. Eliahy Goldratt, Pioneer of Theory of Constraints, sees project management as the next frontier in continuous business improvement [2].

Telecommunications is no exception. Network development, expansion of coverage areas, the introduction of new services (design and installation of fiber optic networks, the creation of a "smart home"), the continuous modernization of existing cable lines, the reduction of infrastructure maintenance costs, the use of alternative energy sources to power base stations, etc. is impossible without the implementation of special programs and projects. However, often design decisions are not fully implemented, unaccounted restrictions appear at the construction stage, design data lose relevance, and nobody is safe from design errors. Analysis of omissions and failures of design solutions will minimize these problems or take them into account during the construction process - which will reduce the level of unused materials, equipment.

Solving of complex management problems cannot be fruitful without involving information that is not quantified, often it is semantic, quality information. Using a fuzzy logic apparatus allows you to take into account quality information. L.A. Zadeh (Lotfi Askar Zadeh) proposed a linguistic model that uses not mathematical expressions, but words that reflect quality. [3]

The aim of the study is to build a hierarchical fuzzy model for assessing project quality - a key factor in deviations in project and actual volumes to reduce inventory levels.

To build a fuzzy model, it is necessary to determine all its elements: the rule base, the number and type of membership functions for each variable of the model, the parameters of membership functions, logical operators, etc.

Input variables or fuzzification phase. A linguistic variable differs from a numerical variable in that its values are not numbers, but words or sentences in a natural or formal language. The linguistic variable used in formalizing decision-making tasks has a basic term set consisting of 2-10 terms. Each term is described by a fuzzy subset of the values of U of some basic variable u and is considered as the linguistic value of the variable. It is assumed that the union of all these elements of the term set completely covers U. [4]

The practical use of the theory of fuzzy sets assumes the presence of membership functions that describe linguistic terms. [5] Analytical and expert methods are used to construct membership functions.

According to T. DeMarco and T. Lister, serious problems are not so much technological as sociological in nature. The main reason why people tend to focus on the technical rather than the human side of work is not the first priority over the second. Technical issues are easier to solve. Human interactions are complex, their manifestations are not obvious and transparent, but they are more important than any other aspect of the work. [6].

We put the human factor at the forefront of the quality of the project. The first input variable will be the experience of the designer.

According to A. Gross (Rabota.ru) [7], HeadHunter.ru [8], Fortune.com [9], the optimal term of work in one place is from 3 to 5 years. The main disadvantages of a frequent job change: the inability to fully immerse you in business processes, as a result of low productivity, a misunderstanding of the situation and the adoption of incorrect decisions. The main advantage of a frequent job change is stress resistance (according to E. Ehrlich [8]), high adaptability.

Long work at one place leads to stagnation, inflexibility, imprisonment under one corporate structure, reduces the generation of new ideas, the work goes “well-groomed”, stereotyping of thinking, lack of desire for new knowledge, as a result of professional deformation and emotional burnout [10,11].

According to the Economic News Release (Bureau of Labor Statistics) study, the average tenure in the same position differs in age characteristics (25-34 years - 3.4 years, 65 and more years - 10.3 years), and areas of employment (managers, professional environment - 5.5 years, service industry - 3.2 years). In the field of telecommunications, there is a tendency to reduce the length of tenure in the same position [12].

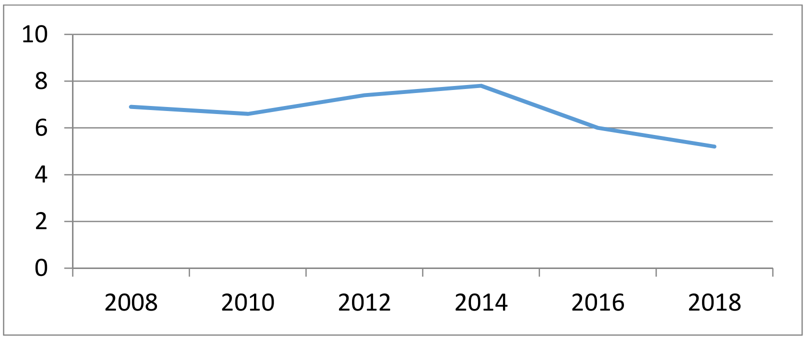


Fig. 1. Average tenure at the current position in the telecommunications sector 2008-2018 according to the Bureau of Labor Statistics

In addition to psychological aspects, there are also physiological difficulties, so according to a study by V.Skirbekk and M. Planck (Institute for Demographic Research), mental abilities decrease with age.

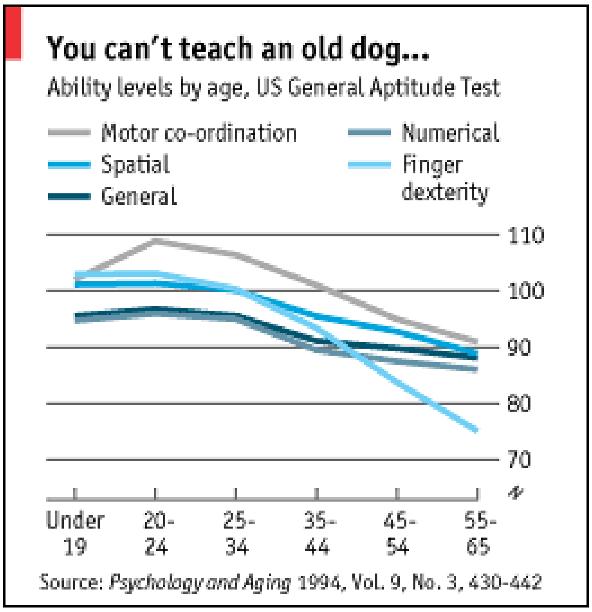


Fig. 2. Dynamics of changing abilities with age

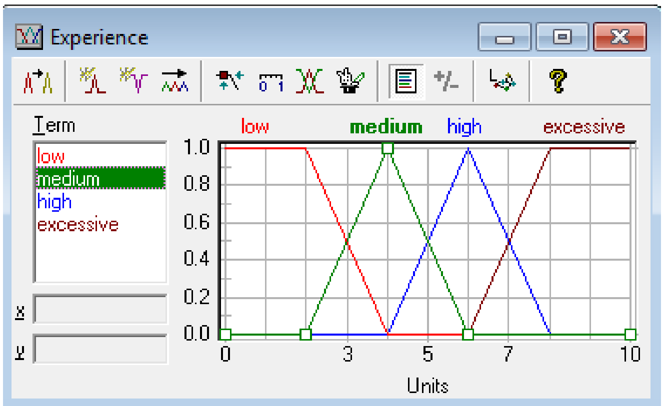
According to the most studies, mathematical and conceptual abilities are at their peak from 20 to 35 years old. Other abilities depend on the level of knowledge, so speech ability improves with age. According to the study, speech fluency at a maximum of 53 years on average. Figure 2 shows the change in ability with age [13].

Work experience is not only experience. It is also a variety of tasks to be solved, participation in large projects, improving knowledge, searching for new methods of solving, using various technologies.

As the term sets of the linguistic variable “Designer's Experience” (“Projector_Experience”) we will use the set of term sets: T_1 = {" low", "medium", "high", "excessive"}

Table 1 - Assessment of particular indicators “Experience”

Particular indicator	Performance Rating Level			
	low	medium	high	excessive
Work experience in the industry EX_1	<4	>5	>10	>15
Work experience in this position EX_2	<2	approximately 4	approximately 6	>8
Participation in large projects EX_3	none	help in certain sections	creating sections	creating sections, consulting
Participation in seminars EX_4	never	sometimes	often	never
Mastery of old methods EX_5	null	medium	high	very high
Mastery of new methods EX_6	null	medium	high	low
Knowledge of modern technology EX_7	medium	high	high	low
Enthusiasm EX_8	high	high	medium	low
Level of doubt EX_9	know nothing	know something	can do a lot	know everything
Desire to learn EX_{10}	high	high	medium	low
Emotional burnout EX_{11}	none	low	medium	high
Corrosion (Scrupulousness) EX_{12}	none	medium	high	low



Rice. 3. Functions of the input variable "Work Experience”, EX_2

The application of the principle of a thermometer in the assessment of qualitative variables consists in the fact that the expert assessment of a certain variable is carried out by filling in the part of the scale, the left and right borders of which correspond to the lowest and highest levels of the variable in question. The principle of a thermometer is conveniently applied in cases where the expert is not able to evaluate a certain variable with either a number or a quality term, but only intuitively feels its level [14].

Fig. 4. Assessment of experience on the principle of a thermometer for 12 particular indicators

As a term of the second linguistic variable “Universality” we will use the term set T_2 = {" low", "medium", "high"}

When constructing membership functions, each expert fills out a questionnaire, which indicates his opinion about the presence of fuzzy set properties in elements. We assume that expert estimates are binary, where 1 - indicates the presence of a fuzzy set property in the element, and 0 - indicates their absence.

According to the results of the questionnaire, the degrees of membership in a fuzzy set are calculated by the formula (1).

$$\mu_{l_i}(u_i) = \frac{1}{K}\sum_{k=\overline{l,K}} b_{j,i}^{k}, i = \overline{1,n}, \quad (1)$$

where K – number of experts,

$b_{j,i}^{k}$ – opinion of the k-th expert on the presence of the properties of the fuzzy set j_j in the element u_i [5].

The columns are indexed by the type of work performed during the creation of the design and estimate documentation, and the rows are indexed by the term-set elements “low”, “medium”, “high”. U_1 - work with preparatory data, U_2 - Pre-design work, U_3 - Identification of inaccuracies in the source data, U_4 - Survey work, U_5 - Surveying, U_6 - Drawings, U_7 - Creating specifications, U_8 - Obtaining approvals, U_9- Estimating, U_{10} - Evaluation of the results.

Table 2 - The result of a survey of experts

	Term	U_1	U_2	U_3	U_4	U_5	U_6	U_7	U_8	U_9	U_{10}
Expert 1	low	1	1				1	1			
	medium	1	1	1	1		1	1	1		
	high					1				1	1
Expert 2	low	1	1				1	1			
	medium		1		1		1	1			
	high			1		1			1	1	1
Expert 3	low	1	1		1						
	medium					1	1	1			1
	high			1					1	1	
Expert 4	low	1	1		1		1	1			
	medium		1	1	1				1		1
	high					1				1	
Expert 5	low	1	1					1	1		
	medium			1	1		1				1
	high					1				1	
Expert 6	low	1	1		1						
	medium						1	1	1		
	high			1		1				1	1
Expert 7	low	1	1		1				1		1
	medium			1			1	1			
	high					1				1	

Table 3 - The result of the processing of expert opinions

	U_1	U_2	U_3	U_4	U_5	U_6	U_7	U_8	U_9	U_{10}
low	7	7	0	4	0	3	4	2	0	1
medium	1	3	4	4	1	6	5	3	0	3
high	0	0	3	0	6	0	0	2	7	3

Table 4 - Membership functions based on the processing of expert opinions

	U_1	U_2	U_3	U_4	U_5	U_6	U_7	U_8	U_9	U_{10}
low	1,00	1,00	0,00	0,57	0,00	0,43	0,57	0,29	0,00	0,14
medium	0,14	0,43	0,57	0,57	0,14	0,86	0,71	0,43	0,00	0,43
high	0,00	0,00	0,43	0,00	0,86	0,00	0,00	0,29	1,00	0,43

As the term of the third linguistic variable "Percentage of errors of the designer" ("Error_Bar") we will use the term-set

T_3={"low","medium","high"}

We will consider a low error of about 3%, a medium of about 10%, and high is about 18% of the calculated volumes indicated in the specification.

As a term of the fourth linguistic variable "Project Complexity" ("Complexity") we will use the term-set

$T_{\_4}$={"low","medium","high"}

According to Russell D. Archibald, the indicator of project complexity is the variety of its goals and content, as well as the number of internal departments and external organizations involved in it (the latter often determines the number of narrow-profile specialists, sources of technology or financing required). A project requiring special skills and other resources that can be found within the same functional unit is usually considered less complex from a managerial point of view than a joint venture project carried out by two separate corporations. Complexity grows exponentially with increasing number of participating organizations. The intersection of project work with the organization’s day-to-day operations is a recognized source of complexity, especially for projects involving facilities and structures that are directly involved in manufacturing, assembly, and other operational operations. Projects carried out under the control of one or several state regulatory bodies, as a rule, turn out to be more complicated than projects launched without such control. [1]

Projects for the modernization of communication lines are associated with the daily activities of a telecommunications company, the data flow is continuous. The laying of new lines, the repair of existing lines, and the dismantling of unusable lines are constantly taking place. The construction of new residential buildings, shops and offices, the creation of modern infrastructure is also not without the telecommunications market. To carry out excavation work, it is necessary to open an order in the executive authorities, coordination with engineering and operational services. The implementation of government programs is constantly monitored and controlled.

Table 5 - Assessment of particular indicators “the complexity of the project”

Particular indicator	Performance Rating Level		
	low	medium	high
<u>Excavation:</u>			
telephone drainage construction:			
Wells:			
Installation KKC-1, TS_1	up to 2	up to 10	> 10
Installation KKC-2, TS_2	up to 2	up to 5	> 5
Installation KKC-3, TS_3	none	<2	>2
Installation KKC-4, TS_4	none	none	>1
Pipelines:			
laying of single-hole cable duct, TS_5	< 100 м	100 <м<1000	>1000
laying of double-hole cable duct, TS_6	< 100 м	100 <м<1000	>1000
channels adding, TS_7	100 <м<1000	>1000	>2000
Territoriality:			
green area laying, S_1	roadside		park
strip with the demolition of asphalt pavement, S_2	none	<100 м^2	> 100 м^2
strip with dismantling tile coating, S_3	<50м^2	<100м^2	>300 м^2
laying the cable line in the ground:			
Territoriality:			
on the territory of agricultural lands, CLS_1	none	< 1 km	> 1 km
on the territory of the forest fund, CLS_1	none	mess	deforestation
the intersection of rivers and reservoirs (on elongated lines), CLS_3	none	mess	> 200 м on elongated cables
crossing of gas and oil pipelines, CLS_4	none	mess	up
crossing of railway tracks, CLS_5	none	mess	up
crossing of motorways, CLS_6	none	mess	up
crossing of power lines, CLS_7	none	mess	up
Method of laying:			
manually	none	>200	>500
cable layer	none	<1000	>1000
laying a cable line in an existing sewer:			
on a free channel	<1000	100-10000	>10000
on a busy channel	<500	500-1000	>1000
<u>Multiplicity:</u>			
the presence of many buildings (houses), Set_1	1-5	5-20	>20
the presence of many owners, Set_2	1-3	3-10	>10
multi-stored buildings, Set_3	1-5	5-10	>10
<u>Presence of particularly important subscribers (schools, hospitals, police, etc.), VIP</u>	none	1-10	>10
<u>Insets:</u>			
presence of insets in local lines, I_1	1-2	3-10	>10
insets in long-distance lines, I_2	none	1	>1
insets to international lines, I_3	none	none	>1
<u>Implementation of state programs, Gov</u>	none	yes	yes

The thermometer principle is used to construct the accessory functions.

For proper planning in the preparation of the project, any developer needs the initial data for setting goals, objectives, performing survey work. As a term of the fifth linguistic variable "Quality of source data" ("Basic_data") we will use the term-set T_5={"low\"","medium","high"}

After analyzing TCH 214-2010 you can evaluate the particular indices of the quality of the source data (table 6).

Table 6 - Partial indicators of the variable "Quality of initial data»

Particular indicator	Performance Rating Level		
	low	medium	high
Reliable plans for detailed planning and development of housing estates, RPl	not updated	updated once 5 years	annually
Actual and reliable schemes of existing cable ducts, RSc	not updated since construction	updated after reconstruction	daily update
Actual schemes of the existing backbone, distribution, subscriber networks, RLCL	not updated since construction	updated after reconstruction, accident	monthly update
Lists of unsatisfied applications for the provision of telecommunications services, RS	updated during construction	annual update	daily update
Lists and acts of measurements of cables to be replaced, RC	not updated since construction	annual update	quarterly
Technical capability of LCS, TF	annual update	quarterly	daily update
Lists of equipment to be replaced, SE	annual update	quarterly	daily update
Current passports of wells, RWR	not updated since construction	updated after reconstruction, accident	daily update
Reliable loading of trunk and distribution cables, USSN	on special request	annual update	daily update
Reliable loading of cables and transmission systems in the areas of MCC, ULD	on special request	annual update	daily update
General plans of the city on the planned volume of housing construction for the next 1-3 years, GPC	every 3 years	annual update	quarterly
General plans of the city on the planned improvement of the streets for the next 1-3 years, GPI	every 3 years	annual update	quarterly

To build membership functions, the principle of a thermometer is used.

As the term of the sixth linguistic variable “Development Time” (“Engineering_time”) we will use the term set

T_6= {"low", "medium", "high"}.

In a similar way, a system of private indicators is being developed. By the principle of a thermometer, membership functions are built.

Rule base, output variables, defuzzification stage. We will use “Project Error” as the output variable. As the term of the output linguistic variable “Project Error” (“Project_Error”) we will use the term set

T_$_{7}$ = {"\" very low \ "", "low \", "medium", \ "high \" "," very high "}

The first block of rules with the name “Designer Rating” (“Projector_Rating”) is used for an intermediate assessment of the general level of the project developer and for the considered fuzzy inference system contains 36 fuzzy production rules. The input linguistic variables of this rule block are the first three input linguistic variables of the project, and the output linguistic variable of this rule blog is the intermediate variable of this project with the name “Projector_Rating”. A fragment of the knowledge about the relations "Projector_Rating" is presented in Table 7.

Table 7 - Fragment of knowledge about ratios "Projector_Rating»

Designer’s experience	Universality	% errors'	Designer's rating
Low	Low	Low	Medium
Low	High	High	Low
Medium	Low	Low	High
Medium	High	Low	Medium
High	Medium	Medium	Medium
High	Medium	High	Low

To build a fuzzy model, the FuzzyTech program is used. The matrix block of rules for the intermediate variable "Projector_Rating" is shown in Figure 5.

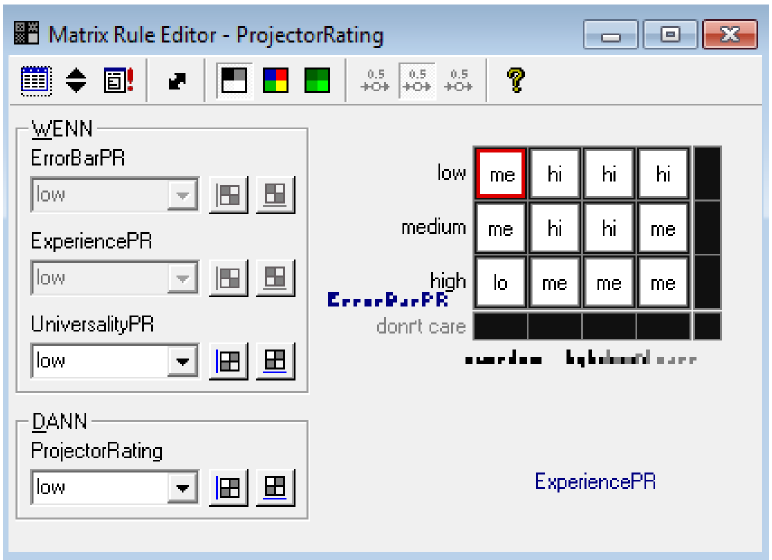


Fig. 5. The matrix block of rules for the intermediate variable "Projector_Rating"

Similarly, the “Project Evaluation” rule blocks are created. The “Project Evaluation” rule block contains 81 rules of fuzzy products, a rule block. A fragment of knowledge about the ratios of particular indicators for the linguistic variable "quality of the source data" is presented in table 8, a fragment of knowledge about the ratios "Assessment of the project" is shown in table 9. Columns represent linguistic variables, columns of a term set. The last column shows the output variable and the resulting value, after the composition rule.

Table 8 - Fragment of knowledge about the ratios of private indicators for the "quality of the source data"

RPl	RSc	RLCL	RS	RC	TF	SE	RWR	USSN	ULD	GPC	GPI	BD
H	H	C	B	H	H	H	H	H	H	B	B	H
C	C	H	C	H	H	H	C	C	C	B	B	C
B	H	H	C	C	B	B	B	B	B	C	C	B

Table 9 - Fragment of knowledge about the relationship "Project Evaluation"

BD	C	ET	PR	PE
H	H	H	H	B
H	C	B	C	H
C	H	B	B	OH

The fuzzy model is implemented through fuzzyTech 5.54 d Professional Edition. In figures 6, 7, 8, and 9, fuzzy inference surfaces are constructed on a three-dimensional surface for the fuzzy model “Project Error”.

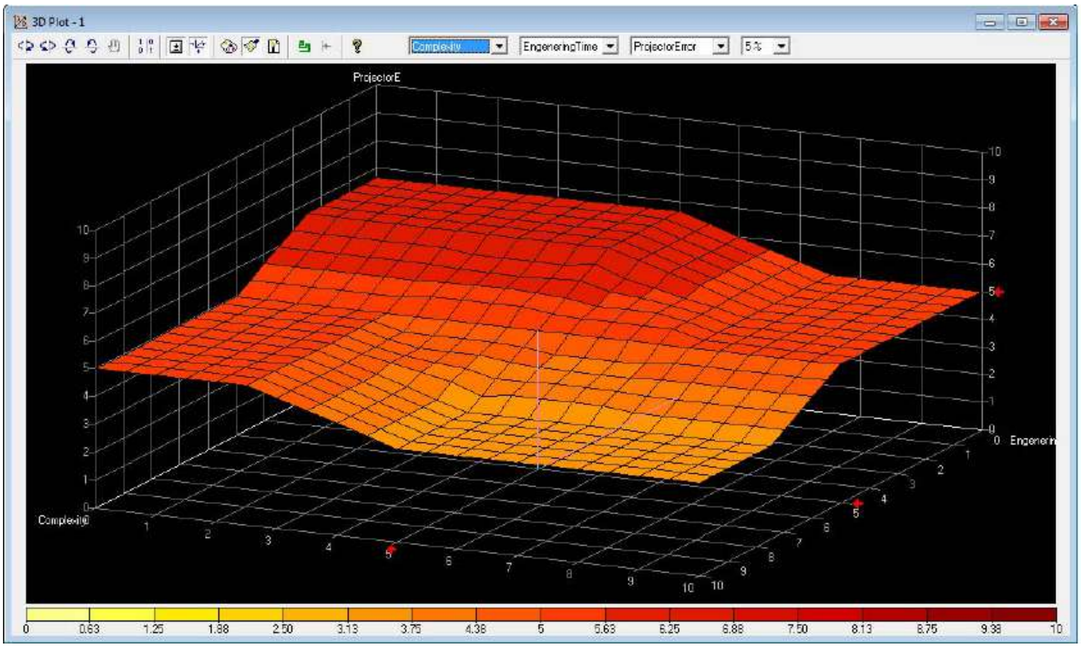


Fig. 6. Fuzzy inference surface view on a three-dimensional surface for the developed model in the interactive debugging mode (complexity, development time, project error)

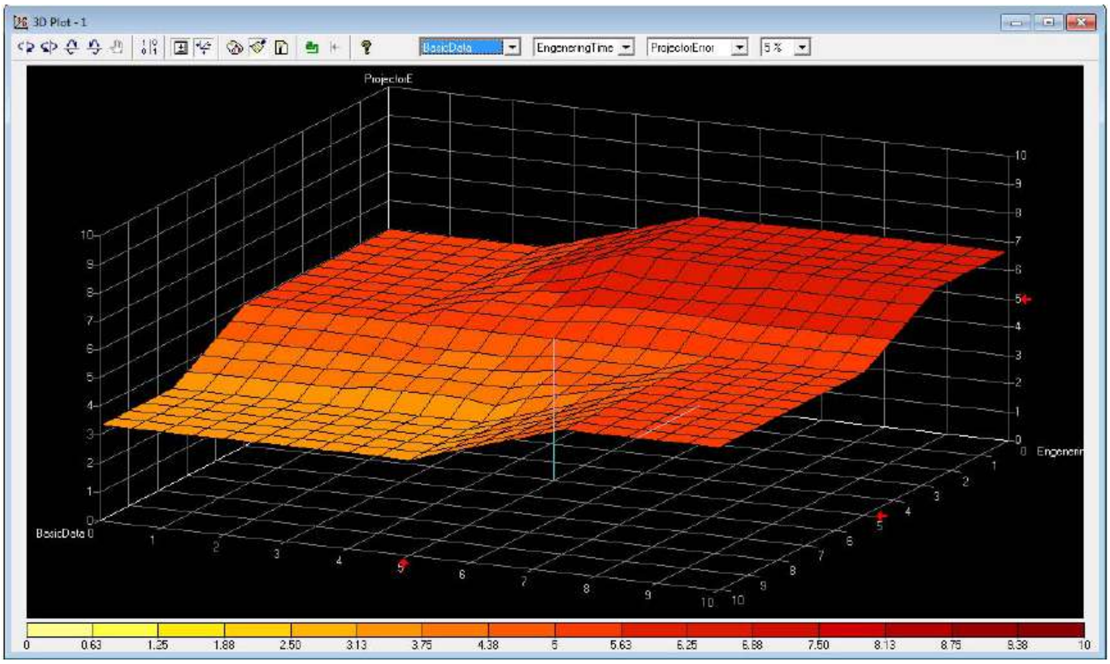


Fig. 7. Surface type of fuzzy output on a three-dimensional surface for the developed model in the interactive debugging mode (initial, development time, project error)

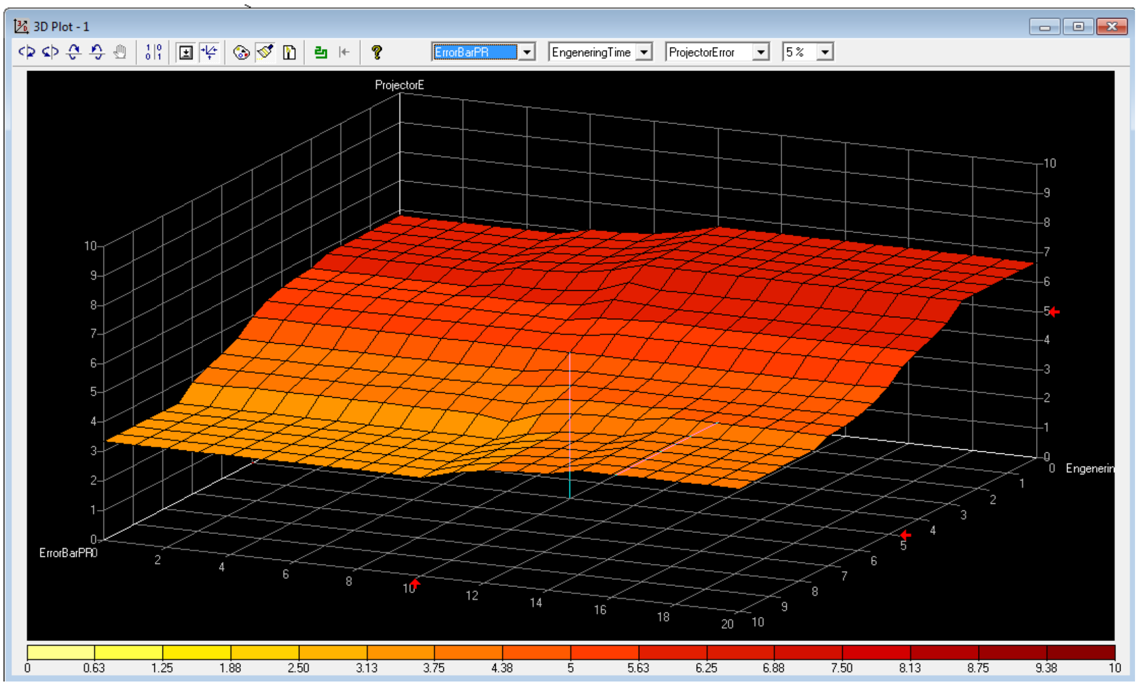


Fig. 8. The surface type of the fuzzy output on a three-dimensional surface for the developed model in the interactive debugging mode (% of the designer's reject, development time, project error)

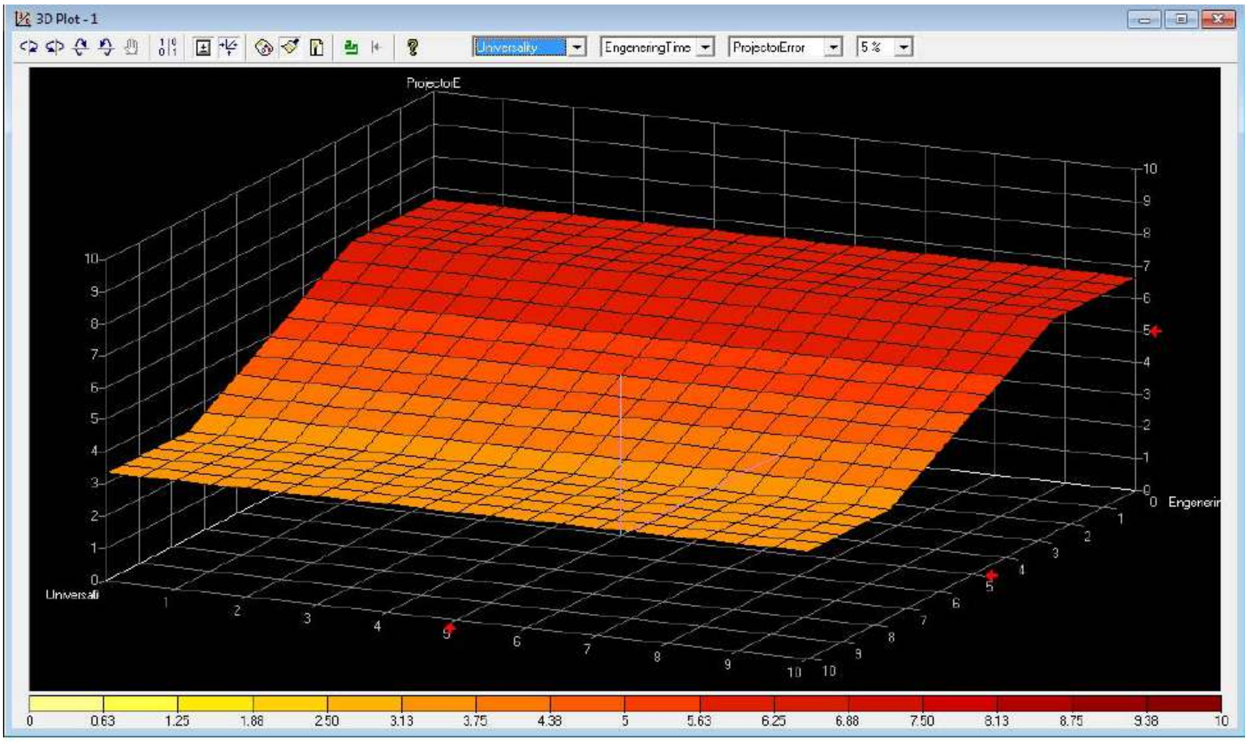


Fig. 9. The surface type of the fuzzy output on a three-dimensional surface for the developed model in the interactive debugging mode (% of the designer's reject, development time, project error)

Figure 10 shows the fuzzy production rules analyzer for the intermediate variable "designer rating".

Figure 11 shows the working interface "Project Error" under the given conditions and the project error is calculated.

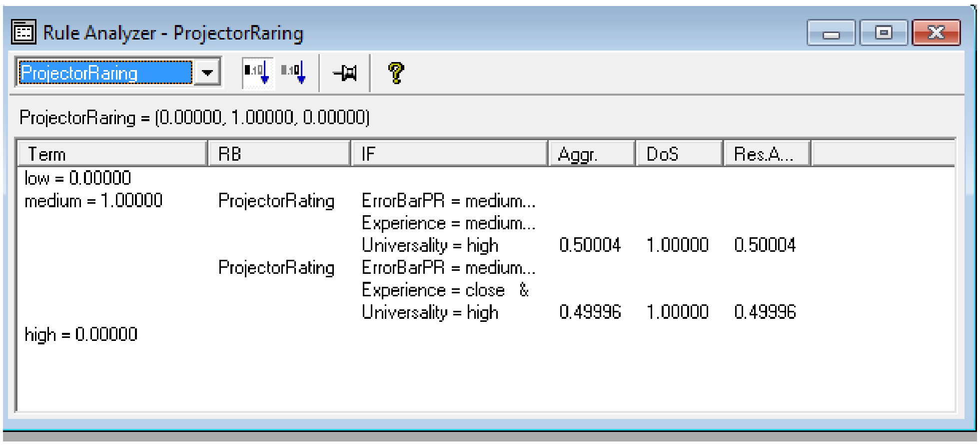


Fig. 10. Fuzzy Production Rule Analyzer

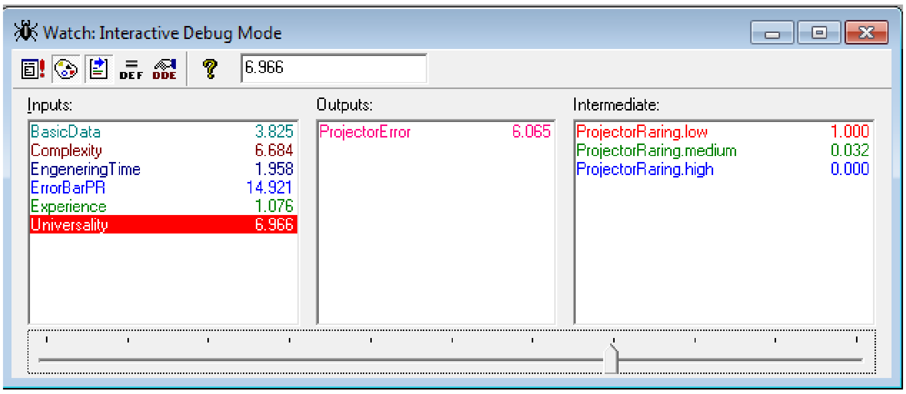


Fig. 11. View of the working interface in debug mode

The standard method (Center-of-Maximum or CoM for short) is used as the defuzzification method, which is represented by the best compromise method to obtain the final value of the input variables. In fuzzyTECH, this method works similarly to the center of gravity method. The main advantage of the center of gravity method is that all activated membership functions of defuzzification (all active rules), i.e. the center of gravity method is "democratic" and provides a higher sensitivity of the fuzzy model to changes in input signals.

Further, analyzing the input variables accumulated in the database, and using the basic principles of constructing membership functions, a self-tuning fuzzy model is constructed to analyze the newly developed project.

Table 6 - Analysis of the results

	Project value	Fuzzy model value	Actual value
Project A, material 1	1,631	1,61	1,590
Project A, material 2	1,937	1,879	1,856
Project Б, material 1	4,694	4,597	4,421
Project Б, material 2	2,508	2,403	2,311

Thus, the value of material 1 calculated for project A, according to the fuzzy model, is less than the design value by 1.29% and higher than the actual value by 1.25%, the value of material 2 calculated according to project A, according to the fuzzy model, is less than the design value by 2 , 99% and more than the actual value by 1.24%, the value of material 1 calculated according to project B, according to the fuzzy model, is less than the design value by 2.01% and higher than the actual value by 3.98%, the value of material 2 calculated according to the project B, according to the fuzzy model, it is 4.19% less than the design value and more actual its value by 3.98%.

Therefore, the values obtained by the fuzzy model are closer to the actual data compared with the projected data by an average of 5.4%.

Calculation of the efficiency:

The decrease in reserves of 5.4% allows to obtain savings

5,4%*24 900 935.57 = 1 344 650.52 RUB 662 389 $

where 24 900 935.57 - annual volume of construction and installation works.

Efficiency is achieved due to the fact that the quality of the project and the quality of work of the contractor affects both the materials of the contractor and the customer, and the amount of work performed with these materials.

The accumulation of input information will improve the response of the model.

Conclusion. Linguistic models allow you to make decisions for poorly structured tasks. Using fuzzy logic allows to take into account the human factor (through analysis of work experience, interest in the work, the psychological state of the designer, the level of knowledge, the universality of the tasks performed, and the analysis of errors in the previous stages). The linguistic variable “source data” allows to analyze the current state of line-cable lines, the timeliness and relevance of updates during network modernization, long-term construction plans to improve the degree of relevance in the design. The linguistic variable “Project Complexity” allows you to take into account both specific features (earthworks on forest lands, crossings over water bodies, etc.) and typical issues (length of cable routes). The linguistic variable "Development time" allows to take into account, depending on the complexity of the project, how much time is needed for high-quality design, the degree of pressure exerted by the leadership and, as a result, the decrease in the effectiveness of design decisions due to the lack of time.

Using fuzzy logic allows to reduce the level of inventories, by taking into account deviations according to the specification of the project. A fuzzy model for assessing the quality of the project was built, which, depending on the result, gives an acceptable estimate of the number of materials to be laid, which will allow to order the optimal amount of materials and build objects in a timely manner. The construction of fuzzy models for evaluating projects can be used for various construction projects, allowing you to take into account deviations of design values from actual volumes based on an analysis of the quality of the developed project. Improvement of design indicators by 5.4% for all projects during the year gives significant savings.

Gathering expert information and building knowledge bases is the first step to improve design decisions. The accumulation and analysis of retrospective data can improve the response of the model. Expert information can also be used to improve the current accounting of communication lines (work on the initial data for the design), analyze the professional and emotional level of the designer, and as a result, develop measures to prevent emotional burnout, create training programs to reduce the percentage

Reconfiguring the fuzzy model by setting other specific criteria and collecting expert information on the influence of factors allows us to use this model for other areas of the economy.

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15. MARKING OF INCOMPLETE INFORMATION IN THE DATABASES OF TOPOGRAPHIC DATA USING VALIDATION

Zarytskyi O.V., Kostenko O.B., Bulaienko M.V.

Annotation

The purpose of the study is to investigate the geospatial data set, to identify differences and errors using the validation method. Validation accelerates data validation and improves the processing of large volumes of geospatial data. The above approach allows to check and consistently record the results that meet the established criteria. Models designed to convert differentiated geospatial data sets into a single digital description space are considered. The result of the audit is proposed to be reported.

Keywords: information system, geospatial data, topographic database, class copy, validation, report, missing data marking.

Introduction

As a result of the adoption of the new concept of the National Geospatial Data Infrastructure of Ukraine (NGDI) [1], the organization of relevant geospatial databases became necessary for all subjects of land and urban planning relations. Thus, at the local level, new structures of the classifier are being approved, which are focused on unification and uniqueness of creation of spatial objects for all enterprises, as moderators of geospatial data in Ukraine.

Since 2013, the work on standardized digital form of submission of basic geospatial data sets has been intensified [2]. By now considerable archives of information have been formed, which are quantitatively and qualitatively differentiated. Such circumstances today complicate the transition of enterprises and institutions to new standards of work [3]. At the same time, it remains economically viable to use existing archival information, even if it was not initially complex in its early stages.

Conversion models based on validation need to be developed for data from previous years to have regulatory acceptability for further analysis and processing. These models are designed to convert differentiated geospatial data sets into a single digital description space. In other words, datasets should be tested for adequacy.

Systems for verifying information in topographic databases must be implemented both when converting archives to updated standards and after converting them. That is, approaches that would allow experts in geodetic, mapping, land management and urban planning industries to mark the missing information in large arrays of spatial data are needed.

Verification of different datasets for correctness should formulate its criteria according to the regulatory framework and output the result in a text document.

Analysis of recent research and publications

Validation is a procedure that gives a high degree of confidence that a particular process, method or system will consistently produce results that meet pre-established eligibility criteria. The validation process is relevant and applicable across a wide range of activities [4].

In [5], models of species and climate envelope that predict future events are investigated. Validation is seen as a potentially useful tool when accompanying such models with appropriate context.

Validation processes are also used to evaluate the utility of huge data sets on vegetation products [6]. Validation helps to form a clear stratification structure (stratification of rock layers) taking into account the factors of climatic and plant classification of population density.

In recent years, the growth of huge transactional and experimental datasets, along with the requirements for data mining, has created a need for clustering algorithms that are scalable and applicable across fields. In a study [7] it is emphasized that validation based on cluster analysis can conceptually identify groups of similar objects and distribute patterns and correlation features in large datasets.

Article [8] states that validation is a necessary step to adopt a model that works with datasets. In order to evaluate the performance of the model, an indicator of the correspondence between observed and simulated data is implemented.

According to the study materials [9], validation is used in the transfer of databases, which is relevant today. Validating of large and complex data sets does not concern their content, but the entire data schema. In order to reduce resource costs, the verification process is proposed to be performed only on the number of rows of data that migrate between two databases.

In [10], the validation process is used to detect and correct errors in the file system. The application considered in this study checks and detects errors in system settings and saves the scan results to CSV files.

Validation methods play an important role in identifying possible errors or inconsistencies. Thus, in the literature [11] validation with the relevant criterion of requirements is considered as a heterogeneous process based on the use of different independent methods.

Having conducted an analytical review, one can emphasize the obvious advantages of the method of validation in the information age. For information systems to be viable, the data sets they use require proper verification.

Therefore, this study concerns the comparative algorithms for checking the results of the conversion of topographic databases.

The work has the following tasks:

- to analyze the experimental set of topographic database;
- to create a number of rules for verification;
- to implement the validation process and to get the result of verification in the reporting form as markings of missing data in databases.

Presentation of the main material of the study

There are many models that address geospatial datasets. If there is a question of verifying the content of the information for adequacy (as in our case), then a method such as validation is used.

For example, in the UK GMP Rules (Orange Guide, 1983): validation is the act of proving that any material, process, procedure, activity, equipment or mechanism used to produce or control it can achieve the expected result. And the definition of validation in the US FDA (US FDA, 1987) is as follows: validation - obtaining credible evidence, which gives a high degree of confidence that the process will constantly produce a product that meets the established quality criteria.

The results of the validation method can be used to evaluate the quality, reliability and consistency of analytical results; this is an integral part of any good analytical practice.

Since validation is used in different areas, it is applied in different ways depending on the limitations of the validation data.

1. Character check. Such verification is performed in the user interface and can serve as a lexical analysis of the compiler to detect invalid characters, so it is also called "lexical".

2. Individual values check. This check is set in a separate field and is performed during data entry and after completion of the input, when the field loses focus. Such checks, by analogy with compiler terminology, are called "syntactic".

3. The set of input values. Verification occurs after the application has received the data. During this validation, you can perform so-called "semantic" checks that target not only the individual values, but also the relationships between them.

4. Checking the status of the system after data processing. This method is used when the input validation fails, i.e. the data is processed with the possibility of returning everything to its original state. This kind of check is often called "transactional".

So, validation is a proof that the process is working properly. The above fourth method of application is fully within the scope of this study.

Validation is similar in meaning to the term "verification". Verification is proof that a plausible fact or statement is true. In other words, verification is just validation, and validation is validation.

Topographic Database (TDB) is a collection of centrally managed interconnected geospatial data [12].

TDB can represent information of different information systems [13], which interact with each other and operate information about different geospatial objects.

The Decree of the Cabinet of Ministers of Ukraine [14] defines the mechanism of information exchange between cadasters and information systems and the list of information that can be exchanged in the course of such interaction. This resolution seeks to achieve the following objectives:

- formation of a unified cartographic basis for geoinformation systems;
- guaranteeing mutual replenishment of information systems;
- guaranteeing the mandatory transmission of geospatial data, guaranteeing objectivity, reliability and completeness of information;
- prevention of duplication of works on information content of information systems;
- unification of information systems;
- provision of up-to-date geospatial data of public authorities, local self-government bodies, legal entities and individuals.

Spatial data sets of the sphere of land management, geodesic, cartographic and town-planning activities are presented as elements of the Zoning system [15]. The data used in this regard relate to a separate residential quarter of the settlement Kotliary Kharkiv district of the Kharkiv region. A fragment of the TDB zoning system of the experimental object is shown in Figure.

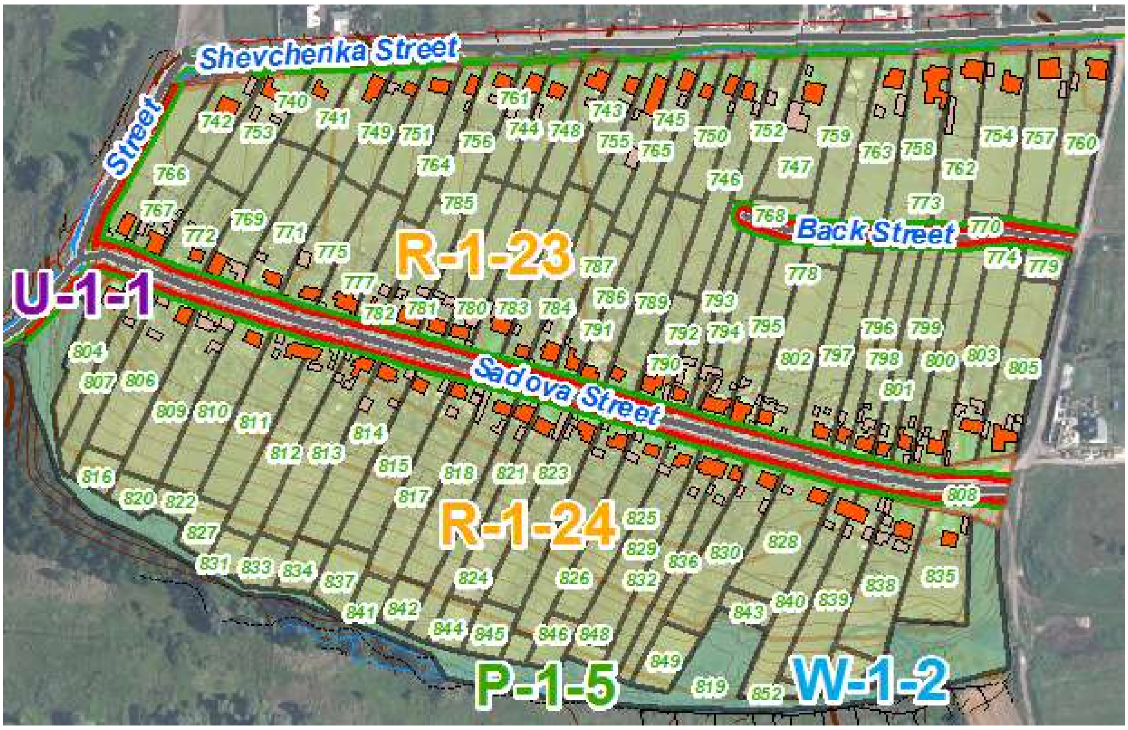


Fig. 1. Composition of vector and raster mappings of a residential area of a settlement (R - Residential Districts, P - Park Districts, U - Utilities Districts, W - Water District)

The structure of the experimental set of information systems and their classes relating to the Zoning system is presented in Figure 2.

The TDB data is different, differentiated, collected according to different rules, which according to the NGDI concept is not acceptable as the database should represent unambiguous information. Therefore, we need to verify this information.

The input for validation comes from a topographic dataset. Each TDB facility has its own peculiarity and status.

The state of an object is represented by a set of values of its attributes, and many objects with the same set of attributes and features form a class. Each class is matched by its geometric type, which describes the class structure; the instance is a class representative.

Figure 3 shows the classes tested by the algorithms developed in the study.

The initial data should be the result of verification of the results of the conversion of the TDB in the form of a table report. The result is then written to a text document and marks objects that do not meet the pre-set regulatory criteria.

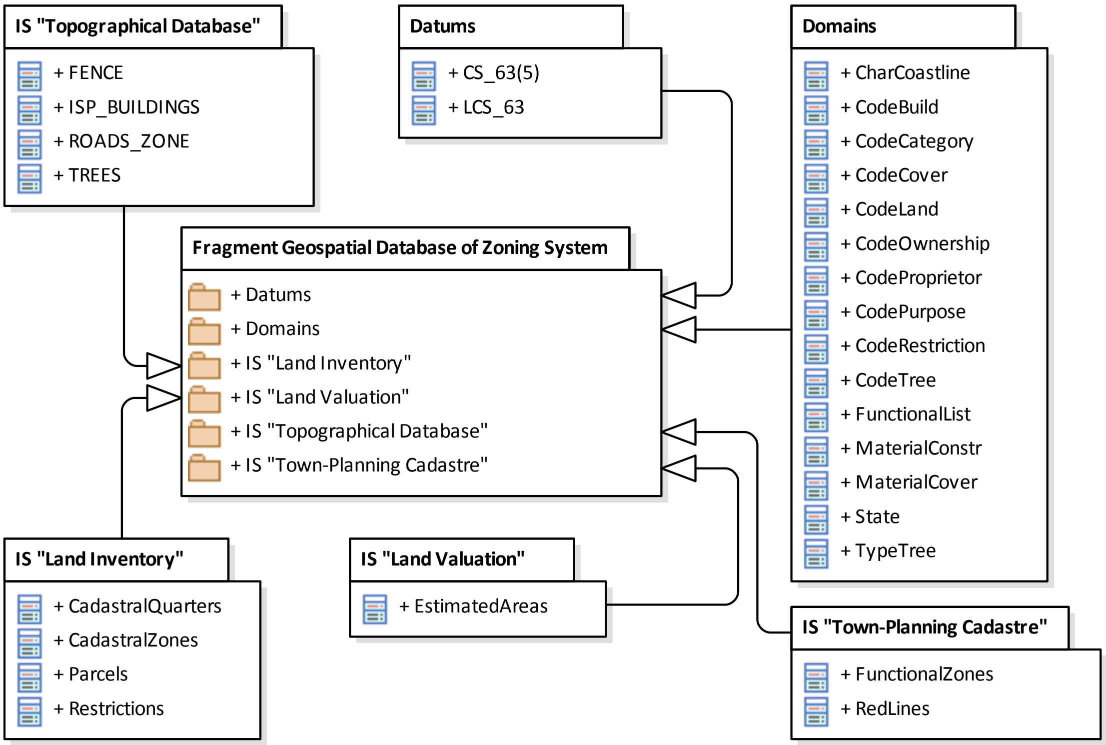


Fig. 2. UML diagram of packet association of information systems and classes with the TDB of Zoning system

Modeling the conceptual scheme of algorithms for checking the database of topographic data, four groups of rules were formed: syntax rule, topology rule, relevance rule, semantic correspondence rule.

Syntax rule - Check for syntax errors that deviate from common spelling rules.

Topology rule is the intersection of land boundaries with red lines, the entry of personal land plots into a residential functional area, the entry of buildings and structures into a certain land plot.

The rule of relevance is to compare the dates of measurements according to the frequency of updating of topographic data.

The rule of semantics is to check the suitability of the land use for the intended purpose, to check the percentage of construction, to determine the occupied land.

Figure 4 shows a block diagram of an algorithm for defined validation rules.

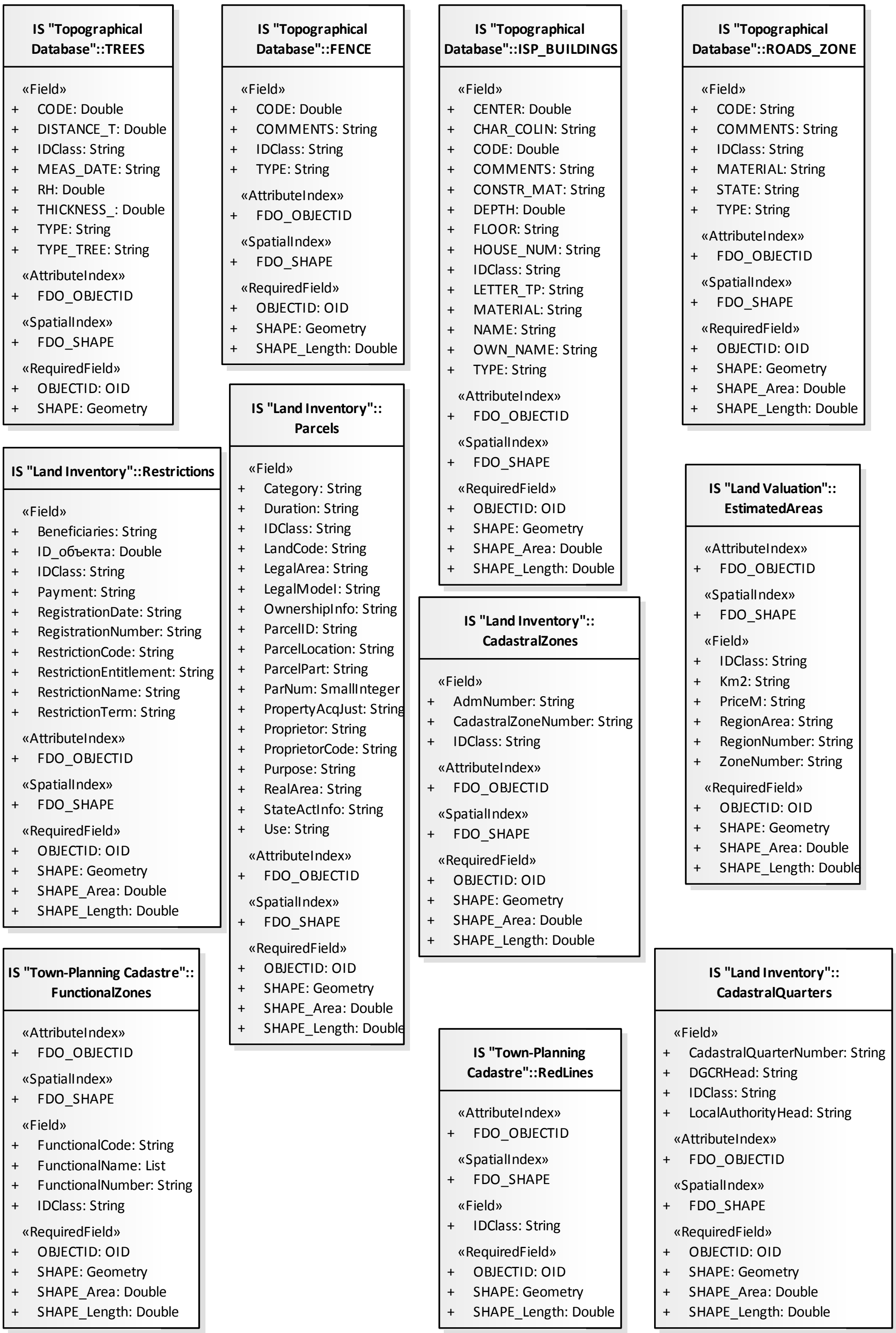
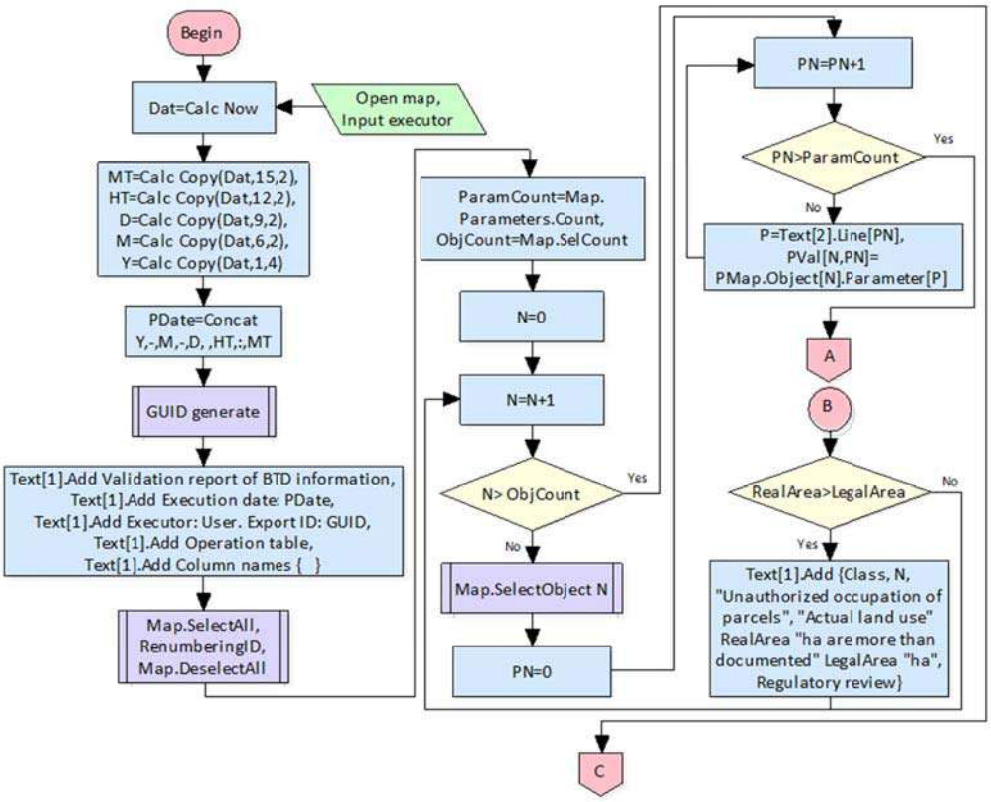


Fig. 3. UML diagram of classes of experimental geospatial data set


Begin
Dat=Calc Now
Open map,
Input executor
MT=Calc Copy(Dat,15,2),
HT=Calc Copy(Dat,12,2),
D=Calc Copy(Dat,9,2),
M=Calc Copy(Dat,6,2),
Y=Calc Copy(Dat,1,4)
PDate=Concat
Y,-,M,-,D, ,HT,:,MT
GUID generate
Text[1].Add Validation report of BTD information,
Text[1].Add Execution date: PDate,
Text[1].Add Executor: User. Export ID: GUID,
Text[1].Add Operation table,
Text[1].Add Column names { }
Map.SelectAll,
RenumberingID,
Map.DeselectAll
ParamCount=Map.
Parameters.Count,
ObjCount=Map.SelCount
N=0
N=N+1
N> ObjCount
Yes
No
Map.SelectObject N
PN=0
PN=PN+1
PN>ParamCount
Yes
No
P=Text[2].Line[PN],
PVal[N,PN]=
PMap.Object[N].Parameter[P]
A
B
RealArea>LegalArea
No
Yes
Text[1].Add {Class, N,
"Unauthorized occupation of
parcels", "Actual land use"
RealArea "ha are more than
documented" LegalArea "ha",
Regulatory review}
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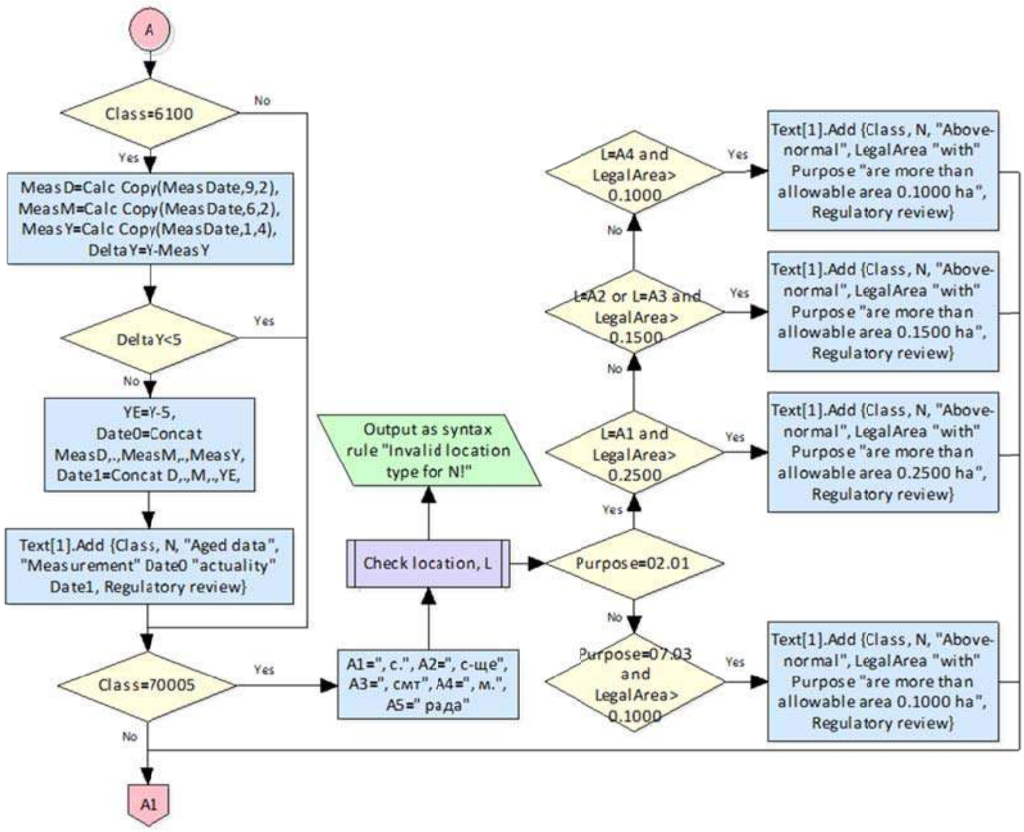
A
Class=6100
No
Yes
MeasD=Calc Copy(MeasDate,9,2),
MeasM=Calc Copy(MeasDate,6,2),
MeasY=Calc Copy(MeasDate,1,4),
DeltaY=Y-MeasY
DeltaY<5
Yes
No
YE=Y-5,
Date0=Concat
MeasD,.,MeasM,.,MeasY,
Date1=Concat D,.,M,.,YE,
Text[1].Add {Class, N, "Aged data",
"Measurement" Date0 "actuality"
Date1, Regulatory review}
Class=70005
Yes
No
A1
A1=", с.", A2=", с-ще",
A3=", смт", A4=", м.",
A5=" рада"
Check location, L
Output as syntax
rule "Invalid location
type for N!"
Purpose=02.01
Yes
No
L=A1 and
LegalArea>
0.2500
No
L=A2 or L=A3 and
LegalArea>
0.1500
No
L=A4 and
LegalArea>
0.1000
Yes
Purpose=07.03
and
LegalArea>
0.1000
Yes
Text[1].Add {Class, N, "Above-
normal", LegalArea "with"
Purpose "are more than
allowable area 0.1000 ha",
Regulatory review}
Text[1].Add {Class, N, "Above-
normal", LegalArea "with"
Purpose "are more than
allowable area 0.1500 ha",
Regulatory review}
Text[1].Add {Class, N, "Above-
normal", LegalArea "with"
Purpose "are more than
allowable area 0.2500 ha",
Regulatory review}
Text[1].Add {Class, N, "Above-
normal", LegalArea "with"
Purpose "are more than
allowable area 0.1000 ha",
Regulatory review}

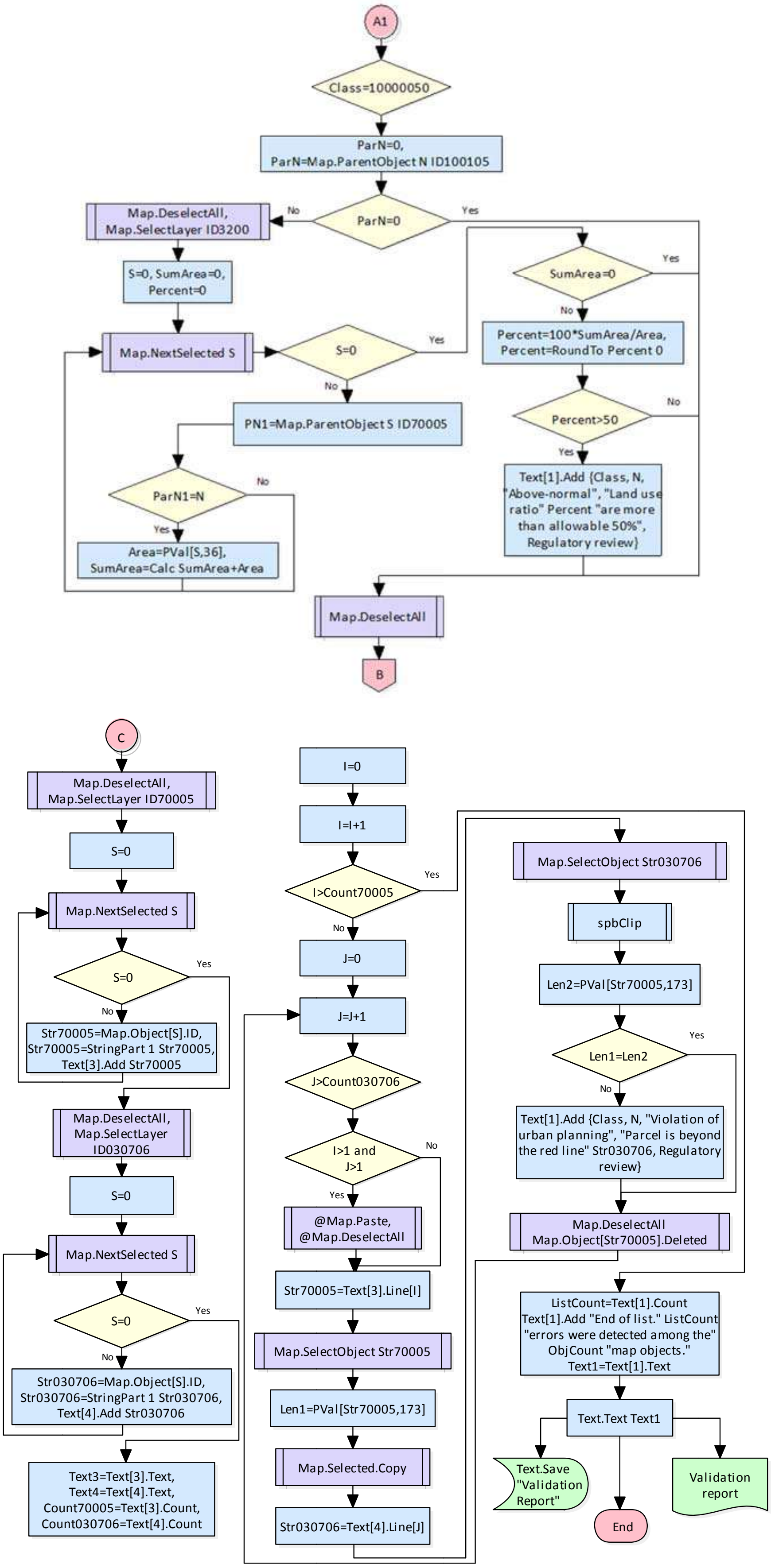

Fig. 4. Block diagram of data validation algorithm

In the process of the proposed algorithm, the following happens, namely:

- generating a report title;
- marking of objects with unauthorized occupation of land;
- marking of objects with outdated information and data that exceed the normative indicators for the targeted use of land;
- marking of objects exceeding the limit parameter of land development;
- marking objects that intersect with red lines;
- generation of statistics.

To implement the verification of the data array, the software for creating digital maps "Digitals" was used [16]. The program is designed to create/update topographic and special maps, maps, urban cadaster and land management, solutions of engineering and applied problems. Provides unlimited opportunities for writing various types of script applications to facilitate the work with geopositioning arrays is also useful for creating/editing/viewing digital topographic maps.

According to the defined groups of rules (systaxis, topology, relevance, semantics), the following TDB verification criteria have been developed:

- data is outdated;
- exceedance of the normative index;
- illegally occupied land;
- violation of urban planning conditions.

As a result of the proposed TDB validation algorithm, a generalized report on the missing data in the classes of the experimental object classes is generated. The verification report is presented in Figure 5.

Conclusions

The paper considers the existing analogues of the validation process. A conceptual model of the validation process based on the developed rules is formulated. Each rule is described for the implementation of certain regulations.

The scheme and structure of the topographic database are shown, showing which information systems the data was used for verification.

The study describes the attributes, classes, and information systems that are the input to the experiment object.

The presented TDB verification script allows to mark errors in information of information systems and to generate a report document.

Report on the verification of information in the TDB on the results of conversion
Performance Date: 2019-05-19 18:07
Artist: Sazcheg Export ID: 43604-60-38-46
Table of operation

No	Name of the layer	Object code	Contents of the error	Subject of the error	Note, base, regulatory reference
1	2	3	4	5	6
1	Layer 6100 “Trees”	26	Data is out of date	Date of measurement 25.01.2014, the latest actual date 19.05.2014	Decree "On Approval of the Procedure of National Topographic and Thematic Mapping", paragraph 11. The periodicity of updating of orthophoto maps (photocards) shall be no more than five years.
2	Layer 6100 “Trees”	28	Data is out of date	Date of measurement 25.01.2014, the latest actual date 19.05.2014	Decree "On Approval of the Procedure of National Topographic and Thematic Mapping", paragraph 11. The periodicity of updating of orthophoto maps (photocards) shall be no more than five years.
3	Layer 6100 “Trees”	29	Data is out of date	Date of measurement 25.01.2014, the latest actual date 19.05.2014	Decree "On Approval of the Procedure of National Topographic and Thematic Mapping", paragraph 11. The periodicity of updating of orthophoto maps (photocards) shall be no more than five years.
…	…	…	…	…	…
49	Layer 10000050 "Land boundary"	100	Exceedance of the normative index	Land use area of 0.1900 ha for the intended purpose code-07.03 is greater than the allowable 0.1000 ha	Land Code of Ukraine. Article 121. Norms of free transfer of land to citizens: r) for individual cottage construction - no more than 0.10 hectares. CCIP code 07.03 - For individual cottage construction.
50	Layer 10000050 "Land boundary"	100	Unauthorized occupied land	The actual land area of 0.1998 hectares is larger than the 0.1900 hectares of formalized land	Land Code of Ukraine. Article 211. 1. Citizens and legal persons shall bear civil, administrative or criminal liability in accordance with the law for the following violations: b) unauthorized occupation of land.
51	Layer 10000050 "Land boundary"	102	Exceedance of the normative index	The land is built at 62 per cent, which exceeds the maximum of 50 per cent	DBN B.2.2-12: 2018 Territory planning and development. Manor building area. Table 6.2 "Indicators of boundary parameters of land development". 3 floors without attic - not more than 50 per cent.
52	Layer 10000050 "Land boundary"	100	Violation of urban planning conditions	The land is outside the red line ID25!	DBN B.2.2-12: 2018 Territory planning and development. Paragraph 6.1.34. The fence of the land plot cannot stand for the red line and the boundaries of the plot. Item 10.7.7. Note 2. The red intersection lines at one or the different levels prohibit the placement of any buildings and structures except the relevant cross-sectional elements and engineering communications.
…	…	…	…	…	…
54	Layer 10000050 "Land boundary"	101	Violation of urban planning conditions	The land is outside the red line ID25!	DBN B.2.2-12: 2018 Territory planning and development. Paragraph 6.1.34. The fence of the land plot cannot stand for the red line and the boundaries of the plot. Item 10.7.7. Note 2. The red intersection lines at one or the different levels prohibit the placement of any buildings and structures except the relevant cross-sectional elements and engineering communications.
55	Layer 10000050 "Land boundary"	102	Violation of urban planning conditions	The land is outside the red line ID98!	DBN B.2.2-12: 2018 Territory planning and development. Paragraph 6.1.34. The fence of the land plot cannot stand for the red line and the boundaries of the plot. Item 10.7.7. Note 2. The red intersection lines at one or the different levels prohibit the placement of any buildings and structures except the relevant cross-sectional elements and engineering communications.

End of list. Among the 102 map objects, 55 errors were detected.

Fig. 5. Report of the validation application marking the missing information in the TDB

Conclusions

The paper considers the existing analogues of the validation process. A conceptual model of the validation process based on the developed rules is formulated. Each rule is described for the implementation of certain regulations.

The scheme and structure of the topographic database are shown, showing which information systems the data was used for verification.

The study describes the attributes, classes, and information systems that are the input to the experiment object.

The presented TDB verification script allows to mark errors in information of information systems and to generate a report document.

The mechanisms and tools proposed in this study for constructing an algorithmic model can be applied to further programmatic implementation of the system. Thus, marking the missed information in the TDB can significantly reduce the processing time of information archives and the results of their conversion.

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16. INSTRUMENTAL APPARATUS OF METHODOLOGY OF PROJECT MANAGEMENT UNDER THE CONDITIONS OF LINGUISTIC UNCERTAINTY OF PROJECT INFORMATION

Tymchuk O., Rach V.

Annotation. A project management methodology is proposed under the linguistic uncertainty of project information. It is proposed to use the concept of soft computing as an instrumental apparatus, namely, the perceptual computation apparatus and interval fuzzy sets of the second type. Based on the proposed methodology, a model for the formation of a managerial decision has been developed.

Key words: project management, uncertainty, soft computing, interval fuzzy set of the second type, perceptual computing

Introduction

Project management is carried out in conditions of uncertainty due to the uniqueness, disposability and temporary nature of projects. These features of projects lead to the impossibility of accumulating experience and statistics on a specific project in the traditional sense of these terms. Therefore, the uncertainty of project information that arises already at the first stage of the project life cycle appears at each subsequent stage of its implementation for any type of project. Accumulation of uncertainty in the project management process violates the balance between cost indicators, deadlines and quality of the final product and in many cases leads to the inability to complete the project within the framework of the planned indicators. It follows that the ability to manage the uncertainty of project information in project management is a basic requirement for the project manager.

Analysis of existing publications on uncertainties in project management showed that in the field of project management there is no unambiguous interpretation of this concept. This also applies to the uncertainty of design information. Despite this, in [1], uncertainty is used as the main criterion for project complexity, and its appearance is associated with the presence of problems, misunderstanding, and confusion in the process of solving design problems. In some works, the uncertainty in project management is directly or indirectly associated with unknown events or conditions in the future [2, 3]. In practice “uncertainty” is often identified with the concept of “risk” (for example, in [4]), despite a sufficient number of works in which the authors describe in detail their vision of the difference between these concepts in project management [5-8]. The basis for this erroneous use of terms is work in which risk is clearly associated with uncertainty. For example, in the latest edition of PMBOK [3], the concept of risk is described through uncertainty: "Risk is an uncertain event or condition, the occurrence of which negatively or positively affects the objectives of the project", but there is no definition of "uncertain event" and "uncertain condition". From the foregoing, it can be concluded that managing of uncertainty is an important process in project management. However, at present there is no understanding of the sources, types of uncertainty and, as a consequence, the general methodology of uncertainty management in project management.

Linguistic uncertainty in project management

Uncertainty when making decisions by project managers is caused by uncertainty about the sufficiency of knowledge of a problem or situation [2], that is, the lack or excess of information. At the same time, the process and the methods used in making decisions depend on the subjective understanding by the manager of the source and the type of uncertainty that he encounters. Existing uncertainty publications provide various classifications of types of uncertainty. For example, in [8] there are five types of uncertainty associated with measurement, process, model, estimation and implementation; in [10] there are two types of uncertainty associated with the fuzziness of information and the ambiguity of information.

In this paper, to determine the main source and type of uncertainty, an analysis is made of the methods that are used in project management. For analysis, the recognized PMBoK 6ed was chosen as the base document. The authors of this work have analyzed all the tools and methods offered in PMBoK for managing 49 processes from 10 areas of knowledge. In total, 6 groups of tools and methods are allocated in PMBoK, as well as 60 tools and methods that are not divided into groups.

Table 1 shows the ten most recommended tools and methods that together cover all areas of expertise in project management. The names of the fields of knowledge, tools and methods in table 1 are given according to PMBoK.

Table 1 shows that the most popular method is the method of expert assessments. In PMBoK, it is recommended to use it in 35 processes out of 49, which is about 72%. It should also be noted that expert evaluations are present implicitly in other tools and methods, for example, in data analysis, meetings, data collection, etc. Therefore, the share of expert evaluations in project management significantly exceeds 72%. The popularity of the expert assessment method in project management is primarily due to the fact that the inputs and outputs of most project management processes cannot be described quantitatively and quantitative relationships cannot be established between them.

Table 1 - The most recommended PMBoK project management tools and techniques

Instruments and methods	Project Management Knowledge Area * / Number of processes										Total
	K1/7	K2/6	K3/6	K4/4	K5/3	K6/6	K7/3	K8/7	K9/3	K10/4	
Expert review	7	4	3	4	1	2	2	6	3	3	**35**
Data analysis	3	4	4	4	3	2	0	6	3	3	**32**
Meetings	6	1	3	1	2	3	3	4	1	4	**28**
Interpersonal skills and teamwork	3	2	0	0	0	4	3	5	1	2	**20**
Data collection	2	1	0	0	3	0	0	4	1	2	**13**
Making decisions	2	3	1	1	2	1	0	1	0	2	**13**
Project management information system	1	0	3	2	0	3	2	1	0	0	**12**
Data display	0	1	0	0	3	1	2	1	0	3	**11**
Communication technologies	0	0	0	0	0	1	2	0	0	0	**3**
Parametric assessment	0	0	1	1	0	1	0	0	0	0	**3**
Total (by field of knowledge)	**24**	**16**	**15**	**13**	**14**	**18**	**14**	**28**	**9**	**19**	**170**

*- decoding of areas of knowledge:
K1-project integration management; K2-project content management;
K3-project schedule management; K4-project cost management;
K5-project quality management; K6-project resource management;
K7-project communications management; K8-project risk management;
K9-project procurement management; K10-project stakeholder management.

When using the method of expert assessments, the project manager is faced with problems obtaining data on the status of the project and their subsequent processing. The main sources of the problem of obtaining data should include: the difficulty of collecting expert estimates; the propensity of experts to conformism; subjectivity of the opinion of an individual expert; establishing the degree of consistency of expert assessments; comparisons of divergent opinions of experts.

When processing the received data, which are provided in a linguistic form, the project manager is faced with the uncertainty of this data, which arises due to the lack of an unambiguous interpretation among the experts of the parameters used and their assessment scales, as well as the dictionary used to evaluate the parameters. In addition, the parameters used are descriptive, projects evolve over time (which leads to a change in its structure and functions), and the components of the project are active in nature with not always predictable behavior.

From the foregoing, it follows that in project management there is a significant linguistic uncertainty of expert data. Given the indirect presence of the method of expert assessments in the collection and analysis of data, meetings, the manifestation of interpersonal skills and working with a team, a ranked list of areas of knowledge by level of uncertainty will be as follows: K8, K1, K10, K6, K2, K3, K7, K5, K4, K9. It should be noted that more than 50% of the peer review method is applied in four areas of knowledge, such as risk management, project integration, stakeholders and project resources. This method is least in demand in project procurement management.

In due time "..the need for humanization of science gave rise to the idea of soft mathematics, which increasingly began to ask for a paradigm" [11]. In our opinion, such a need is already ripe in the science of project, program and portfolio management. This is confirmed by the above context analysis of PMBoK.

The structure of the instrumental apparatus of the methodology of linguistic uncertainty in project management

The presence of linguistic uncertainty in all knowledge areas of project management, which makes urgent the development of new project management methodology, application of which should significantly enhance the efficiency and effectiveness of project managers in terms of linguistic uncertainty. To achieve this only possible with a systemic-holistic approach to the development and presentation of this methodology, working title is "Methodology LN". The instrumental apparatus such methodology is proposed to construct, using concept of soft computing. This approach is consistent with the process of project management methodology [12], which is currently the position with the forms of organization of scientific knowledge [13], has acquired the status of prospects as a forerunner of a new paradigm in project management [14]. In addition, it is consistent with the concept UICS-methodology, holistic thinking of the modern scientist-practice [15].

As the first instrumental component of the methodology LN will use the technique of interval fuzzy sets of the second type. This is substantiated by the following judgments.

Management model based on fuzzy logic is a set of linguistic variables with linguistic values that express the qualitative expert assessment, and fuzzy knowledge base of logical statements "IF-THEN". The classic approach to description of linguistic values involves the use of fuzzy sets of the first type (T1 FS). Since T1 FS do not allow to fully take into account the uncertainty of the expert evaluations due to the fact that the words for different experts mean different [16], the logical is the use of fuzzy sets of second type (T2 FS). Such sets provide an additional degree of freedom when working with the uncertainty due to the fact that the membership functions of T2 FS are ' fuzzy.

In order to avoid an ambiguous interpretation of the understanding of T2 FS type, we consider the main terms and their interpretation, which today is the most used in the theory of fuzzy sets and systems of the second type.

T2 FS $\tilde{A}$ imagine in the form

$$\tilde{A} = \{ \left((x,u), \mu_{\tilde{A}}(x,u)\right) | \forall x \in X, \forall u \in J_x \subseteq [0,1] \},$$

where X – primary universal set on which is defined $\tilde{A}$,

u – secondary universal set on which is defined $\tilde{A}$,

J_x – primary relationship function,

$\mu_{\tilde{A}}(x,u)$ – secondary relationship function $\tilde{A}$, $0 \le \mu_{\tilde{A}}(x,u) \le 1$.

Graphic illustration of membership function T2 FS $\tilde{A}$ is shown at Fig. 1.

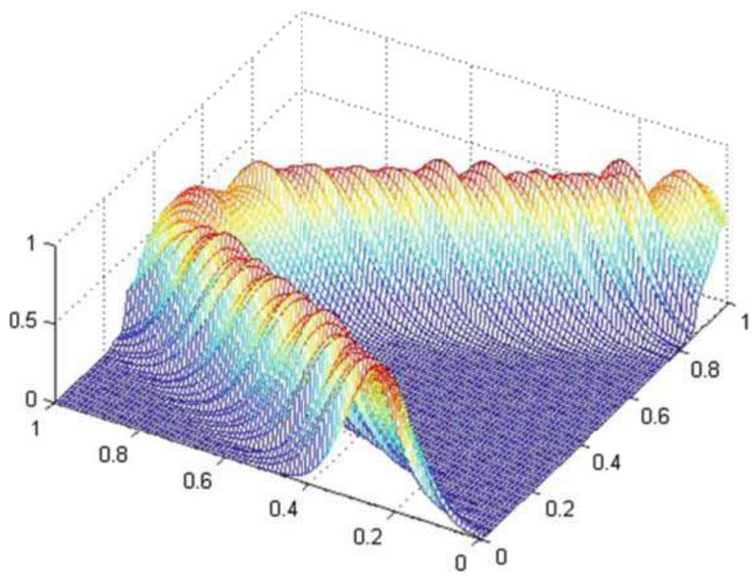

Fig. 1. Graphical 3-D representation of the membership function T2 FS Source: [16].

Due to the high computational complexity of T2 FSs, the interval T2 FS (IT2 FS) - T2 FS, for which all secondary estimates $\mu_{\tilde{A}}(x,u)$ are equal to 1 (this allows us not to consider the third dimension in IT2 FS), is currently more widely used. The combination of all the primary membership functions of IT2 FS $\tilde{A}$ is called the imprint of uncertainty. (FOU) $\tilde{A}$.

$$FOU(\tilde{A}) = \bigcup_{x \in X} J_x = \{(x,u): u \in J_x \subseteq [0,1]\},$$

$$J_x = \left[\ \underline{\mu}_{\tilde{A}}(x)\ ,\ \bar{\mu}_{\tilde{A}}(x)\ \right],$$

where $\underline{\mu}_{\tilde{A}}(x)$ – value of lower membership function, $LMF(\tilde{A})$;

$\bar{\mu}_{\tilde{A}}(x)$ – value of upper membership function, $UMF(\tilde{A})$.

Graphic illustration IT2 FS $\tilde{A}$ is shown at Fig. 2.

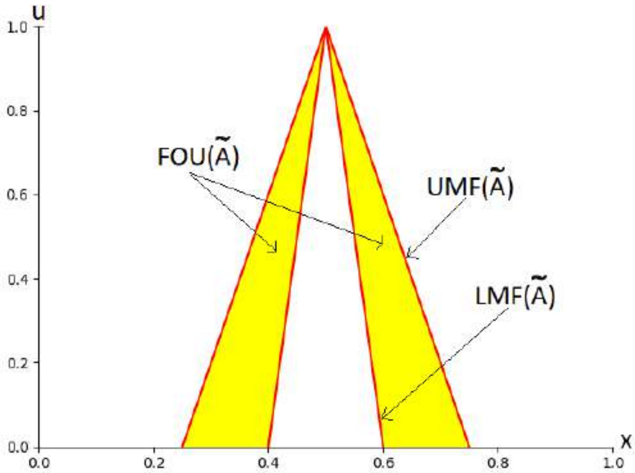

Fig. 2. Graphical representation GT2 FS

Source: [16] with revision by the authors.

As the second component of the instrumental apparatus of the LN methodology, we will use the methodology of perceptual calculations proposed by L.A. Zadeh, and further developed by J.M. Mendel. She proved herself well when applied to the processing of subjective opinions of experts on a specific parameter of the problem being solved. This methodology is based on a linguistic dictionary, the words from which are used both to activate the perceptual computer (Per-C) and to form the resulting recommendation. We consciously abandon the terminology that is not yet used in project management (Per-C), so as not to distort its original interpretation. Per-C consists of three blocks (Fig. 3):

- encoder - converts the words of experts into IT2 FSs;
- word handler - performs processing of words presented in the form of IT2FSs;
- decoder - displays the result of perceptual calculations in the form of recommendations (subjective judgment) with relevant supporting data.

According to J.M. Mendel, at least interval fuzzy sets of the second type (IT2 FS) should be used for word modeling.

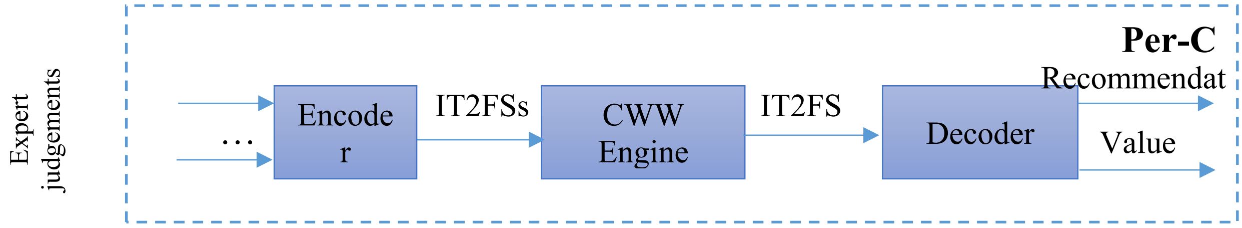

Fig. 3. Perceptual computer architecture

Source: [16] with revision by the authors.

As the third component of the instrumental apparatus of the FL methodology, we will use the interval fuzzy system of the second type (IT2 FS). It is applicable for the formation of management decisions. IT2 FS consists of five blocks (Fig. 4): fuzzifier block, rules base, fuzzy inference, type-reducer block, defuzzifier block.

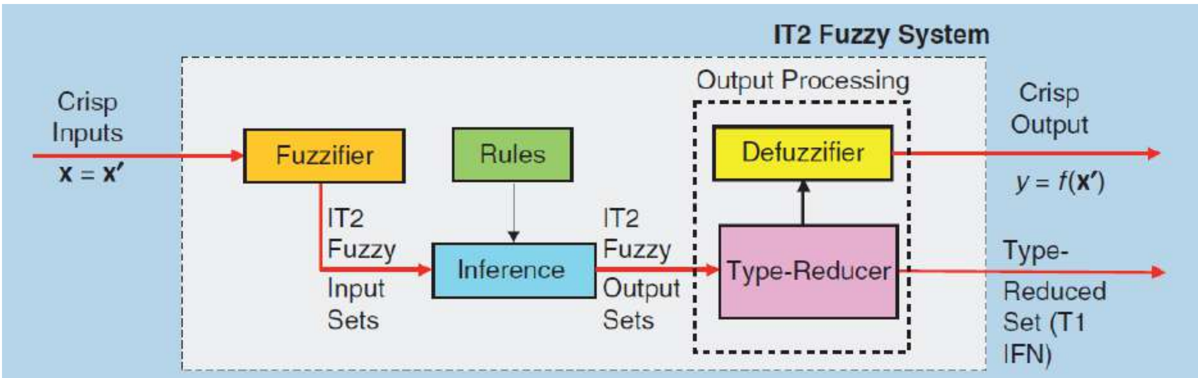

Fig. 4. Architecture of IT2 FS Source: [17].

In accordance with the theory of verbal computing and IT2 FS_s, the model of formation of a managerial decision will have the following form:

$$y = F(LI, LO, R, IN),$$

$$y = \langle \tilde{Y}, T, s \rangle,$$

$$LI = \langle li_n \rangle \,, n = \overline{1, N},$$

$$R = \langle r_m \rangle \,,\; m = \overline{1, M} \,,$$

$$IN = \langle in_n \rangle,$$

where y – evidence-based recommendation,

$\tilde{Y}, T, s$ – recommendation presented as IT2 FS, words and numbers respectively,

F – fuzzy inference operation (Mamdani algorithm),

LI – a set of input linguistic variables of the second type that describe the parameters of the project management task being solved,

N – number of input linguistic variables,

LO – the resulting linguistic variable of the second type, which describes the recommendations for solving the project management problem,

R – a set of fuzzy rules on the basis of which a recommendation is formed,

M – number of fuzzy rules,

IN – set of expert opinions,

$$in_n = F^*(V, W_n),\ in_n \in IN,$$
$$V = \langle v_j \rangle,\ j = \overline{1, J},$$
$$v_j = \langle T_j, \tilde{Y}_j \rangle\ ,$$
$$W_n = \langle w_k^n \rangle,\ w_k^n \in V,\ k = \overline{1, K},$$

where F^* – verbal operator,

V – vocabulary,

v_j – granular term,

T_j – word,

J – number of granular terms in a dictionary,

$\tilde{Y}_j$ – IT2 FS, which describes the word,

W_n – a set of expert verbal evaluations,

w_k^n – expert review,

K – the number of experts who take part in the survey.

The proposed toolkit of the FL methodology is an integral part of the project management information system (ISPM). To integrate the tools of the FL methodology with ISPM, the approaches proposed in [18, 19].

Conclusions

The conducted studies allow us to draw the following conclusions:

1. Project information in project management is uncertain. The PMBoK contextual analysis showed that uncertainty is manifested in all areas of project management knowledge, while the most uncertain are the areas of risk management, project integration, stakeholders and the content of the project, the least uncertain is project procurement management. Also,

as a result of PMBoK analysis, it was found that the main type of design information uncertainty is linguistic.

2. Taking into account the requirements for the organization of the project manager, it is necessary to develop a new methodology for project management in the context of linguistic uncertainty of project information.

3. The concept of soft computing is proposed to be used as a tool of the new methodology. At this stage, two instrumental components are identified: the apparatus of interval fuzzy sets and systems of the second type and the apparatus of perceptual calculations. The perceptive "computer" allows to manage expert estimates at decision-making by the project Manager, and interval fuzzy sets and systems of the second type – to consider linguistic uncertainty of these expert estimates.

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17. STOCHASTIC MODELING OF OPERATING DEVICES OF COMPUTER SYSTEMS WITH TWO-PHASE REQUEST PROCESSING

Litvinov A. L.

The article considers probabilistic models of operating devices of computer systems on which two-phase processing of requests using various algorithms is performed. In the general case, such devices operate under conditions of random flows of events, and their mathematical models will be mass service systems with two phases of processing requests on the serving device. A number of processing algorithms were studied for which the basic characteristics of operation were obtained.

Introduction

Microprocessor-based operating devices can process incoming processing requests using several algorithms, implementing multiphase maintenance. An example is the control processor exchange processor. The mode of inputting information from a peripheral device (PD) to the central processor (CP) can be divided into two sub-modes:1) input of information from the PD, its intermediate storage and preliminary processing; 2) transfer to the CP. Each sub-mode is run under its own program. The same thing, only in the reverse order, occurs when information is displayed. In the general case, such devices operate under conditions of random flows of events, and their mathematical models will be mass service systems with several phases of processing requests on one device.

In the work, as the functioning models of such operating devices, Poisson service systems with double query processing on one device are used under the following assumptions: the input stream of the first phase is Poisson with intensity λ; the request service time in the first and second phases is distributed exponentially with parameters μ_1 and μ_2, respectively; the request is first served on the first, and then on the second phase of one device. Queues before both phases are unlimited.

Three query processing algorithms are considered;

1) the first processing phase has a relative priority over the second;

2) the first phase has absolute priority; the request, the service of which in the second phase was interrupted, after the interruption is serviced;

3) the second phase has priority over the first (sequential servicing of the request in two phases).

The study of all three cases is given for the stationary state, the condition of which is the implementation of inequality $\rho = \rho_1 + \rho_2 < 1$, where $\rho_i = \dfrac{\lambda_i}{\mu_i}$.

1. Study of a system with a relative priority of the first phase

Let us consider in detail the case when the first processing phase has a relative priority over the second. Let us denote: $\{0\}$ - the system idle state (the probability of this is p_0); $\{n,\ m\}$ - the state when in the first phase $n,\ n \geq 1$, and in the second - $m,\ m \geq 0$, requests and the request is processed in the first phase (probability p_{nm}); $\{n,\ m'\}$ - the state of the system when in the first phase $n,\ n \geq 0$, and in the second - $m,\ m \geq 0$, of requests and the device serves the request in the second phase (probability q_{nm})..

For the operating mode of the service device under consideration, in accordance with the queuing theory [1], the following system of stationary equations can be compiled (which is supplemented by the usual normalization condition):

$$\begin{aligned}
&-\lambda p_0 + \mu_2 q_{01} = 0,\\
&-(\lambda+\mu_1)p_{10} + \lambda p_0 + \mu_2 q_{11} = 0,\\
&-(\lambda+\mu_1)p_{n0} + \lambda p_{n-1\,0} + \mu_2 q_{n1} = 0,\ n > 1,\\
&-(\lambda+\mu_1)p_{1m} + \mu_1 p_{2\ m-1} + \mu_2 q_{1\ m+1} = 0,\ m \geq 1,\\
&-(\lambda+\mu_1)p_{nm} + \mu_1 p_{n+1\ \ m-1} + \lambda p_{n-1\ m} + \mu_2 q_{n\ m+1} = 0,\ n > 1,\ m \geq 1,\\
&-(\lambda+\mu_2)q_{0m} + \mu_2 q_{0\ \ m+1} + \mu_1 p_{1\ m-1} = 0,\ m \geq 1,\\
&-(\lambda+\mu_2)q_{nm} + \lambda q_{n-1\ m} = 0,\ n \geq 1,\ m \geq 1,
\end{aligned} \tag{1}$$

To solve system (1), we introduce the generating functions

$$P_n(z) = \sum_{m=0}^{\infty} p_{n\,m} z^m,\ n \geq 1;\ Q_0(z) = p_0 + \sum_{m=1}^{\infty} q_{0\,m} z^m;\ \ Q_n(z) = \sum_{m=1}^{\infty} q_{n\,m} z^m,\ n \geq 1.$$

Then the following system of equations for the introduced generating functions will correspond to the system of equations (1):

$$\begin{aligned}
&[\mu_2 - (\lambda+\mu_2)z]Q_0(z) + \mu_1 z^2 P_1(z) - \mu_2(1-z)p_0 = 0,\\
&-(\lambda+\mu_1)zP_1(z) + \mu_1 z^2 P_2(z) + \mu_2 Q_1(z) + \lambda z p_0 = 0,\\
&-(\lambda+\mu_1)zP_n(z) + \lambda z P_{n-1}(z) + \mu_2 Q_n(z) + \mu_1 z^2 P_{n+1}(z) = 0, n > 1,\\
&-(\lambda+\mu_2)Q_1(z) + \lambda Q_0(z) - \lambda p_0 = 0,\ -(\lambda+\mu_2)Q_n(z) + \lambda Q_{n-1}(z) = 0.
\end{aligned} \tag{2}$$

From the fourth and fifth equations of system (2) it follows:

$$Q_n(z)=\left(\frac{\lambda}{\lambda+\mu_2}\right)^n\left[Q_0(z)-p_0\right],\ n\geq 1.$$

We introduce the generating functions $R(z,y)=\sum_{n=1}^{\infty}P_n(z)y^n$ и

$$D(z,y)=\sum_{n=0}^{\infty}Q_n(z)y^n=Q_0(z)+\frac{\lambda y}{\lambda+\mu_2-\lambda y}[Q_0(z)-p_0].$$

The second and third equations of system (2) can be transformed to one equation with respect to $R(z,y)$; if then we substitute into it the value $Q_1(z)$ expressed from the first equation of system (2), then in the end we get:

$$R(z,y)=\frac{Q_0(z)\left[(\lambda+\mu_2)zy-\mu_2 y+\dfrac{\lambda\mu_2 y^2}{\lambda y-(\lambda+\mu_2)}\right]+\left\{\left[(1-z)\mu_2 y-\lambda y^2\right]\cdot\left[z-\dfrac{\mu_2}{\lambda y-(\lambda+\mu_2)}\right]\right\}p_0}{\left[\lambda y^2-(\lambda+\mu_1)y+\mu_1 z\right]z}.$$

The denominator of the expression $R(z,y)$ has a zero ξ in the circle $|z|\leq 1$. Then

$$Q_0(z)=\frac{(z-1)\mu_2+\lambda\xi\left[z+\dfrac{\mu_2}{\lambda\xi-(\lambda+\mu_2)}\right]}{(\lambda+\mu_2)z-\mu_2+\dfrac{\lambda\mu_2\xi}{\lambda\xi-(\lambda+\mu_2)}}p_0$$

Using the normalization condition, which for the given system has the form $\left[R(z,y)+D(z,y)\right]_{z=1,\,y=1}=1$, we obtain $p_0=1-\rho$. Define the average number of requests awaiting processing before the first phase:

$$J_{11}=\sum_{n=1}^{\infty}(n-1)\sum_{m=0}^{\infty}p_{nm}+\sum_{n=1}^{\infty}n\sum_{m=1}^{\infty}q_{nm}=\left[\frac{\partial}{\partial z}R(z,y)\right]_{\substack{z=1,\\ y=1}}-\left[R(z,y)\right]_{\substack{z=1,\\ y=1}}+\left[\frac{\partial}{\partial z}D(z,y)\right]_{\substack{z=1,\\ y=1}}=$$

$$=\frac{(1-\rho)(1-\rho_2)(\rho_1^2+\rho_2^2)}{(1-\rho_1)(1-\rho_1-\rho\rho_2)}.$$

We determine the average number of requests awaiting processing before the second phase:

$$J_{12}=\sum_{n=1}^{\infty}\sum_{m=1}^{\infty}mp_{nm}+\sum_{n=0}^{\infty}\sum_{m=1}^{\infty}(m-1)q_{nm}=\frac{\rho(1-\rho)(\rho_1+\rho_2^2)(1+\rho_2)^2}{(1-\rho_1)(1-\rho_1-\rho\rho_2)^2}.$$

Average number of queries in the system:

$$L_1 = \sum_{n=1}^{\infty} n \sum_{m=1}^{\infty} m(p_{nm} + p_{nm}) = \frac{\partial^2}{\partial z \partial y}\left[R(z,y) + D(z,y)\right]_{z=1,\ y=1} =$$

$$= \frac{1-\rho}{1-\rho_1}\left\{\frac{1}{1-\rho_1}\left[\rho_1 + \rho_2^2 + \frac{\rho_2^2(\rho+\rho_2^2)+\rho_1\rho_2}{1-\rho_1-\rho\rho_2}\right] + \frac{\rho(\rho+\rho_2^4+3\rho_1\rho_2^2+\rho_1\rho_2^3)+\rho_2(1+3\rho_1^2-3\rho_1+\rho_2^3)}{\left(1-\rho_1-\rho\rho_2\right)^2}\right\}.$$

We find the Laplace – Stielties transform (LST) of the distribution function of the waiting time for processing before the first phase:

$$\varphi_{11}(s) = (1-\rho) + \sum_{n=1}^{\infty}\left(\frac{\mu_1}{\mu_1+s}\right)^n \sum_{m=0}^{\infty} p_{nm} + \frac{\mu_2}{\mu_2+s}\sum_{n=1}^{\infty}\left(\frac{\mu_1}{\mu_1+s}\right)^n \sum_{m=0}^{\infty} q_{nm}\ .$$

Where does the average waiting time for processing before the first phase:

$$\tau_{11} = -\left[\varphi_{11}'(s)\right]_{s=0} = \frac{\rho_1^2}{\lambda(1-\rho_1)} + \frac{\rho_2(1-\rho)(1-\rho_2)\left[\rho_2(1-\rho_1)+\rho\rho_1^2\right]}{\lambda(1-\rho_1)^2(1-\rho_1-\rho\rho_1)}.$$

Let’s define the LST of the distribution function of the waiting time for processing in the second phase. The request that made the system in state $\{0\}$ and $\{01'\}$ at the time of its arrival will wait in the second phase until the period of employment of the first phase ends. The probability of this, respectively, is p_0 and q_{01}. We denote the $\Gamma(s)$ of LST functions of the distribution of the period of employment of the first phase. According to [2]:

$$\Gamma(s) = \frac{\mu_1+s+\lambda-\sqrt{(\mu_1+s+\lambda)^2-4\lambda\mu_1}}{2\lambda},$$

and the average time of the period of employment of the first phase $g = (\mu_1-\lambda)^{-1}$. The request, which made the system able at the time of its arrival $\{02'\}$, will wait before the second phase with a probability q_{02} for a time δ equal to the service time of the previous request in the second phase plus the service time r of requests received during the time δ in the first phase, and those requests that received and served during the period of employment of the first phase. In fact, δ is the busy time of the service device, with the first request being served with intensity μ_2, and all the others with intensity μ_1

We define $G(s)$ - LST of the time distribution function δ. During the servicing of the first requirement described by the distribution function $1-\exp(-\mu_2 t)$, r requests will arrive in the first phase (the probability of this is $(\lambda\delta)^r / r! \cdot \exp(-\lambda\delta)$. Each of them will generate a period of employment of the first phase with the LST of the distribution function; then, according to [2]

$$G(s) = \beta_2[s+\lambda-\lambda\Gamma(s)] = \frac{\mu_2}{\mu_2 + \left[s+\lambda-\lambda\frac{\lambda+\mu_1+s-\sqrt{(\lambda+\mu_1+s)^2-4\lambda\mu_1}}{2\lambda}\right]},$$

where $\beta_2(s) = \mu_2/(\mu_2+s)$ – LST maintenance time in the second phase. Average time δ – $\bar{\delta} = -[G'(s)]_{s=0} = \frac{\mu_1}{\mu_2(\mu_1-\lambda)} = \frac{\rho_2}{\lambda(1-\rho_1)}$. The service request, which made the system at the time of its arrival $\{nm'\}$, will wait for processing before the second phase with a probability q_{nm} of one period of employment of the first phase plus $n+m-1$ time intervals, each of which is distributed similarly δ. The LST of the latency function of this application is defined by the expression $\Gamma(s)[G(s)]^{n+m-1}$.

Reasoning similarly, we find that the LST function of the time-out distribution of the request, which at the time of its arrival the system in the state $\{nm\}$, with probability p_{nm} is equal $\Gamma(s)[G(s)]^{n+m}$. At the end, the LST of distribution function of waiting time for the second phase will be determined as follows:

$$\varphi_{12}(s) = \Gamma(s)\left\{p_0 + \sum_{n=1}^{\infty}\sum_{m=0}^{\infty} p_{nm}[G(s)]^{n+m} + \sum_{n=0}^{\infty}\sum_{m=1}^{\infty} q_{nm}[G(s)]^{n+m-1}\right\} = \Gamma(s)[p_0 + R(z,y) + D(z,y)]_{z=y=G(s)}.$$

Let's define the average processing time before the second phase:

$$\tau_{12} = -[\varphi'_{12}(s)]_{s=0} = \frac{\rho_1}{\lambda(1-\rho_1)}\left\{1+\frac{\rho_2}{\rho_1}\left[J_{11}+J_{12}+\frac{\rho_1(1-\rho)(1+\rho_2)}{1-\rho_1-\rho\rho_1}\right]\right\}.$$

2. Study of a system with absolute priority of the first phase

We denote by {0} the system idle state (probability p_{00}), and - $\{nm\}$ the state when there are *n* requests in the first phase and *m* requests in the second phase (probability p_{00}). If $n > 0$, then the request is served in accordance with the absolute priority in the first phase. The system of stationary equations for state probabilities has the form:

$$\begin{aligned}
&-\lambda p_{00} + \mu_2 p_{01} = 0;\\
&-(\lambda+\mu_1)p_{n0} + \lambda p_{n-1\ 0} = 0, n \ge 1;\\
&-(\lambda+\mu_2)p_{0m} + \mu_1 p_{1\ m-1} + \mu_2 p_{0\ m+1} = 0,\ m \ge 1;\\
&-(\lambda+\mu_1)p_{nm} + \lambda p_{n-1\ m} + \mu_1 p_{n+1\ m-1} = 0,\ n \ge 1,\ m \ge 1.
\end{aligned} \tag{3}$$

We introduce the generating functions: $P_n(z)=\sum_{m=0}^{\infty}p_{nm}z^m$, $n\geq 0$. The system of equations (3) for state probabilities will correspond, after certain transformations, to the following system of equations for generating functions:

$$\begin{aligned}&[\mu_2-(\lambda+\mu_2)z]P_0(z)+\mu_1z^2P_1(z)-\mu_2(1-z)p_{00}=0,\\&-(\lambda+\mu_1)P_n(z)+\lambda P_{n-1}(z)+\mu_1zP_{n+1}(z)=0,\ n\geq 1.\end{aligned}\tag{4}$$

Introduce the generating function $Q(z,y)=\sum_{n=1}^{\infty}P_n(z)y^n$.

System (4) can be transformed to the following form:

$$\begin{aligned}&[\mu_2-(\lambda+\mu_2)z]P_0(z)+\mu_1z^2P_1(z)-\mu_2(1-z)p_{00}=0,\\&Q(z,y)=\frac{\mu_1zP_1(z)-[(\lambda+\mu_1)y-\mu_1z]-P_0(z)}{\lambda y^2-(\lambda+\mu_1)y+\mu_1z}\end{aligned}\ .\tag{5}$$

The denominator of the expression for $Q(z,y)$ has two zeros relative to *y:*

$$\xi=\frac{\lambda+\mu_1-\sqrt{(\lambda+\mu_1)^2-4\lambda\mu z_1}}{2\lambda},\ \eta=\frac{\lambda+\mu_1+\sqrt{(\lambda+\mu_1)^2-4\lambda\mu z_1}}{2\lambda},$$

Moreover $\xi\eta=\frac{\mu_1z}{\lambda}$, $(\xi+\eta)=\frac{\lambda+\mu_1}{\lambda}$, and $|\xi|<1$. Zero ξ must be zero and the numerator of the expression for $Q(z,y)$, therefore:

$$P_1(z)=\frac{(\lambda+\mu_1)\xi-\mu_1z}{\mu_1z\xi}P_0(z).\tag{6}$$

Substituting (6) into the first equation of system (5), we can express $P_0(z)$ in terms of p_{00}. Using the normalization condition, which will have the form $|Q(z,y)|_{z=1,\,y=1}=1$, we find $p_{00}=1-\rho$. As a result, we obtain the expression for $Q(z,y)$ *:*

$$Q(z,y)=\frac{\mu_1\mu_2(1-z)(\xi-y)(1-\rho)}{[\lambda y^2-(\lambda+\mu_1)y+\mu_1x]\cdot[(1-z)\mu_2\xi+\mu_1z(\xi-z)]}.\tag{7}$$

Considering the root of the denominator in (7) can be rewritten:

$$Q(z,y)=\frac{\mu_1\mu_2(1-z)(1-\rho)}{\lambda(\eta-y)\cdot[(1-z)\mu_2\xi+\mu_1z(\xi-z)]}=\frac{\mu_1\mu_2(1-z)z(1-\rho)}{\lambda\eta[(1-z)\mu_2\xi+\mu_1z(\xi-z)]}\sum_{n=0}^{\infty}\left(\frac{y}{\eta}\right)^n=\sum_{n=0}^{\infty}P_n(z)y^n,$$

where $P_n(z)=\frac{\mu_1\mu_2z(1-z)z(1-\rho)}{\lambda[(1-z)\mu_2\xi+\mu_1z(\xi-z)]\eta^{n+1}}$.

We determine the probability of finding *n* requests in the first phase:

$$p_n = \sum_{m=0}^{\infty} p_{nm} = \left[P_n(z)\right]_{z=1} = (1-\rho_1)\rho_1^n .$$

This coincides with a similar characteristic for a single-line system, which is to be expected, since the second phase has no effect on the operation of the first. Similarly, the average number of requests in the queue before the first phase J_{21} and in the first phase L_{21} as well as the average waiting time in the first phase τ_{21} coincide with the known results for a single-line system, i.e.

$$J_{21} = \frac{\rho_1^2}{1-\rho_1},\ L_{21} = \frac{\rho_1}{1-\rho_1},\ \tau_{21} = \frac{\rho_1^2}{\lambda(1-\rho_1)}.$$

We determine the average number of requests waiting before the second phase:

$$J_{22} = \sum_{n=1}^{\infty}\sum_{m=1}^{\infty} m p_{nm} + \sum_{m=1}^{\infty}(m-1)p_{0m} = \frac{\partial}{\partial z}\left[Q(z,y)\right]_{z=1,\ y=1} - P_0(z)\big|_{z=1} + p_0 = \frac{\rho(1-\rho_1\rho_2)}{(1-\rho)(1-\rho_1)}$$

The average number of requests in the second phase:

$$L_{22} = \sum_{n=0}^{\infty}\sum_{m=1}^{\infty} m p_{nm} = 1 + \frac{\rho-(1-\rho_1)(1-\rho_2)}{(1-\rho)(1-\rho_1)}.$$

Average number of queries in the system

$$L_2 = L_{21} + L_{22} = \frac{\rho - \rho_1\rho_2}{(1-\rho_1)(1-\rho_2)}.$$

We define the LST of the distribution function of the latency in the second phase $\varphi_{22}(s)$. To do this, we first determine the LST of the distribution function of the service time in the second phase, taking into account possible interruptions from the side of the first phase $\omega_2(s)$. The service time in the second phase $\psi_2 = b_2 + u$, where b_2 is the net service time of the request in the second phase and u is the time of all interruptions due to the arrival of requests in the first phase and the interruption of service of the request in the second phase. Each such interruption is a period of employment of the first phase. From here it is easy to see that the structure of the time interval ψ_2 is the same as the structure of the time interval δ for a system with relative priority of the first phase. Consequently,

$$\omega_2(s) = G(s) = \frac{\mu_2}{\mu_2 + \left[s + \lambda - \lambda\dfrac{\mu_1 + s + \lambda - \sqrt{(\mu_1+s+\lambda)^2 - 4\lambda\mu_1}}{2\lambda}\right]}$$

and average service time in the second phase is $\overline{\psi}_2 = \dfrac{\rho_2}{1-\rho_1}$.

Considering all possible states of the system and using the formula of total probability, we find the LST of the distribution function of the waiting time in the second phase similarly to the system with the relative priority of the first phase:

$$\varphi_{22}(s) = \Gamma(s)\sum_{n=0}^{\infty}\sum_{m=0}^{\infty} p_{nm}\left[\omega_2(s)\right]^{n+m} = \Gamma(s)\left[Q(z,y)\right]_{z=y=\omega_2(s)}.$$

Define the average waiting time for the start of service in the second phase:

$$\tau_{22} = -\left[\varphi'_{22}(s)\right]_{s=0} = \frac{1}{\lambda(1-\rho_1)}\left[\rho_1 + \frac{\rho_2(\rho - \rho_1\rho_2)}{(1-\rho_1)(1-\rho)}\right].$$

3. Researching a system with sequential query processing

With this algorithm, a newly arrived request first passes service in the first phase, and then in the second. For this system, the total service time of a request is the sum of the service time in the first and second phases. The whole system can be reduced to a single-line system with a service time having LST distribution functions $b(s) = \dfrac{\mu_1\mu_2}{(\mu_1+s)(\mu_2+s)}$, an average value $b_1 = 1/\mu_1 + 1/\mu_2$, and a second initial moment $b_2 = 2\left\{(1/\mu_1 + 1/\mu_2)^2 - 1/\mu_1\mu_2\right\}$.

We denote by p_0 the probability of system downtime, and by p_{ni} the probability that there are n requests in the system at an arbitrary instant of time of a stationary state, and the request is serviced at the i-th phase ($n > 0,\ i = 1,\ 2$).

For the probabilities of the stationary state of the system under consideration, the following system of linear equations:

$$\begin{aligned}
&-\lambda p_0 + \mu_2 p_{21} = 0,\\
&-(\lambda+\mu_1)p_{11} + \lambda p_0 + \mu_2 p_{22} = 0,\\
&-(\lambda+\mu_2)p_{12} + \mu_1 p_{11} = 0,\\
&-(\lambda+\mu_1)p_{n1} + \lambda p_{n-1\,1} + \mu_2 p_{n+1\,2} = 0,\ n > 1,\\
&-(\lambda+\mu_2)p_{n2} + \lambda p_{n-1\,2} + \mu_1 p_{n\,1} + = 0,\ \ n > 1.
\end{aligned} \tag{8}$$

Normalization condition: $p_0 + \sum_{n=1}^{\infty}\sum_{i=1}^{2} p_{ni} = 1$.

Note that in accordance with the theory of single-line queuing systems with an unlimited queue [3] loading the system $\rho = \lambda(1/\mu_1 + 1/\mu_2)$ and $p_0 = 1-\rho$.

To solve system (8), we introduce the generating functions

$$Q_1(z) = \sum_{n=1}^{\infty} p_{n1} z^n, \quad Q_2(z) = \sum_{n=1}^{\infty} p_{n2} z^n \quad .$$

The system of equations (8) will correspond to the following system of equations for the introduced generating functions:

$$\begin{aligned} &\left[-(\lambda+\mu_1)+\lambda z\right] z Q_1(z)+\mu_2 Q_2(z)=\lambda z(1-z) p_0, \\ &\mu_1 Q_1(z)+\left[-(\lambda+\mu_1)+\lambda z\right] Q_2=0. \end{aligned} \tag{9}$$

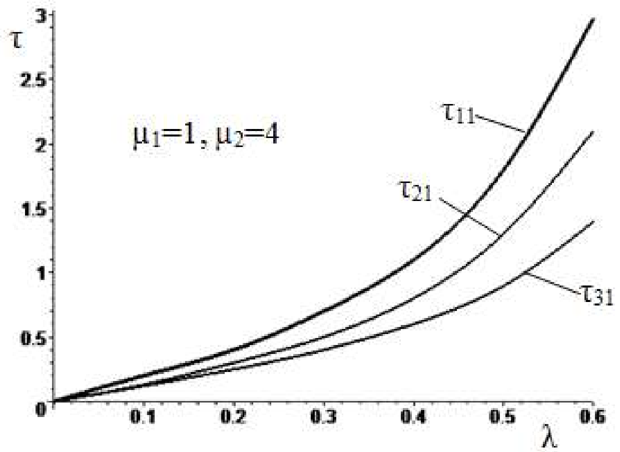
The solution of the system of equations (9) will have the form:

$$Q_1(z)=\frac{\lambda z(1-z)\left[-(\lambda+\mu_1)+\lambda z\right](1-\rho)}{\left[-(\lambda+\mu_1)+\lambda z\right]^2 z-\mu_1\mu_2},\ Q_2(z)=\frac{\lambda\mu_1 z(z-1)(1-\rho)}{\left[-(\lambda+\mu_1)+\lambda z\right]^2 z-\mu_1\mu_2}.$$

Having done calculations similar to items 1 and 2, we find:

– average number of requirements in the system: $L_3=\frac{\partial}{\partial z}\left[Q_1(z)+Q_2(z)\right]_{z=1}=\frac{\rho-\rho_1\rho_2}{1-\rho}$;

– average waiting time for processing before the first phase: $\tau_{31}=\frac{\rho^2-\rho_1\rho_2}{\lambda(1-\rho)}$.



The figure for the three cases considered shows graphs of the waiting time in the first phase of the intensity of the input stream.

Conclusions

Multiphase processing on a single operating device significantly reduces hardware costs. From the analysis it follows that the provision of great advantages of the first phase significantly reduces the time of primary processing of information, especially at high load, which is especially important in real-time systems.

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18. OPTIMIZATION MODEL OF PROJECT MANAGEMENT TO IMPROVE THE TOURIST ATTRACTIVENESS OF REGIONS OF UKRAINE

Chernenko V.P.

Annotation. In this paper, a cluster analysis of the tourist attractiveness of Ukrainian regions in 2012 and 2017 is conducted in order to identify the areas of outsiders. With the help of the project approach in tourism, an optimization model was built to improve the tourist attractiveness of individual regions.

Formulation of the problem. Ukraine's tourism industry as a multifaceted phenomenon of social life is becoming increasingly important for the development of not only the economy but also the social sphere. The tourism sector of the economy is one of the indicators of the standard of living of the population, its development entails increasing employment of the population, expanding the range of services, creating the middle class in the country. Therefore, it requires comprehensive research and analysis. The modern development of the tourism industry as a component of the national economy depends entirely on a number of certain factors, the impact of which will be different not only in different countries but also in the regions of one country.

The tourist attractiveness of the region is the potential of the tourist resources of the region, which meets the needs of tourists and ensures the maximum socio-economic impact of its development within the tourism industry. Project management in the tourism industry is one of the promising areas for creating optimal systems that can be used to develop useful recommendations for each region.

Ukraine has a great potential in developing inland and inbound tourism. However, for the real development of the tourism industry, there is a lack of clear and objective information regarding the tourist attractiveness of Ukrainian regions. Thus, there is a need for a detailed classification of regions of Ukraine by tourist attractiveness and identification of economically feasible measures to improve the unattractive tourist regions.

Literature analysis. Many domestic scientific works are devoted to determining the factors that influence the tourism industry of Ukraine [1–3]. The author of the article [1], on the basis of the SWOT-analysis method, conducts an expert evaluation on the influence of individual factors, determines the necessary number of experts for the objective poll and calculates the degree of agreement of experts' opinions. In [2] the problems of estimation of tourist attractiveness of the territory and objects of the natural and recreational sphere are considered. A network structural model is proposed for evaluating the tourist attractiveness of the territory, which can be used in determining the patterns of interaction of components of a regional tourist complex and improving the process of developing appropriate development strategies, plans and forecasts.

Also, researchers in the tourism industry are interested in the purpose of target management of tourist flow projects in order to optimize costs. For example, the author of [4] carried out a cluster analysis to manage the configurations of tourism projects related to the grouping of tourist flows by the example of the Lviv region in the period 2007–2010.

Article [5] proposes the use of a project approach to tourism management in Ukraine. The peculiarities of application of the project approach at the state level, the level of the tourist region and destination are considered and the methodology of project management in tourism is proposed.

The purpose of the study is to build an optimization model of project management to improve the tourist attractiveness of Ukrainian regions.

Presenting the main material. A cluster analysis of the tourist attractiveness of Ukrainian regions can significantly improve the efficiency and quality of design decisions in the tourism industry. For the clustering of regions of Ukraine, five indicators of tourism activity were selected, which are given in Table. 1. The values of these indicators are taken from the statistical collection "Tourism in Ukraine" for 2017 (this is the latest statistical collection presented on the website of the State Statistics Service of Ukraine) [6].

Table 1 - Characteristics of tourist activity of regions of Ukraine in 2017.

Region	Capital investments in art, sports, entertainment and recreation, mln UAH	Number of subjects of tourist activity by regions, units.	Income from the work of subjects of tourism, thousand UAH	Number of collective accommodation facilities by region, units.	Income of collective accommodation facilities, thousand UAH
1	2	3	4	5	6
Cherkassy	1628,8	92	16027,1	119	98565
Chernigiv	1470,2	51	8016,1	49	61175,1
Chernivtsi	598,4	65	52893,7	81	68420,7
Dnipro	8581,6	325	66271	228	373949,1
Donetsk	1726,9	42	74810,6	121	236178,8
Ivano-Frankivsk	970,8	105	282035,8	274	579154,5
Kharkiv	27106,8	263	66501	175	453797,6
Kherson	736,2	67	197711,9	225	255704,1
Khmelnytskiy	1050	90	13718,2	90	121355,6
Kiev	3449,4	116	38537,9	162	413741,7
Kropiwnicki	1464,2	43	9721,8	46	45804,3

1	2	3	4	5	6
Luhansk	1665	17	2803,6	29	42592,1
Lviv	9642,4	282	413145,6	337	2083775
Mykolaiyv	4471,2	63	9356,8	271	231244,1
Odessa	2230	264	175376,5	529	994814
Poltava	1585,5	93	13415,9	107	455485,1
Rivne	1225,4	60	14564,9	52	99297,1
Sumy	694,7	58	8366,1	52	51593,4
Ternopil	2145,3	45	8806,7	66	64694,9
Vinnytsya	2348,8	69	35811,1	85	355977,5
Volyn	704,2	66	25931,1	131	109903,9
Zakarpattya	5624	63	16701,3	250	646980,3
Zaporizhzhya	3176	160	33133	374	583216,3
Zhytomyr	2316,6	47	6841,5	80	95855,4

Continuation of Table 1

Initially, all baseline data were ranked according to the growth of tourist activity indicators, and then the grouping of regions was carried out by hierarchical clustering in SPSS 21. The results were as follows: Dnipro, Zaporizhzhya, Kyiv, Lviv, Odessa, Kharkiv regions were included in the first cluster, in the second cluster. Vinnytsia, Volyn, Donetsk, Poltava, Rivne, Khmelnytskiy, Cherkassy, Chernivtsi regions, the third cluster includes Zhytomyr, Kropyvnytskyi, Luhansk, Sumy, Ternopil, Chernigiv region. Zakarpattya and Mykolaiv regions (fourth cluster) and Ivano-Frankivsk and Kherson regions (fifth cluster) were grouped separately. For the sake of clarity, the histogram was constructed, showing the average values of the ranks for each indicator by clusters (Fig. 1). Fig. 1 helps to adopt the following abbreviations: STA - subjects of tourism; CP - collective placement.

Fig. 1 shows that in 2017, the first attractive cluster included the most attractive areas in which all indicators of tourism activity are of high importance; areas with average values are grouped into the second cluster; In the third cluster are the areas of outsiders. Two regions are grouped separately into a fourth cluster, in which the situation with the number of tourist entities and their income is bad. Also, a fifth cluster has been formed from two areas where only one out of five is low - capital investments in arts, sports, entertainment and recreation.

In order to identify regions with a tendency for a dynamic development of the tourism industry, a clustering of the tourist attractiveness of the regions of Ukraine in 2012 was carried out according to the method described above. The baseline data (Table 2) are taken from the 2012 statistical compilation Tourism Activity in Ukraine. [6].

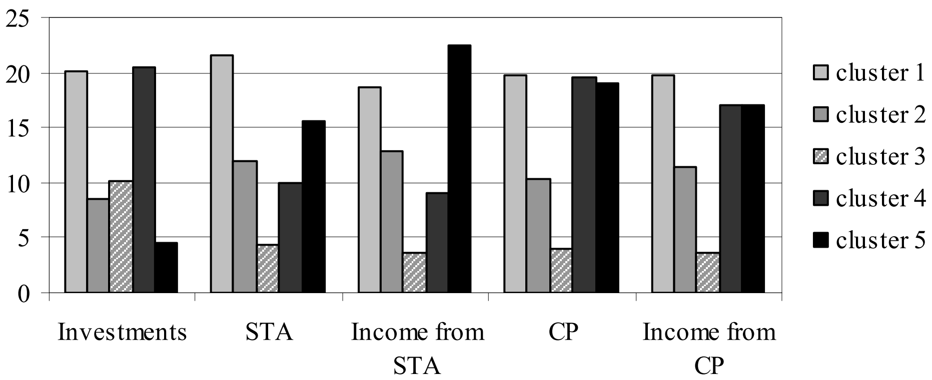

Fig. 1. Average values of tourist activity indexes of regions of Ukraine by clusters in 2017

Table 2 - Characteristics of tourist activity of regions of Ukraine in 2012.

Region	Capital investments in art, sports, entertainment and recreation, mln UAH	Number of subjects of tourist activity by regions, units.	Income from the work of subjects of tourism, thousand UAH	Number of collective accommodation facilities by region, units.	Income of collective accommodation facilities, thousand UAH
1	2	3	4	5	6
Cherkassy	378,1	108	6896,9	115	50124,2
Chernigiv	821,1	59	2961,0	79	40633,7
Chernivtsi	222,9	141	10624,3	100	26344,6
Dnipro	11254,5	404	41028,8	260	646426,4
Donetsk	9516,6	310	85453,4	483	696348,3
Ivano-Frankivsk	0	109	244251,2	200	176764,7
Kharkiv	35421,6	370	42576,0	221	298992,8
Kherson	974,4	79	20276,6	315	197574,5
Khmelnytskiy	348,9	99	10376,7	84	94089,9
Kiev	6110,1	69	10342,0	134	194043,3
Kropiwnicki	0	64	13298,7	73	31414,2
Luhansk	1644,6	87	11548,8	109	49707,7
Lviv	4469,2	279	236575,4	328	1263971,9
Mykolaiyv	1408,8	72	34035,9	300	203907,3
Odessa	1463,1	289	129713,6	623	630012,8
Poltava	0	127	9974,7	133	231467,8
Rivne	277,1	65	5741,5	63	61256,7
Sumy	0	53	4573,2	69	43541,1
Ternopil	337,5	64	5256,5	64	56585,5
Vinnytsya	582,4	87	11097,5	90	243683,8
Volyn	1953,0	83	12766,0	126	68065,2
Zakarpattya	820,8	130	15142,2	208	317680,6
Zaporizhzhya	720,4	160	24461,0	315	334993,9
Zhytomyr	867,9	66	4058,2	70	58164,1

The table shows that in 2012, unlike 2017, there was zero capital investment in arts, sports, entertainment and recreation!

As a result of cluster analysis, the following clusters were formed:

– first cluster: Dnipro, Donetsk, Zakarpattya, Zaporizhzhya, Lviv, Mykolayiv, Odessa, Kharkiv, Kherson regions;

– second cluster: Volyn, Kyiv, Lugansk regions;

– third cluster: Vinnytsya, Poltava, Khmelnytskiy, Cherkassy, Chernivtsi regions;

– fourth cluster: Zhytomyr, Kropyvnytskyi, Rivne, Sumy, Ternopil, Chernigiv regions;

– fifth cluster: Ivano-Frankivsk region.

The results of the cluster analysis in the form of a histogram are presented in Fig. 2.

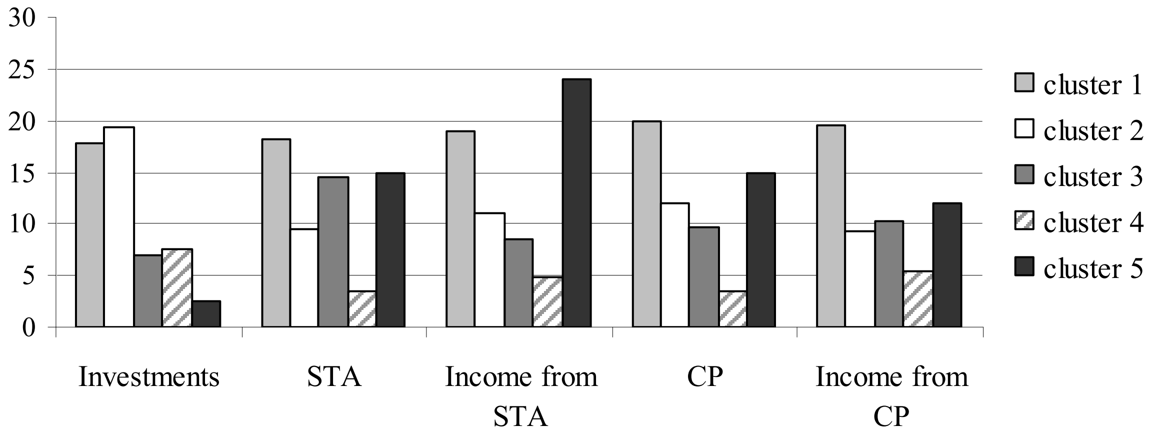

Fig. 2. Average values of tourist activity indexes of regions of Ukraine by clusters in 2012.

Analyzing Fig. 2, we can see that the regions of outsiders in 2012, ie the regions with the least tourist attraction, were in the fourth cluster. Next, compare this cluster with the third cluster in 2017. In both years, Zhytomyr, Kropyvnytskyi, Sumy, Ternopil, and Chernigiv regions came to the cluster of outsider regions. In 2012, the Luhansk region is in a cluster with average tourist activity, and in 2017 it is in the cluster least attractive because in 2017 the indicators are taken for part of the territory of the Luhansk region. Another situation with the Rivne region - in contrast, from the outsider region, in 2012, it was transformed into a cluster with the best indicators of tourism activity in 2017 due to, first, an increase in capital investment in arts, sports, entertainment and recreation, and, second, with a decrease in the number of subjects of tourist activity and collective accommodation facilities, the income from their activity increased (Table 1, 2).

It is also interesting to compare the results of the studies according to the proposed method with the results of the estimation of the generalized integral indicator of tourist attractiveness of the regions of Ukraine in 2012 [3]. According to the methodology proposed by O. Muzychenko-Kozlovskaya, the most significant indicators that influence the tourist attractiveness of the territory include: area of natural recreational resources; the number of anthropogenic tourism resources; the number of tourist accommodation facilities; fixed capital investments in hotels and restaurants; an average level of prices for services in tourism enterprises.

According to the scale of evaluation of tourist attractiveness of a region, which is described in [3], areas for which the value of the integral index is less than 0.4 have an unsatisfactory level of tourist attraction. In the table. 3 all regions of Ukraine are named in the order of increasing the integral indicator of the tourist attractiveness of the region. The Cluster column indicates the cluster number that the region was assigned to using the method proposed in this paper. Italics highlight areas from the fourth cluster, that is, outsiders.

Table 3 - Generalized characteristics of tourist attractiveness of Ukrainian regions by different methods in 2012

Region	An integral indicator of evaluating the tourist attractiveness of the region	Cluster
1	2	3
Sumy	*0,291*	*4*
Chernivtsi	0,3004	3
Ternopil	*0,302*	*4*
Khmelnytskiy	0,3049	3
Cherkassy	0,3057	3
Volyn	0,3125	2
Chernigiv	*0,3135*	*4*
Zhytomyr	*0,3197*	*4*
Poltava	0,3211	3
Zakarpattya	0,3342	1
Vinnytsya	0,3392	3
Rivne	*0,3431*	*4*
Lviv	0,3456	1
Dnipro	0,3747	1
Kropyvnytskyi	*0,3777*	*4*
Kherson	0,3833	1
Ivano-Frankivsk	0,3903	5
Lugansk	0,4165	2
Kyiv	0,4457	2
Mykolayiv	0,4566	1
Kharkiv	0,4663	1
Donetsk	0,4798	1
Zaporizhzhya	0,5421	1
Odessa	0,7877	1

Therefore, the cluster analysis shows the actual tourist attractiveness of the regions of Ukraine, taking into account the existing tourism resources in the region and the capital investments that contribute to the development of tourism. But the question is - how to improve the tourist attractiveness in the regions with the lowest tourist activity?

The strategic orientation of tourism design requires its regulation at the national and regional levels through the adoption of targeted programs for the development of the tourism industry in a particular region, which will increase the socio-economic efficiency of tourism and increase the tourist attractiveness of Ukraine in the world tourist market.

Regional tourism design provides a clear formulation of ideas for the development of the tourist region, determined in accordance with the development of the state portfolio of projects and the establishment of a program of measures to increase the level of tourist attractiveness of the region in terms of limited resources and clearly defined time, a certain amount and quality, to best meet the requirements of tourists.

The essence of an optimization model of project management for improving the tourist attractiveness of the region lies in the choice of such an optimal structure of measures, taking into account the economic feasibility, the implementation of which will significantly affect the efficiency of using the tourist potential of the region.

Measures to increase the tourist attractiveness of the region can be formed in the following directions [3]:

– increasing the attractiveness of tourist resources and historical and cultural sites (1); reconstruction and modernization of the logistics base of tourism (2); improving the quality of service (3); creation of the necessary infrastructure (4); information and promotion of the tourism industry (5); provision of highly skilled workforce training for the tourism industry (6); improving the quality of the environment within tourist areas (7); formation of a system of regional marketing actions aimed at attracting tourists (8).

We build an optimization model of project management to improve the tourist attractiveness of an outsider region, such as the Zhytomyr region. Let each measure to increase the tourist attractiveness of the region consists of four stages. Table. 4 shows the average relative values of expert assessments of each stage of each event, the sum of which is equal to 1 and the average annual expenses for each stage of each event in thousand UAH - in Table. 5.

It is necessary to choose such an optimal structure of activities, the implementation of which should have a significant impact on improving the tourist attractiveness with limited resources available.

The optimal structure of measures to increase the tourist attractiveness of the Zhytomyr region was obtained with the help of MS Excel and is given in Table. 6.

Table 4 - Average values of relative expert judgment on the effectiveness of the event and its stages

Event number	Average values relative performance reviews holding an event,	Stage number			
		1	2	3	4
		The average values of relative peer reviews on-stage performance, q_{ij}			
1	2	3	4	5	6
1	0,25	0,35	0,15	0,25	0,35
2	0,15	0,25	0,20	0,10	0,25
3	0,10	0,30	0,25	0,25	0,30
4	0,10	0,10	0,10	0,30	0,10
5	0,20	0,20	0,15	0,20	0,20
6	0,05	0,10	0,30	0,25	0,10
7	0,05	0,30	0,15	0,15	0,30
8	0,10	0,20	0,40	0,30	0,20

Table 5 - Average annual expenses for activities in thousand UAH

Event number	Stage number				Limitation by resources, b_i
	1	2	3	4	
1	5045,731	7568,597	2522,866	5045,731	16000
2	74400,73	111601,1	37200,37	74400,73	380000
3	3053,832	4580,748	1526,916	3053,832	10000
4	9134,592	13701,89	4567,296	9134,592	32000
5	1032,84	1549,26	516,42	1032,84	4000
6	262,884	394,326	131,442	262,884	1100
7	39031,78	58547,66	19515,89	39031,78	140000
8	2163,948	3245,922	1081,974	2163,948	6500

The general mathematical model of the optimization problem has the form [7]:

$$Z = \sum_{i=1}^{8} r_i \sum_{j=1}^{4} q_{ij} x_{ij} \to \max, \ \sum_{i=1}^{8} \sum_{j=1}^{4} s_{ij} x_{ij} \le b_i,$$

$$0 \le x_{ij} \le 1; \ x_{ij} \text{ – targets}; i = 1,\dots,8; \ j = 1,\dots,4,$$

where x_{ij} – required Boolean variable equal to 1 if the j-th stage of the *i*-th event is held, and 0 - in case its conducting is impractical.

Table 6 - Results of calculations of the optimal structure of measures

Event number	Stage number			
	1	2	3	4
1	0	1	1	1
2	1	1	1	1
3	0	1	1	1
4	1	1	0	1
5	1	1	0	1
6	1	0	1	1
7	1	1	0	1
8	0	1	1	1

Table 7 shows the optimal structure of the resource cost of conducting measures to improve the tourist attractiveness of the Zhytomyr region.

Table 7 - Results of calculations of the optimal structure of the resource cost of activities

Event number	Stage number				Total expenses, thousand UAH
	1	2	3	4	
1	2	3	4	5	6
1	---	5045,7	7568,6	2522,9	15137,2
2	148801,5	74400,7	111601,1	37200,4	372003,7
3	---	3053,8	4580,7	1526,9	9161,5
4	18269,2	9134,6	---	4567,3	31971,1
5	2065,7	1032,8	---	516,4	3614,9
6	525,8	---	394,3	131,4	1051,5
7	78063,6	39031,8	---	19515,9	136611,2
8	---	2163,9	3245,9	1082,0	6491,8

Conclusions. The application of the project approach to managing the development of regional tourism allows effective use of territorial features that have a positive effect on the tourist attractiveness of the region. Further scientific research is advisable in building an optimization model of project management for the tourist attractiveness of the region, taking into account the economic efficiency of the program activities.

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19. MODERN ASPECTS OF CONSTRUCTION OF INFORMATION SYSTEM WITH THE USE OF ARTIFICIAL INTELLECTUAL ON THE BASIS OF NEURAL NETWORKS

Petrenko V.O., Fonarova T.A., Bushuiev K.M.

Abstract. The authors investigate the information component of behavioral economics. The possibilities of using artificial intelligence based on neural networks for decisions under conditions of limited analytical capabilities of the individual are substantiated. The result of the study is specific recommendations for building an information system that incorporates an intelligent neural network decision support system. The results of the testing of such a system in the current conditions of Ukrainian enterprises in different directions of using the capabilities of neural networks and systems based on them.

Introduction

It is well known that effective management decisions are based on information, intellectual resources and knowledge that the company possesses. At the same time, enterprises operate in the context of a global information society. Behavioral economic theory designed to combine psychology and economics. It is a behavioral economics that leads to a change of view on attitudes and decision-making in today's economy.

The aim of this study is to improve the enterprise information system through the introduction of intellectual system of support of decision-making (ISSDM) with the use of neural networks and consideration of its capabilities, in the forecasting of a condition of the marketing environment. The relevance of the study lies in the fact that the basis of successful market operation of a modern enterprise is an information system that covers all functional areas of its activities and becomes an important Foundation in making strategic and tactical decisions. Using the possibilities of artificial intelligence through the implementation of ISSDM in an enterprise information system will provide management with quality information to make effective managerial decisions under conditions of limited analytical possibilities of the person, and this, in turn, will enhance competitiveness and ensure sustainable development of the enterprise. But, the possibilities of applying neural networks have not been studied enough and have not spread in the practice of Ukrainian enterprises. At the same time, the capabilities of neural networks are gaining more and more industries, thanks to the relative ease of use and quality results in modeling and forecasting of economic processes and market situation.

The study of the use of neural networks was addressed by domestic and foreign scientists: Khikin S., Rudenko O.G., Bodiansky E.V., Osovsky S. and others. Neural Networks is a fairly flexible product that gives developers a lot of opportunities to achieve specific goals. Questions of application of information-analytical decision-making systems were investigated by both foreign and domestic scientists: S.M.Bratushka, M.A. Demidenko, V.F. Sitnik, S.O. Subbotin, L.V. Shavelyov and others. [1]

Problems of building an enterprise information system are covered in the works [2], Frolenko O. M. [2], Panuhnik Y. G. [3], Sokhatska O. [4], but improved with the use of ISSDM based on neural networks is not highlighted. The paper [5] investigates the issues of improving the MIS of the enterprise on the basis of NN, but did not address the issues of forecasting the macroeconomic indicators of the enterprise, which, for example, influence the development of the strategy of entering foreign markets. The work [6] investigates the mathematical model of forecasting macroeconomic indicators of the Ukrainian economy, but does not cover the role of neural networks for the prediction of internal environment processes, such as, for example, forecasting the value of engineering services projects, or accounting and assessing the creditworthiness of customers in the activities of the bank.

The development of credit rating systems was undertaken by such Ukrainian scientists as Sivchuk T. [7], Velikoivanenko G.I. [8], Kozhukhivska O.A. [9], but the use of neural networks is not sufficiently covered, there are no specific methodological recommendations for the implementation of neural network systems in the activities of banks and financial institutions.

Therefore, many more questions on the practical application of the capabilities of artificial intelligence based on NN need to be developed and tested in the current conditions of Ukrainian enterprises.

Research methodology

The main element of the neural network is a formal neuron that performs the operation of nonlinearly converting the sum of the products of the input signals by weighting factors. Different training algorithms and their modifications are used for network training. It is very difficult to determine which training algorithm will be the fastest when solving a particular problem. Of greatest interest to us is the reverse propagation algorithm, as it is an effective tool for learning multilayer neural networks. The algorithm minimizes the root mean square error of the neural network. To do this, a gradient descent method in the space of neural network weights and thresholds is used to set up synoptic connections. To accelerate the learning procedure, it is suggested to use the adaptive learning step $\alpha(t)$ instead of a continuous learning step. An adaptive step learning algorithm works 4 times faster. At each stage of network learning, it is chosen to minimize the root mean square error of the network. [5]

For the prediction of NN-based systems, a heterogeneous network consisting of hidden layers with a nonlinear activation function of neural elements and an output or a linear neuron is of the best quality. In the paper, we propose to use a logarithmic activation function for solving prediction problems, which allows obtaining a prediction much more accurately than when using a sigmoid function.

NM architecture plays a big role in the effectiveness of network learning. In the work, we used a three-layer NN, which allows approximating any function with any desired accuracy. [5]

This study is aimed at developing specific recommendations for the use of NN in the information system of enterprises of different ownership and activity in different directions.

In a changing economic environment, it is important not only to analyze macroeconomic indicators but also to be able to forecast their future status. Therefore, forecasting macroeconomic performance through models becomes an integral part of strategic planning for the development of any organization or country as a whole. The study used model LAM 3. The model is easy to operate and simple enough to maintain. There is a possibility of quick access to model correction when the new data appears. The structure of the model for different national economies does not change, only different input parameters. The model itself consists of 25 equations: four of them describe long-term dependencies, twenty-one - short-term ones. The basis of the LAM-3 model is the Bilinear Vector AutoRegressive model - BiVAR. [10] Therefore, the authors have developed an econometric macromodel to analyze and short-term forecast aggregate demand in Ukraine, including endogenous and exogenous variables. Endogenous variables are GDP; final consumption of households and non-profit organizations serving them; final consumption of public institutions; gross accumulation; export of goods; import of goods; export of services; import of services; foreign trade balance; cash income of the population; remuneration of employees; foreign currency purchase and sale balance. Exogenous variables in the macromodel are the nominal hryvna against the US dollar; nominal first-rate tariff; the average number of employees employed in the economy; nominal average wage per employee; productivity. These interrelationships are critical to the choice of key economic policy orientations in Ukraine, so in the macromodel, they are represented by a system that includes autoregressive equations of GDP and money supply (M2) deflator. The macromodel is also supplemented by a regression equation for the foreign currency balance of trade indicator. [6]

One of the areas of application of neural networks which is proposed in the work is the development of accounting systems and assessing the creditworthiness of Bank customers. The credit portfolios of Ukrainian banks are characterized by a high level of overdue, prolonged and hopeless debts, the excessive concentration of credit risk. In this regard, increasing the relevance of the research question of modern methods and improvement of existing methods of assessing the creditworthiness of Bank's clients, the so-called scoring models. Scoring is a mathematical model in the form of a weighted sum of certain characteristics, based on the credit history of previous customers, the Bank is trying to figure out the likelihood that a particular borrower will return the loan within a certain period of time. [7] work in the context of credit scoring, the task of introducing the use of a subsystem the analysis and evaluation of creditworthiness of individuals on the basis of predicted results obtained by using neural networks.

Research results

Exploring some time MIS of Ukrainian enterprises, the authors came to the conclusion that basically, they have a marketing information system has an open architecture and support the strategy of gradual functional capacity. But, according to the authors, this may lead to loss of competitive advantage, profits and in General to the bankruptcy of the enterprise. The new economic reality is inherently connected with the lack of time and increase the speed of operations, which is why artificial intelligence technology is transformed into a virtual environment in which not only the processes of purchase and sale but the process of sharing knowledge, power and capital, therefore, the allocation of economic resources. Thus, marketing information system needs to be continually updated in accordance with the development of modern IT technologies, virtual environments and artificial intelligence.

Based on [11], the authors try to solve these problems. This should be facilitated by a refined information system as shown in Figure 1.

As can be seen from the figure, to extend the capabilities of the system, the authors propose to improve its subsystem of analysis and forecasting by creating an intelligent decision support system (IDSS) using NN.

According to the authors, the creation of an information system should choose the way to harmonize relations between man and his organization in the development of his creative abilities, so that their creative behavior is organized by the use of limited resources in harmony with the flow of natural processes. That is, it is necessary to motivate the generation of new ideas and corresponding goals. The information system must, on the one hand, assess the value and quality of the innovation achieved compared to the goals that were initially set.

On the other hand, it must be able to formulate a conclusion so that it contains the impetus to start creating a new innovation, that is, the process of developing the level of creative achievement must be continuous. [11] This is the fundamental difference between the proposed information system and traditional systems, the continuous stimulation of motivation for creative activity. This process is schematically presented in Figure 1.

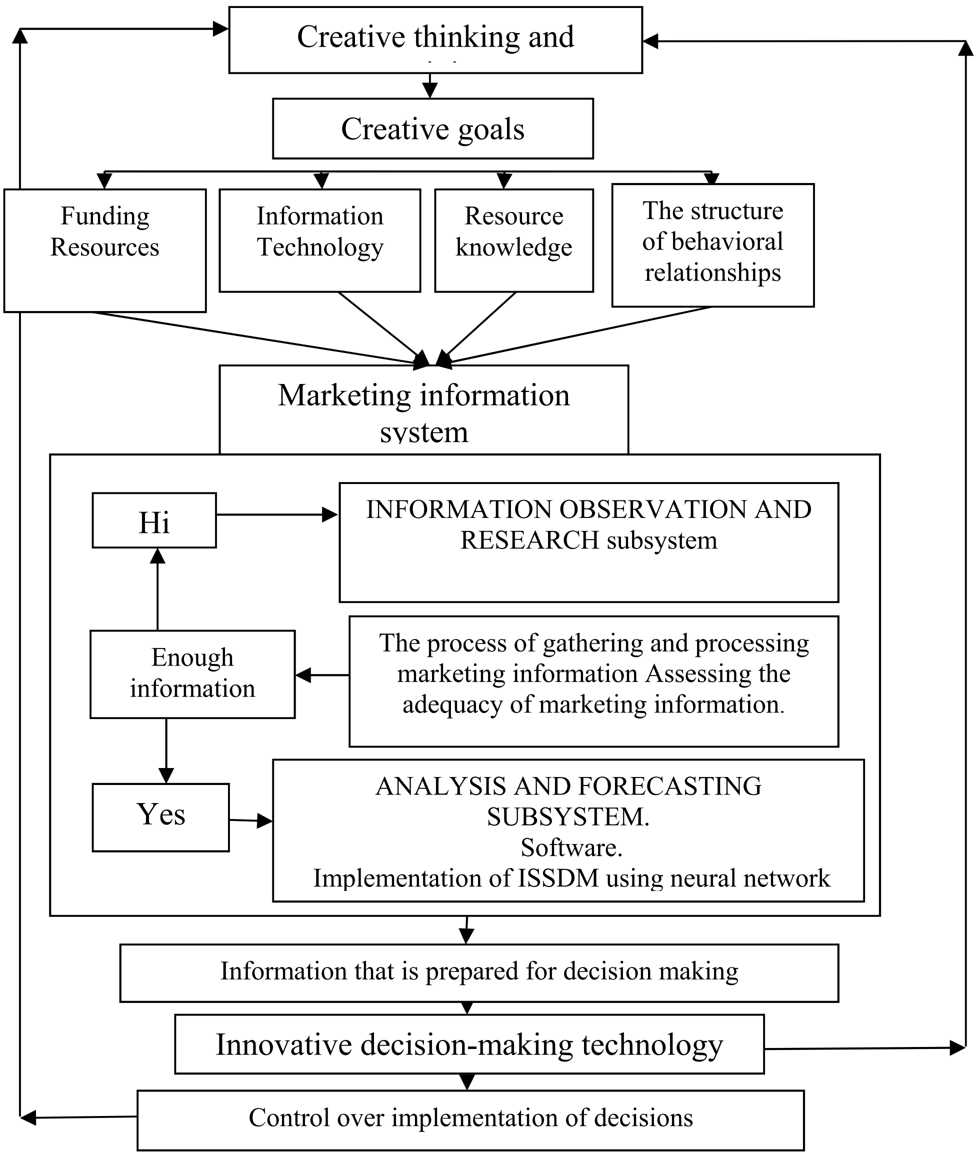

Fig. 1. Information system in the process of continuous stimulation of motivation of creative activity.

The proposed improvement was tested in three directions:

- first, the possibility of analysis of the macro-environment of the enterprise and forecasting of macroeconomic indicators were carried out on the example of Ukraine, for this purpose the data of the State Statistics Committee and the corresponding econometric model were used;

- secondly, one of the complex problems for the enterprises providing the engineering services has been solved, namely, the estimated project cost of the automation project, which will provide access to the foreign market;

- thirdly, a system of indicators for accounting and assessment of the creditworthiness of customers of a bank or other enterprise is formed, which performs such analysis and developed a software product for implementation of such accounting using ISSDM based on NN.

Let us consider in more detail the results of testing in three directions.

In the first direction, the LAM-3 model based on international trade equations was used to analyze the enterprise macro-environment. For verification, statistics were collected on selected model indicators from 1991 to 2018. The following software was used to perform the practical calculations and further analysis of the results: EXCEL package, to perform statistical analysis and calculations of parameters and criteria of the simplified macroeconomic model of the Ukrainian economy; own developed software product, which made it possible to obtain the forecast value of the GDP of Ukraine for a certain year [6] and to analyze different algorithms of training neural networks for predictive quality, to study different structures of neural networks and to compare results. [12]

Thus, using the neural networks, the predicted value of GDP for 2019 was obtained. For each structural equation, a neural network that was trained on relevant statistics over a 28-year period was used. For the training of neural networks, as already mentioned, the user can use two learning algorithms: genetic and reverse error propagation and different types of neural networks: based on radial basis functions, multilayer perceptron with sigmoidal activation function.

The authors consider the testing of the developed software product in the second direction of research. Therefore, the estimated cost of the engineering and consulting services provided was calculated. For this purpose, the method of calculating actual cost rewards plus fixed remuneration was used. After learning the neural network for data in previous years, the user had the opportunity to switch using the menu buttons on the form of the input data. In the following tab, the user enters new input data and receives a projected value of the project cost [5]. The test showed that the ISSDM with the trained neural network provided the user with comprehensive information about the future project. The manager received the estimated cost of the equipment, the cost of the installation work, equipment adjustments, and the number of workers who will perform the installation and adjustment, the expected amount of wages to the workers, all taking into account the estimated hryvna rate. So, as a result, he received the estimated cost of the project. [5]

The third direction of testing the advanced information system with the use of neural networks was carried out on the example of accounting and assessment of the creditworthiness of bank customers. Therefore, in order to enhance the analysis and forecasting capabilities of the existing bank lending system, it is proposed to improve it by introducing a neural network (see Figure 2).

Such an improvement in the bank's lending system will allow it to make decisions regarding online lending, which will allow it to analyze, plan and control various lending activities and design them on a "what if" basis. As a result, a number of complex credit assessment questions that previously only qualified lending professionals could accomplish with a neural network can be handled by a regular lending manager.

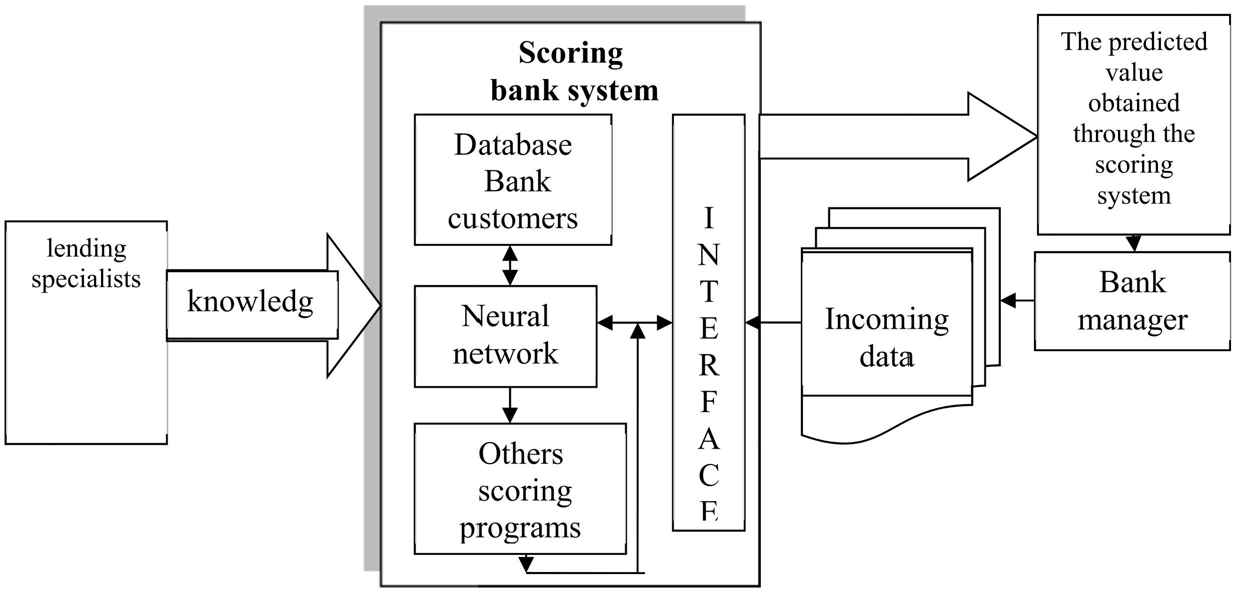

Fig. 2 - Scheme of bank lending system using neural network

After launching the software product, the user is given the opportunity to choose the type of learning algorithm and neural network structure, that is, to customize the software product. For convenience, the user is also shown the data form and basic parameters that characterize the bank's customers (see Figure 3).

Once the options are selected, the Add Data to Training Sample tab button is activated. Training data are obtained from the bank's scoring system (see Figure 2). A reduced sample of anonymized socio-demographic and aggregated bank customer account data was used to build the models. The paper introduced 50 data on real bank customers who have already or have not received a loan. Therefore, the data sample contains both demographic data obtained from both internal sources (Database) and external (Credit Bureau, borrower questionnaires, etc.). In addition, most interval data are presented as discrete groups of values, which make the model more accurate and easily interpret the results and relationships. From the visual representation, we can conclude that the data has one target variable and all other variables are numeric.

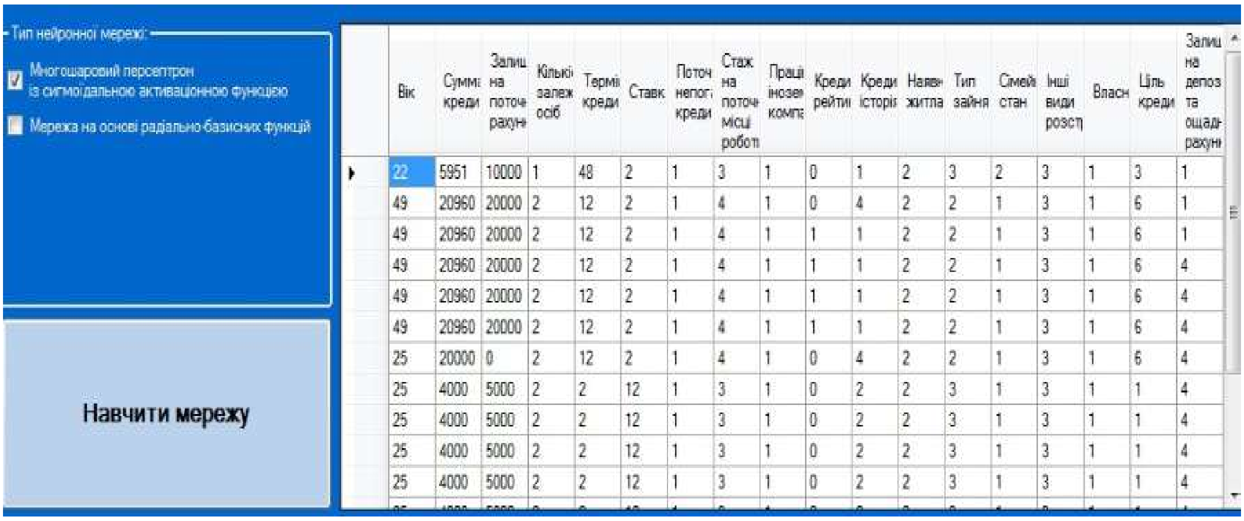

Fig. 3 - Structural form and basic parameters that characterize the bank's customers

Clicking the Add to Database button and the "Learn Network" button will teach the network. Once the network is trained, the user receives a NN training schedule. After that, the user goes to the "Credit Yes / No" tab. Enter the data in the form shown in Figure 4.

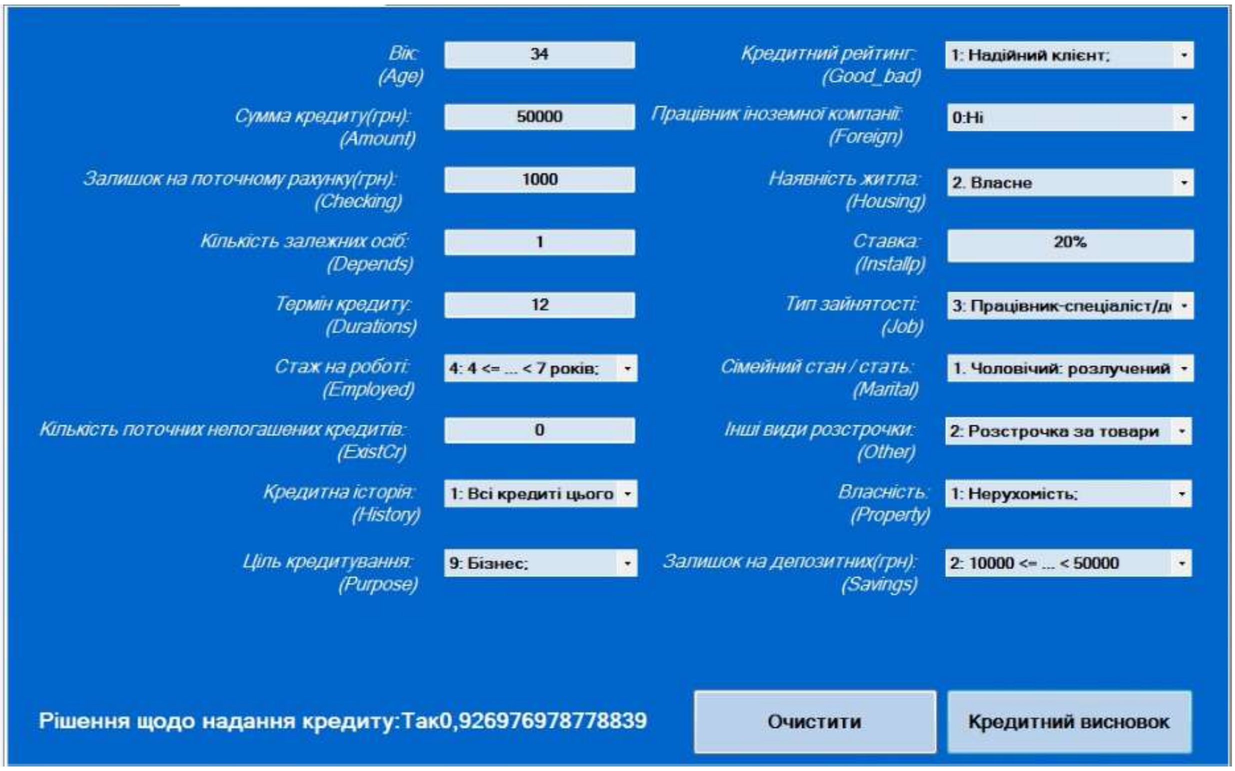

Fig. 4 - Input form and decision to provide credit to a bank customer.

Developed neural network software enables support in deciding whether to grant or deny credit to a bank customer.

Thus, in the presented lending system there is a considerable amount of versatile information circulating, but the purpose of such a system is to support decisions on lending to customers of the bank, providing them with information that is minimal but sufficient for decision making. The system provides information processing for further learning of the neural network. At the same time, you can use the database to drill down into individual calculations and other scoring software to change inputs or methods for solving problems.

Conclusions

1. The enterprise information system was developed, which includes the subsystem of analysis and forecasting with the built-in ISSDM based on neural networks. Such a system will make more informed decisions, will ultimately lead to the harmonization of human relations and organization, will make possible the development of creative abilities, will motivate the generation of new ideas and corresponding goals.

2. Implementation of NN-based ISSDM is proposed, which will make the most important decisions online, will allow to analyze, plan and control various aspects of the activity and design them on the principle of "what if".

3. The created software product provides training of the neural network on the basis of the input data for the previous years and allows on the trained neural network to make indicators of different directions of activity of the enterprise.

4. The developed software is tested. The results of the trial proved the effectiveness of using NN for forecasting macroeconomic indicators, for forecasting the cost of an automation project for the participation of an enterprise in the tender for the order.

5. To expand the capabilities of analyzing and forecasting the existing bank lending system, it is proposed to improve it by introducing a neural network. Such an improvement in the bank's customer lending system will support the decision-making regarding online lending.

The results obtained prove the necessity of introducing neural networks into the existing information system of the enterprise in accordance with the modern development of information technologies in order to make more informed decisions and to obtain on this basis more profit of the company, which will ensure sustainable development of the enterprise.

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20. METHOD FOR FORMALIZING THE CUSTOMER'S ATTITUDE TO POSSIBLE CHANGES TO THE BASIC PROJECT PARAMETERS IN THE PHASE OF ITS IMPLEMENTATION

Rach V.A., Borulko N.A.

Annotation

A distinctive feature of the work of project managers is a significantly large number of decision-making situations in the face of uncertainty and dynamic changes in the environment. One of the main sources of uncertainty is the project customer. At the stage of project development, he concentrates on putting forward requirements for the parameters of the project and the project product from the standpoint of his subjective idea of the success of the project. At the same time, his reaction to deviations from planned indicators remains unformalized. This makes it difficult for project managers to make current management decisions that are adequate for understanding the admissibility of deviations for the customer. The article describes the conceptual and mathematical models of the proposed method of collecting information from the customer about his attitude to possible risk situations in the project, which are associated with the deviation of the basic indicators “time-quality-value”. The method is based on the transformation of a well-known 2D template into a 3D template while maintaining the structure and relationships between the components of the model. This allowed us to introduce quantitatively measured parameters of the customer’s attitude both to the risk situation as a whole and to possible deviations of each basic indicator of the project individually.

Introduction

As it was noted in 2018 at a conference of the European Academy of Management, the current stage in the development of project, program and portfolio management is characterized by a transition from the perspective of classical project management to the perspective of rethinking project management. This conclusion was made in a report by Lars Kristian Hansen and Per Svejvig from Aarhus University (Denmark) based on a comparative analysis of the most cited publications of all years and the most cited publications over the past five years [1]. The main characteristics of the first perspective include aspects of instrumentality and controllability. In the second perspective, against the background of much less dominance of the characteristics of the first, new steadily growing tendencies are appearing: an increase in increased attention to project stakeholders; wider recognition of intuitive alternative solutions that differ from those with a rational explanation; increased attention to adaptation in the implementation of projects, programs and portfolios to a rapidly changing world [1]. This allows us to argue that such trends will determine the direction of future world and European studies, primarily related to project management. It should be noted that the new described perspective fully fits into the framework of the triadic project management paradigm [2]. It was formed within the framework of the scientific school to which the authors of this article belong and assumes a system-integral presentation of the project, in which both the components of the project-system and the relationships between them are analyzed.

One of the complex tasks in which the focus of the above three trends, is the task of selecting a team of project management objectives of the implementation of the project in situations of deviations from the planned option. Planned variation can be attributed to the category “the selected alternative that has a rational explanation” (classic project management). And unplanned deviations, which avoid even theoretically impossible, require you to select one of the fairly intuitive alternative solutions (rethinking project management). In this case, you need at least a fuzzy criterion. Given that the main stakeholder of the project is the customer, it is desirable that this criterion took into account its estimated vision. This mechanism is used in the soft control methodologies in the implementation of small projects and their individual increments [3]. However, in practice, for very large and complex projects, the availability of the customer is limited. Therefore, management decisions on the project taken by the team management projects are often based on information that reflects poorly formalizable relation to the customer and other stakeholders to deviations from the planned values of the basic parameters of the project (time, quality, cost). Weak formalization of information and the prior lack of coordination between stakeholders are one of the main sources of potential risks in the implementation phase of the project. Therefore, it is important to develop a method of formalizing the relationship of the customer to possible changes in the basic parameters of the project in the phase of implementation. The urgency of development enhanced by the General trend emerging in the project management - the offset in the implementation of projects focus of project control at agility project [4].

Conceptual model of the method

In the framework of a scientific school, we widely use the template for representing system models developed in it [5]. It involves placing the system components in a flat two-dimensional space at the vertices of a square so that the connections between the components are four sides and two diagonals of the square. The total number of bonds is six with four components of the system. Figure 1 presents a template for such a system model [6] taking into account the recommendations [7] on the openness of one of the components of the external environment. This allows considering as an open component planned or risk situations at the same time as part of the external environment (supersystem) and system.

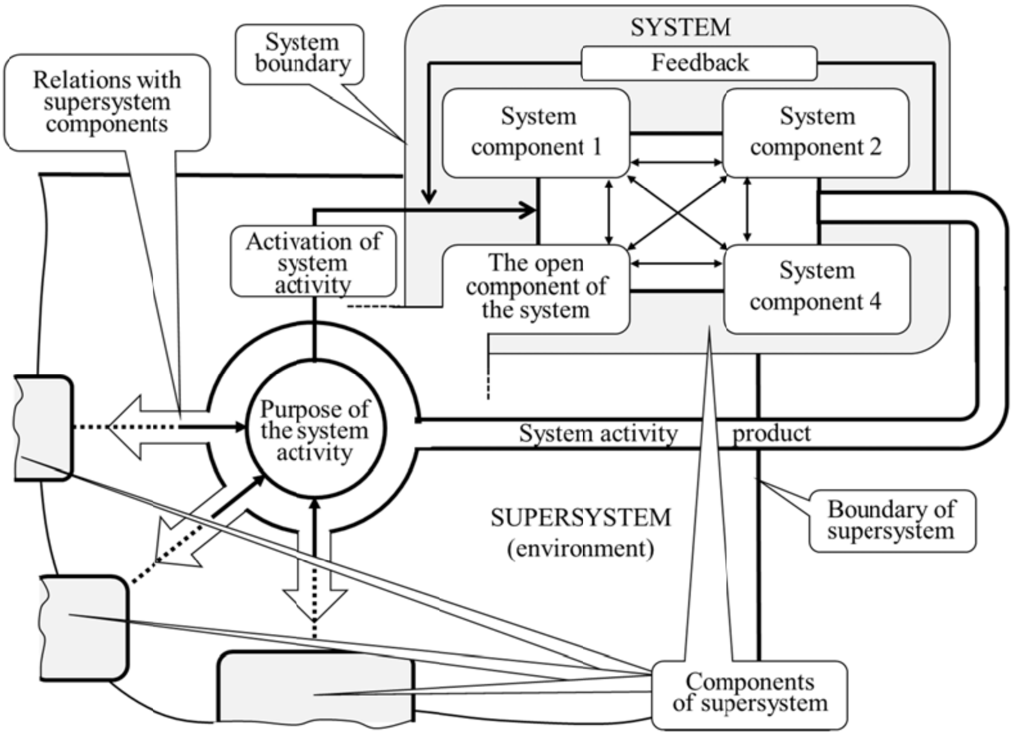


Fig. 1. 2-D template of a system model as a component of a supersystem [5-7].

However, an attempt to use a 2-D template to develop a system of measurable indicators to identify customer reactions to possible deviations of the basic parameters of the project during its implementation was unsuccessful. Therefore, the transformation of the 2D template into a 3D template was carried out while maintaining the structure and relationships between the components of the model. As a result, a model in the form of a tetrahedron was obtained (Fig. 2). To simplify further calculations, the edge of the tetrahedron is taken equal to unity. With this transformation, the previous number of components of the 2D template is saved, namely four (vertices of the tetrahedron), and the same number of bonds (six) which are the edges of the regular tetrahedron.

We define the state of the project in the form of four components (vertices of the tetrahedron): a planned or risk situation (vertex V_0), and three basic parameters of the project - time, quality, cost (vertices V_1, V_2, V_3). For the project state that corresponds to the planned one, points are placed on the edges of a regular unit tetrahedron, which divide the edges in half. The midpoints thus obtained on the edges correspond to the ratio of the segments 0.5: 0.5 (Fig. 2). Connecting the points on the edges, we get five volumetric figures: the “vertex” planar tetrahedral with edges of 0.5 each and the inner figure is the octahedron.

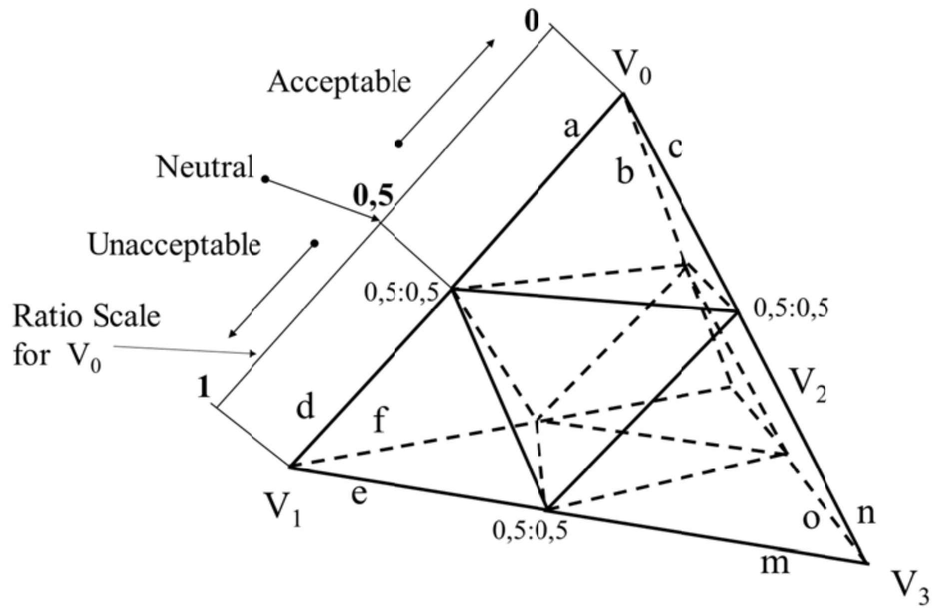


Fig. 2. 3D model of the presentation of the basic parameters of the project at the planning stage

Given that the vertices of the tetrahedron in the 3D model of representing the basic parameters of the project have a different essence, let us dwell on the consideration of the vertex V_0 "Situation". We represent each edge emanating from this vertex in the form of a ratio scale (Fig. 2). Such a scale is necessary to fix the customer's response to risk situations, which can lead to a deviation of the basic parameters of the project from the planned.

Denote the value of the scale equal to 0.5 as "neutral attitude to the risk situation". Then a part of the scale from 0.5 to 0 is used to fix the degree of acceptable attitude to the situation, and from 0.5 to 1 to fix the unacceptable attitude. To indicate the degree of acceptability/unacceptability, it is proposed to use the four-element linguistic set "low – medium – high – very high". Then a very high degree of acceptability will be in the region of the scale "0", and a very high degree of unacceptability in the region "1".

In the process of removing information from the customer about the degree of acceptability/unacceptability of the risk situation in question, he is invited to put a dot on each edge. Then the current will divide the unit scale into two segments (for example, d and a Fig. 2). Each rib will reflect not just the attitude of the customer to the situation, but the attitude to a possible change in a specific basic parameter of the project. Trial tests of this method of collecting information showed the occurrence of difficulties in putting a point in a particular location of the rib. This difficulty was removed when the customer was asked to put down two points between which there was a zone of a fuzzy border for choosing the degree of relation to the risk situation, for example, points p_{010} and p_{011} on the edge V_0 - V_1 (Fig. 3).

The mathematical model of the method

It is proposed to use volumes of vertex tetrahedrons as initial information for calculating the integral indicators of the customer's response to risk situations.

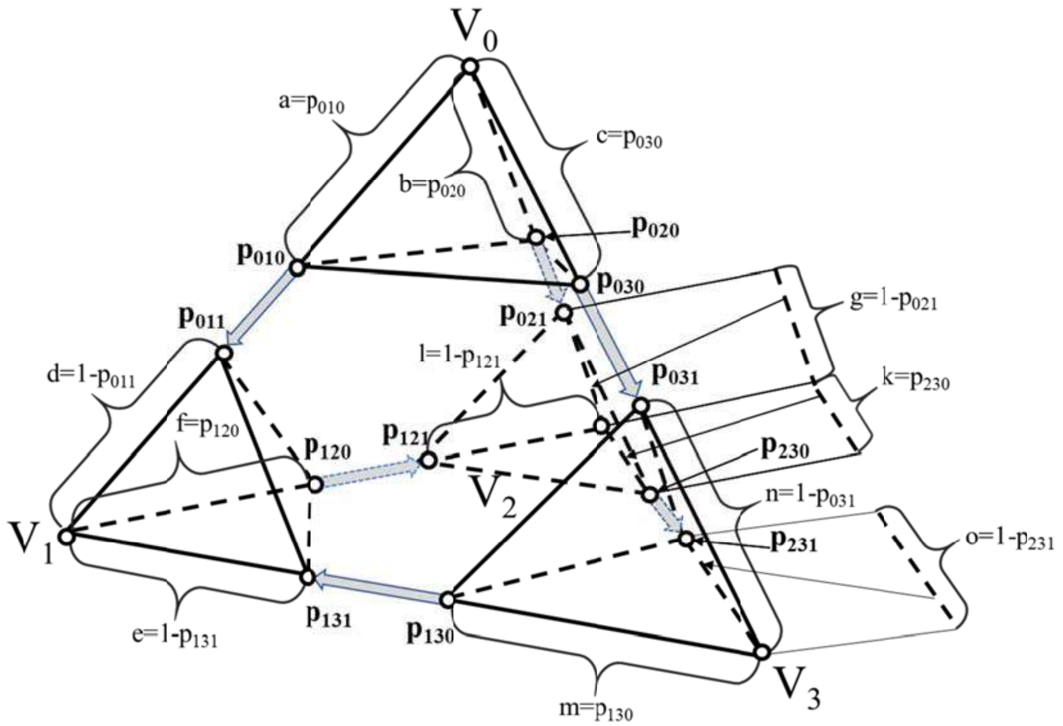


Fig. 3. 3D model of representing the customer's attitude to the risk situation and deviation of the basic parameters of the project from those planned in this situation

These volumes, the volume of the internal octahedron, as well as the ratio of the volumes of the octahedron and the base tetrahedron to the sum of the volumes of the vertex tetrahedra, are calculated by the following formulas:

$$V_0 = \frac{\sqrt{2}}{12} abc\,, V_1 = \frac{\sqrt{2}}{12} dfe\,, V_2 = \frac{\sqrt{2}}{12} glk\,, V_3 = \frac{\sqrt{2}}{12} mno\,, \tag{1}$$

$$V_{oct} = V - \frac{\sqrt{2}}{12}\left(abc + dfe + glk + mno\right), \tag{2}$$

$$\frac{V_{oct}}{V_0 + V_1 + V_2 + V_3} = \frac{12V}{\sqrt{2}\left(abc + dfe + glk + mno\right)} - 1\,, \tag{3}$$

$$\frac{V}{V_0 + V_1 + V_2 + V_3} = \frac{12V}{\sqrt{2}\left(abc + dfe + glk + mno\right)}\,, \tag{4}$$

where V_0, V_1, V_2, V_3 – volumes of vertex tetrahedra,

V_{oct} – volume of the obtained octahedron,

$V \approx 0{,}11785113$ – base unit tetrahedron volume.

If the relations between the ith and jth vertices of the tetrahedron are set in the form of the lower and upper boundaries of the ranges formed by the setpoints p_{ij0} and p_{ij1} on the edge of the tetrahedron, then the lengths of the segments a, b, c, d, e, f, g, l, k, m, n, o will take values:

$$a = p_{010},\ b = p_{020},\ c = p_{030},\ d = 1 - p_{011},\ f = p_{120},\ e = 1 - p_{131},\ g = 1 - p_{021},\ l = 1 - p_{121},$$
$$k = p_{230},\ m = p_{130},\ n = 1 - p_{031},\ o = 1 - p_{231}. \tag{5}$$

Then the volumes of vertex tetrahedra can be calculated using the formulas:

$$V_0 = \frac{\sqrt{2}}{12} p_{010} p_{020} p_{030}, \qquad V_1 = \frac{\sqrt{2}}{12}(1 - p_{011}) p_{120}(1 - p_{131}),$$
$$V_2 = \frac{\sqrt{2}}{12}(1 - p_{021})(1 - p_{121}) p_{230}, \quad V_3 = \frac{\sqrt{2}}{12} p_{130}(1 - p_{031})(1 - p_{231}). \tag{6}$$

The formula for calculating the octahedron will be as follows:

$$V_{oct} = V - \frac{\sqrt{2}}{12}\left(p_{010}p_{020}p_{030} + (1-p_{011})p_{120}(1-p_{131}) + (1-p_{021})(1-p_{121})p_{230} + p_{130}(1-p_{031})(1-p_{231})\right), \tag{7}$$

and volume ratio formulas are calculated as

$$\frac{V_{oct}}{V_0 + V_1 + V_2 + V_3} =$$
$$= \frac{12V}{\sqrt{2}\left(p_{010}p_{020}p_{030} + (1-p_{011})p_{120}(1-p_{131}) + (1-p_{021})(1-p_{121})p_{230} + p_{130}(1-p_{031})(1-p_{231})\right)} - 1, \tag{8}$$

$$\frac{V}{V_0 + V_1 + V_2 + V_3} =$$
$$= \frac{12V}{\sqrt{2}\left(p_{010}p_{020}p_{030} + (1-p_{011})p_{120}(1-p_{131}) + (1-p_{021})(1-p_{121})p_{230} + p_{130}(1-p_{031})(1-p_{231})\right)}. \tag{9}$$

An analysis of formulas (3), (4) and (8), (9) shows that they differ from each other by the value of the constant-coefficient (-1). This property of the project model under consideration requires additional study from the position of harmony mathematics in which the tetrahedron is the simplest polyhedron among the five Platonic solids, which in the ancient world were considered the geometric expression of harmony of the Universe [8].

Based on the above-fixed assumption, the volume V_0 of the vertex tetrahedron will act as the initial information for calculating the integral indicator of the customer's response to the risk situation. Theoretically, the values *a, b, c* included in the formula for calculating it can have different values in the range 0-1 for tetrahedra with the same volume value. This makes it possible for given *a, b, c* to calculate the value of the segment a_0 for the regular vertex tetrahedron, i.e., a tetrahedron in which all faces are equal to each other

$$a_0 = \sqrt[3]{abc}\,. \tag{10}$$

Then, for each of the basic components of the project, the customer's attitude to the risk situation can be calculated as

$$\propto_T = \sqrt[3]{\frac{a^2}{bc}},\ \propto_Q = \sqrt[3]{\frac{b^2}{ac}},\ \propto_C = \sqrt[3]{\frac{c^2}{ab}}\,. \tag{11}$$

For the integral indicator of the customer's attitude to the risk situation as a whole, it is proposed to use the triple-peer operator $\bar{Q}^3_{h,g,a,r}$ for values *a, b, c* [9]. It provides for the implementation of three steps. At the first step, four power means are calculated (harmonic $\overline{a_h}$, geometric $\overline{a_g}$, arithmetic $\overline{a_a}$ and quadratic $\overline{a_r}$). At the second step, for the obtained power means, the calculation of the new four means is carried out. In the third step, the procedure is repeated with power averages calculated in the second stage. As a result of calculations, all averages are reduced to one value.

For an integral characteristic of the customer's attitude to the risk situation, an acceptability function has been introduced (Fig. 4).

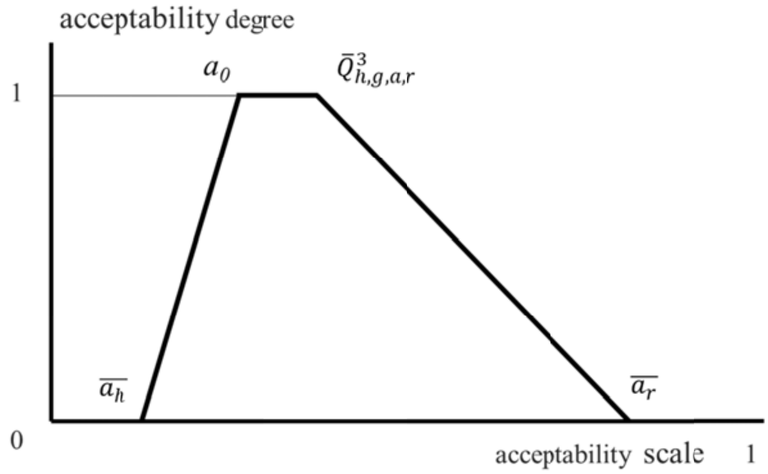


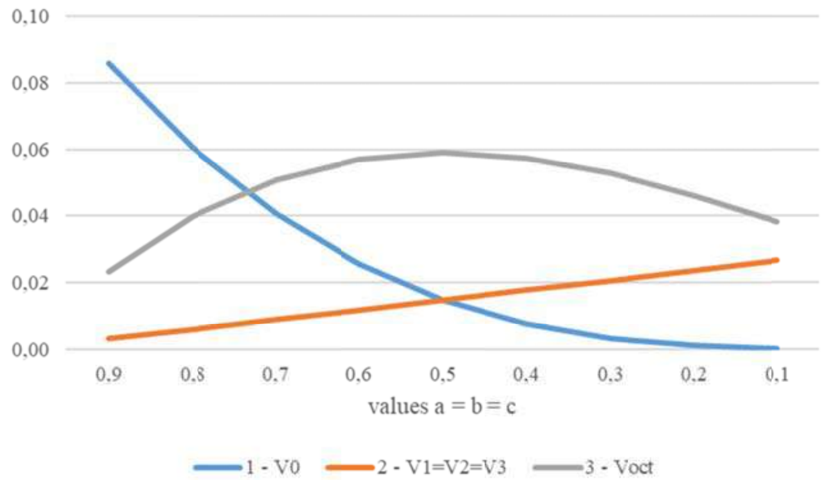
Fig. 4. Parameters of constructing the relationship function

It is built on the basis of four indicators on the principle of constructing trapezoidal membership functions. The horizontal axis is the ratio scale described above, which reflects the acceptability/unacceptability of the customer to the risk situation. The vertical axis is the acceptability scale. The carrier of the acceptability function is determined by the mean values of the harmonic $\overline{a_h}$ and quadratic $\overline{a_r}$, and the nucleus is determined by the length of the tetrahedron a_0 and the value of the makeup operator $\bar{Q}^3_{h,g,a,r}$.

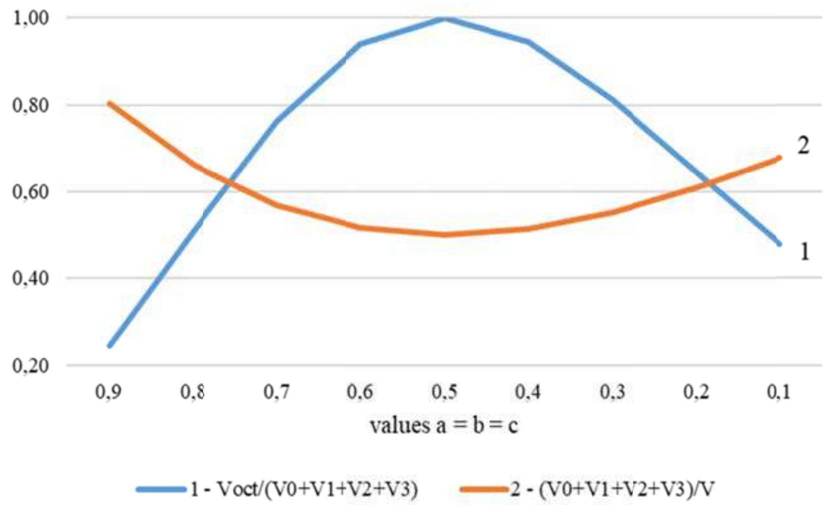
Test Calculation Results

Based on the constructed mathematical models, a computer program in the JAVA language was developed in the IntellijIDEA environment. The user interface of the program visualizes the 3-D model in the form of a basic regular unit tetrahedron and provides for the arrangement of points on the edges. After placing the points, the screen displays information about the scale values for each of the points, the volumes of the corresponding "vertex" tetrahedrons, the internal octahedron, the base tetrahedron, as well as the ratio of the internal octahedron to the sum of the vertex tetrahedrons, the base tetrahedron to the sum of the vertex tetrahedrons, their inverse relationships and the whole information regarding the integral indicator of customer response to a risk situation.

Test calculations made it possible to establish the nature of changes in the volumes of vertex tetrahedra (Fig. 5 a), their ratios to the volume of the base tetrahedron and octahedron (Fig. 5 b) depending on the size of the edges of the regular vertex tetrahedron V_0.



a)



b)

Fig. 5. Dependencies of changes in volume indicators that reflect the customer's attitude to the risk situation in the project.

The dependence of the size change of the edge "c" of the tetrahedron V_0 was also established for different values of the edge "a" and "b" under the condition that the volumes are kept the same (for a = 0.4, the volume is 0.0075, a = 0.5 - 0.0147, a = 0.6 - 0.0255) (Fig. 6).

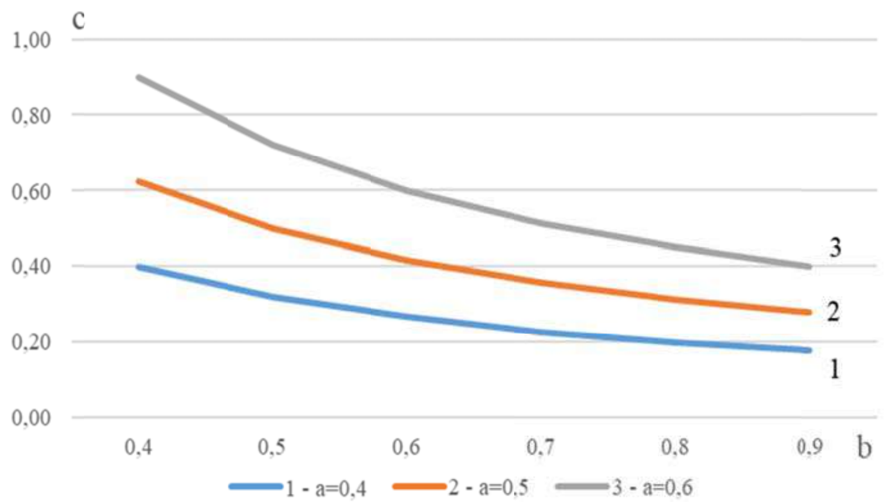


Fig. 6. Dependence of changes in the parameters of edges for fixed volumes of the vertex tetrahedron

The calculation of the acceptability function for a wide range of changes in the ratio between the edges of the vertex tetrahedron V_0 showed that as the difference between the sizes of the ribs decreases, the trapezoidal function degenerates into a triangular one, which becomes a vertically located segment (Fig. 7).

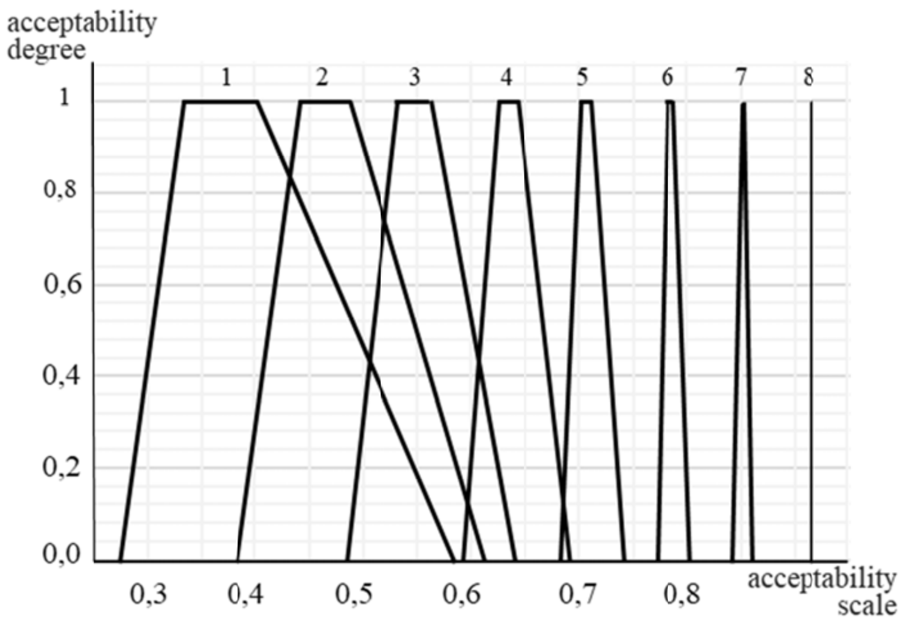


Fig. 7. Acceptance functions for a = 0.965 and the same values of b and c.

1 – b=c=0,2; 2 – 0,3; 3 – 0,4; 4 – 0,5; 5 – 0,6; 6 – 0,7; 7 – 0,8; 8 – 0,9.

Therefore, by the form of the acceptability function, one can judge not only the opinion of the customer on the acceptability/unacceptability of the risk situation but also the degree of certainty (reliability) of such a judgment.

Conclusions

The results of our study allow to draw some conclusions.

1. The current trend of shifting focus in the implementation of projects from control to project adaptability leads to the need to take into account new factors and adaptability conditions. These include the adaptability of the project management team to the subjective attitude of the customer about the acceptability/unacceptability of management decisions in specific diverse risk situations that are very common in the project. For this, it is necessary to have the appropriate tools for obtaining such information in a formalized form. Today, the existing tools do not satisfy, first of all, the temporary criteria for the operational continuous receipt of such information. Therefore, it is urgent to develop new methods that can be the basis for creating tools.

2. The conceptual basis of the developed method is a four-component system 2D template, which is transformed into a 3D template in the form of a tetrahedron. Using the edges of the tetrahedron as scales of the customer's attitude to the acceptability / unacceptability of deviation of the basic parameters of the "time-quality-cost" project allowed us to construct vertex tetrahedra, the sizes of which correlate with the customer's judgments on the acceptability / unacceptability of the alleged deviations in a particular risk situation.

3. The mathematical models of the method are deduced from considering the lengths of the segments formed by the points that the customer affords on the edges, the coordinates of these points and the features of the tetrahedron as the simplest polyhedron among the five Platonic solids.

4. It is proposed to use the ratio of the lengths of the edges of the vertex tetrahedron to the length of the edges of the correct vertex tetrahedron as indicators of the customer's attitude to changes in the basic categories of the project in a risk situation. And to display the integral attitude of the customer to the risk situation, a new acceptability function was introduced and a rule for its construction was developed.

5. The performed test calculations confirmed the efficiency of the proposed method and the possibility of using the developed software as a tool for collecting information from the customer about his attitude to deviations in risk situations of the planned values of the basic parameters of the project - "time-quality-value".

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21. MODELING OF DESTRUCTION PROCESSES OF THE INSTALLATION CONNECTION OF ELECTRONIC EQUIPMENT

Nevliudov I., Demska N., Starodubcev N., Nevliudova V.

Modern technologies move away from the traditional design of hard electronics into the form factors of flexible switching structures, which are often operated in a dynamic mode and can be subjected to such actions as alternating loads, bending and twisting, stretching, vibration, the presence of a chemically aggressive environment, etc. Despite a large number of existing studies using an arsenal of achievements in the field of materials science, means of classical and quantum physics, the theory of chemical reactions, statistical physics, fracture mechanics, up to date, some essential phenomena occurring at the atomic-molecular level during the implementation of the manufacturing process and design of flexible structures have not been fully disclosed. In this paper, we consider the processes of the appearance in the materials and structures of connectors of products of physicochemical reactions associated with the presence of two sources of medium formation, which are interpreted as the formation in a certain place, over a certain period of time, of a substance with new properties, the appearance of which can cause degradation processes. As a result, the obtained dependences, together with the statistical processing of the obtained information, can provide a sufficient description of the process for its optimal control, even under conditions of incomplete certainty about the subtle mechanisms of atomic-molecular interaction between the materials involved in the process.

At the moment, production trends are based on the introduction of new solutions and technologies Industry 4.0, IoT, cloud services, etc. [1-2], the most important role in the performance of which is played by modern automation equipment (sensors, actuators, regulators, etc.), which are designed to provide the necessary level of accuracy, performance parameters, small overall mass characteristics, high functionality, low power consumption and cost [1].

The main problem of integrating modern technical means for introducing Industry 4.0 technology remains that now, all finished parts are based on traditional electronic components of rigid (flexible-rigid) printed circuit boards, which are significant in thickness and limited in flexibility, and also cannot be fully adapted hardware solution for each specific size and shape of the automation object [3]. Therefore, modern technology is moving away from the traditional design of hard electronics in the future of flexible form factors that can offer new features that were not previously possible, especially in markets such as medicine, IoT, sensors and smart textiles [4].

The scope of application of flexible electronics is quite wide and covers both household appliances and components of military, aviation, space, medical and industrial equipment. Their widespread use in these areas is due to several advantages: compactness, even with a large number of contacts; simple and quick replacement of damaged cable; organization of conductors, eliminating entanglement; connection of modules and actuators, remote from each other, within one unit or product; "Mobility" of the connection [5].

Most flexible circuits are just passive connectors that are used to connect electronic components such as integrated circuits, resistors, capacitors. However, some of them can be used to create mutual communication between other electronic units either directly or through connectors.

More than 50% of the failures of the electronic equipment (EE) are connected to the connectors. Their possible causes may be: corrosion, loose connection, loss or deformation of the cable due to vibration [6].

Molecular-kinetic models, using an arsenal of classical and quantum physics, the theory of chemical reactions, statistical physics, fracture mechanics [7], etc., give an idea of atomic-molecular interaction, revealing the subtle mechanism of physicochemical processes in production and operation of EE.

The use of these models is a prerequisite for the creation of EE with new operational and technical properties and the corresponding technological processes. The success of these models is associated with the processing of a large amount of information, often obtained using unique tools and mathematical methods.

The basis for modeling the destruction processes of the EE mounting joint can be the theory of the destruction of solids, the basic principles of which are to consider the destruction process as the action of creep phenomena and brittle fracture arising under the action of an external force load, while conditions arise for exceeding the allowable tensile strength. It seems important to ensure such a fracture mechanism [8] when there is no significant rearrangement of the internal structure of the material, i.e. creep effect reduction [9].

Many properties of materials and, in particular, mechanical and dielectric properties exhibit peculiar features due to the partially delayed reaction of the material to external influences. Any deformation of the material under the action of an external force is not accompanied by an instantaneous restructuring of the internal structure to an equilibrium state that meets new conditions. This requires a certain period of time until all particles in accordance with these conditions come to equilibrium. So, if you quickly deform the material and maintain the degree of deformation constant, then the stress required for this gradually decreases (stress relaxation). If, having quickly deformed the material, to maintain a constant voltage, then for some time the strain (strain relaxation) will increase. The physical mechanism of this process is currently presented as follows.

Atoms of a solid make thermal fluctuations with period $t_{p0} \approx 10^{-12} \div 10^{-13} c$. Under the influence of thermal fluctuations from time to time, there is a rupture of chemical bonds. The probability of this event, equal $\exp(-U_a / kT)$, depends on the height of the activation barrier U_a and temperature T, decreasing with increasing U_a and decreasing T. In the absence of external voltage (at $\sigma = 0$), the energy required to break the bond is equal $U_0 = Q_{subl}$ for metals and $U_0 = Q_{destr}$ for polymers. The stress σ created in the body reduces the activation energy of the destruction process from U_0 to $U_0 - \gamma\sigma$ and thereby increases the probability of bond breaking, and, consequently, the number of broken bonds in a unit volume.

The formation of submicroscopic regions with broken bonds and their fusion with each other leads to the fact that the body is destroyed by the applied voltage. The higher is a so the stronger the activation energy decreases, the faster and in a larger number of broken bonds, therefore, the less time is required for the development of the destruction process.

Thus, to ensure the fracture mode in the absence of noticeable creep, only a short-term insignificant increase in stress over the tensile strength is necessary.

The theoretical strength of solids σ_0, calculated according to one atomic model or another, is many times greater than the real strength σ_r. At present, it is generally accepted that such a difference between σ_r and σ_0 is explained by the presence of various kinds of defects in real solids, in particular, microcracks, which reduce their strength [10]. The appearance of a crack of length l leads to a stress concentration at its edges if a tensile force F_{out} is applied to the specimen (Fig. 1).

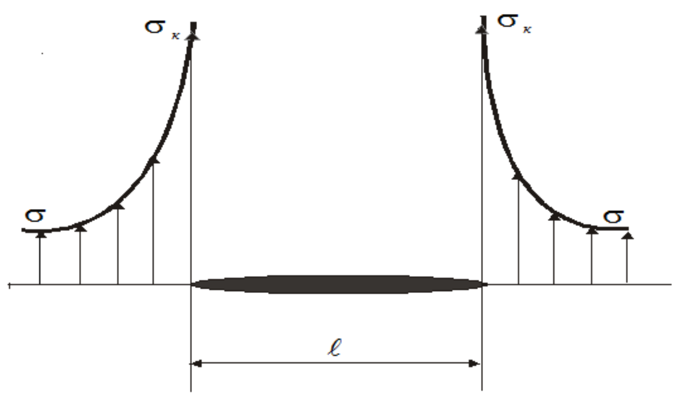

Fig.1. The stress concentration at the edges of the crack

The process of destruction proceeds more or less gradually and takes a certain time t_p to complete. This time required for the development of the process of destruction from the moment of loading the body to the moment of its rupture is called the temporary strength or durability of the material [11-12].

The durability of the material being destroyed t_p, tensile stress σ and absolute temperature T are related by the following relation:

$$t_p = t_{p0} \exp[(U_0 - \gamma\sigma)/kT], \tag{1}$$

where t_{p0}, U_0 and γ – constants, depending on the nature and structure of the material.

Logarithm (1), we obtain

$$\ln t_{p0} = \ln t_{p0} + (U_0 - \gamma\sigma)/kT = \ln t_{p0} + U_a/kT, \tag{2}$$

where $U_a = U_0 - \gamma\sigma$ – fracture activation energy.

These formulas were tested on a large number of various materials (metals, glasses, polymers, crystals, etc.) with a change t_p of 8–10 orders of magnitude and change of T in a wide spread. This means that t_{p0} for all materials is approximately the same. As experiments have shown, t_{p0} for all materials is approximately the same and approximately equal $10^{-12} \div 10^{-13} s$, that is, close to the period of atomic vibrations near the equilibrium positions. Building dependence $\lg t_p$ on $1/T$, for a given σ, U_a can be experimentally determined. It has been established that for metals U_a it coincides well with the energy of sublimation, for polymers - with the energy of thermal destruction, i.e. with energy breaking chemical bonds.

The magnitude of the stress at the edge of an acute crack having a radius of curvature *a* is determined by the following relation:

$$\sigma_{edg} = \sigma(1 + 2\sqrt{l/\mathrm{a}}), \tag{3}$$

where σ_{edg} – stress at the crack edge;

σ – cross-section average stress.

The destruction of the sample occurs at a value $\sigma = \sigma_r$ at which the stress σ_{edg} reaches the theoretical strength of the material σ_0:

$$\sigma_{edg} = \sigma_r(1 + 2\sqrt{l/a}) = \sigma_0. \tag{4}$$

From here you can determine the real strength of the material σ_r:

$$\sigma_r = \frac{\sigma_0}{1+2\sqrt{l/a}} \approx \frac{\sigma_0}{2\sqrt{l/a}}. \quad (5)$$

From relation (5) it can be seen that the real strength of the body is the lower, the longer the crack that appears in it and the smaller the radius of curvature of its edge. In order σ_r for it to be 0.01 σ_0, it is sufficient that cracks in the body of $l \approx 1$ microns in size with a radius of rounding off of the edges are equal to the lattice parameter.

Thus, the fracture mechanism of a compound is based on the nucleation and development of cracks and microcracks in a medium formed during the formation of a compound containing defects in the microstructure. A significant stress concentration at the edges of the crack leads to conditions when the fracture time of the material becomes much less than the relaxation time, i.e. to ensure the minimum impact of the fracture process on the restructuring of the material structure adjacent to the fracture surface. In practice, such conditions can be realized in such a test mode of joint strength, when significant deformations are achieved in a few seconds, which leads to short-term creep, and the process is characterized by brittle fracture.

When installing EE, sufficient conditions are created for the implementation of such a destruction mechanism. One can make an assumption about the presence of two sources of the formation of the medium containing structural defects: firstly, particles of foreign substances; secondly, the products of physic-chemical reactions on the surface and in the volume of the material forming the compound (MFC). These sources are very intense at the stage of MFC activation during installation, especially in the absence of a protective environment.

Removing foreign substances from the surface is fundamentally impossible in real installation conditions since even with perfect cleaning of the surface from mineral and organic contaminants, the metal surface is so active that it is almost instantly covered by environmental molecules that form adsorbed films on it. First of all, oxide films are formed on metals and semiconductors, the thickness of which can vary from a monomolecular layer to tens to hundreds of nanometers. In addition to oxide films, the surface can capture fairly thick layers of water, fat and other substances from the environment. The strength of fixing adsorbed layers, especially oxide films, is very high, and their removal from the surface is very difficult.

A feature of the surfaces of polymeric materials [13] is their high hydrophobicity. The process of adsorption and penetration of moisture through the surface consists of sorption (absorption) of its surface diffusion into the surface layer and possible desorption (separation) at the interface between the surface and the environment. With a weak interaction of moisture with the surface, the speed of its passage through the surface is determined by the law of diffusion

$$Q = DStdc / dx\,, \tag{6}$$

where Q – amount of diffused moisture;

dc/dx – its concentration gradient in the surface layer;

S – surface area;

t – diffusion time.

With a weak interaction of moisture and the polymer, Henry's law is usually fulfilled, according to which the concentration of moisture in the polymer is proportional to the vapour pressure above the polymer p :

$$c = \alpha p\,, \tag{7}$$

where α – sorption coefficient.

Substituting (7) into (6), we find

$$Q = AStdp / dx\,, \tag{8}$$

where $A = D\alpha$ – permeability coefficient, numerically equal to the amount of steam passing through a unit area of the polymer surface per unit time with a pressure gradient equal to one.

For an example Tab. 1 shows the time of formation of a monolayer of moisture calculated by (8) for a number of polymers widely used in EE. The data of the Table1 shows that the time of occurrence of the monolayer can be significantly less than the time of the interoperation gap during the installation of EE.

Table 1 - The time of formation of a monolayer of moisture for a number of polymers

Material	The time of formation a monolayer of moisture, s
Ftoroplast -4	2400-600
Epoxy resin	35
Polyethylene	45-22
Polystyrene	10-5
Silicon-Organic Rubber	5-1

Water permeability substantially depends on the physical state of polymers, the flexibility of their chains, the packing density of molecules, and other factors. Amorphous polymers with flexible chains that are in a highly elastic state (rubbers, rubbers) have the highest permeability, polymers with rigid chains in the glassy state have the lowest permeability. In the same state, the permeability of the polymer decreases with increasing packing density of its molecules and reaches its maximum value in the crystalline or partially crystalline state (fluoroplastic-4).

These patterns are easy to understand by considering the mechanism of diffusion of vapours and gases in polymers. As in the case of liquids, the diffusion of gas molecules in polymers occurs along with voids, which are continuously formed due to the thermal motion of individual sections of the molecules. With the increasing flexibility of chains, their mobility increases, and, consequently, the probability of the formation of voids along which vapour molecules can diffuse, which leads to an increase in the permeability of polymers in a highly elastic state. In glassy polymers with rigid chains, the permeability increases with increasing friability of the molecular packing, leading to the appearance of a large number of micropores.

Thus, it can be assumed that the surfaces prepared for joining are a rather powerful source of foreign particles, which weaken the strength of the material and determine the mechanism of the onset of the fracture process as the occurrence and development of cracks. A significant increase in stress at the ends of a developing crack causes a weakening of the creep processes and towards brittle fracture. The development of microcracks occurs in a layer of material, the structure and properties of which can be determined by the nature of the physicochemical interaction in which the materials to be joined are involved, with the participation of external factors that contribute significantly to the imperfection of the structure and composition of the MFC layer.

Depending on the initial physicochemical properties of the materials being joined, as well as the mounting conditions, the MFC in the composition of the compound may have a different structure and composition.

Polymeric materials are characterized by the manifestation of the basic properties associated with thermosetting and the influence of activators such as solvents, thickeners, and other components, which lead to a significant change in the properties of polymeric MFCs after the formation of the compound. A targeted effect on the course of the process of the compound formation using polymeric materials takes into account the regularities of the influence of solvents and other additional components on the structure of the material, its rheological properties, diffusion and adsorption to joined surfaces.

The main interest is the laws of mass transfer, leading to diffuse phenomena that lag behind in speed from the processes of adsorption and swelling of the initial surfaces. The general idea of the diffusion mechanism during the interaction of polymeric materials is given by the theory of stochastic processes, which relates the value of the diffusion coefficient to the frequency of the molecule jump and its mean free path [13]. This allows us to consider the transition of a diffusing molecule from one position to another as overcoming the energy barrier between two equilibrium states, to characterize the total energy expenditures for the transfer of a substance in the structure of a polymer material, and on this basis to analyze the mass transfer processes during the formation of an assembly joint. The absolute values of the diffusion activation energy for materials of various nature and installation conditions vary widely. A common technique for changing the activation energy is the introduction of an organic solvent, which leads to its decrease, which manifests itself in an increase in the diffusion coefficient and corresponding acceleration of the whole process.

A large role in the installation process using polymeric materials can play the porosity of the connected surfaces. When considering the laws of transport [13] in a system of static micropores whose radius is much larger than the size of diffusing particles, the diffusion coefficient depends on the porosity of the polymer; tortuosity of pores; a change in chemical potential during the transition of a material from a dissolved to an adsorbed state; concentration of adsorption centers.

A simpler version of the interpretation of the diffusion mechanism in polymers is to use the results of the theory of the free volume of the polymer V resulting from the thermal motion of segments of the polymer chain. Since any condensed medium has a free volume, in the presence of solvents, plasticizers, and other components, the total free volume in a first approximation is determined by the sum of the free volumes of the system components, and the free volume of each component increases linearly with increasing temperature. Therefore, the value V can be expressed by the relation

$$V = V_{c1} + \alpha_1 (T - T_{c1})\upsilon_1 + V_{c2} + \alpha_2 (T - T_{c2})\upsilon_2 + \ldots = \sum_{i=1} [V_{ci} + \alpha_i (T - T_{ci})\upsilon_i], \tag{9}$$

where V_{ci} – fraction of the free volume of the *i*-th component at its glass transition temperature T_{ci}; υ_i – volume fraction of the *i*-th component in the system; T – temperature exceeding T_{c1}; α_i – a jump in the temperature coefficient of expansion at a temperature above T_{ci} and below it. It is accepted here that polymer characteristics have an index $i = 1$.

In the case when a practically pure polymer $(\upsilon_1 \approx 1)$ is considered in the presence of a very small amount of a diffusing substance ($\upsilon_2 \approx 0, \upsilon_3 \approx 0$ etc.), the free volume of the polymer

$$V = V_{c1} + \alpha_1 (T - T_{c1}). \tag{10}$$

An increase in the free volume of the polymer leads to an increase in the diffusion mobility of the low molecular weight substance. At the same time, the free volume of the polymer according to formula (9) increases with increasing temperature and the concentration of the solvent or plasticizer. Moreover, the presence of a solvent contributes to a sharper increase in the free volume compared to the initial polymer with increasing temperature, the free volume theory suggests that the diffusing molecule moves without energy consumption and depends only on the probability of the appearance of a required microcavity near the molecule. The temperature dependence of the diffusion coefficient in the form of relation (9) taking into account (10) allows one to reveal the effects of plasticizing substances that lower the glass transition temperature of the polymer.

Conclusions

At present, some essential phenomena occurring at the atomic-molecular level during the implementation of the process are not fully disclosed. In addition, the adequacy of models largely depends on random, unforeseen factors, which can significantly reduce the efficiency of using models in real conditions of production and operation of EE.

In this study, an MFC fracture mechanism is proposed that uses the basic principles of the theory of fracture of solids, which suggest that the fracture process be considered as the action of creep and brittle fracture, provided that the allowable tensile strength is exceeded due to stresses arising from external forces. These conditions are provided when testing the mounting connections for strength and lead to the formation of PR.

The basis of the accepted destruction mechanism is the presence of defects, the source of which is the introduction of foreign atoms and molecules into the MFC. When installing EE, sufficient conditions are created for the implementation of such a destruction mechanism. Under conditions of short-term creep, the process is characterized by brittle fracture, the fracture mechanism is based on the nucleation and development of cracks and microcracks in the medium of the test material.

As a result, the obtained results, together with the statistical processing of the obtained information, can provide a sufficient description of the process for its optimal control even in conditions of incomplete certainty about the subtle mechanisms of atomic-molecular interaction between the materials involved in the process.

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22. VISUAL MONITORING OF THE BREAK SURFACE OF THE INSTALLATION CONNECTION OF ELECTRONIC EQUIPMENT

Nevliudov I., Starodubcev N., Demska N., Omarov Sh.

The progress of modern technology, expansion of the range of tasks assigned to the system control, high accuracy requirements, noise immunity, speed, etc. has led to increasing complexity of electronic technology and the creation of complex systems designed to solve a number of important tasks. In turn, the complexity of the instrument may lead to a sharp reduction in its reliability, which in some cases is dangerous, for example, when used in medicine, the military, while space research, transport, etc. To provide diagnostic functions and subsequently the functions of the prognostics of technical condition of electronic devices and their critical components (e.g., a flexible switch structures) it is necessary to create an effective tool for monitoring the status of the product. The aim of this study is to test the theoretical provisions on a diffuse scattered light surface tear by experimental studies of the spectrum of spatial frequencies of images of the surface of rupture. This paper proposes a method of obtaining images of the analyzed surface with its reflected light flux, providing the quantitative estimate of the amount of diffuse reflective sites, using the software. It is assumed that display physical and chemical processes, for their visual perception greatly enhance monitoring capabilities and will provide recommendations on the optimal scheme of optical control of surface gap, which will greatly reduce the complexity of control operations.

Requirements for electronic equipment (EE) products are constantly growing due to the tightening of their operating conditions. At the same time, there is a serious problem of providing qualitative indicators of flexible components, since they can be subjected to a large number of destabilizing factors at all stages of the life cycle [1]. So, for example, modules installed on moving objects – cars, airplanes, rockets, etc. during operation can be subjected to intense mechanical stress-shock, vibration, linear overload [2].

The implementation of the technological process for the manufacture of EEs is necessarily accompanied by the appearance of products of physicochemical reactions, mass transfer, and restructuring of the medium structure. This allows the interpretation of the results of the process as the formation in a certain place during a certain time of a substance with new properties, which ultimately determine the parameters of EE. Similar phenomena are observed during the operation of EE, here the appearance of a new substance can be interpreted as the result of degradation processes necessarily present in the materials and structures of EE, including rupture of the surface of the conductor [3].

To characterize such processes, sizes, shape, volume, and other geometric parameters of the observed images can be used. An example of a fairly effective use of figurative analysis is the solution of pattern recognition and classification problems based on a geometric interpretation of recognition processes, which leads to the possibility of using the display of patterns and classes of objects of various natures in the feature space in the form of geometric shapes corresponding to recognizable patterns. In this case, the size, shape, volume, relative position, other geometric parameters of the observed images are also used to characterize recognized objects. [3].

The use of figurative analysis to recognize the state of objects of various natures on the one hand, and the presence of certain states of the environment in which the analyzed processes take place, makes it possible to use the same principles for figurative analysis of processes. The implementation of these principles is possible if the "geometric" features and the geometric images formed in the space of these features carry information about the physical nature of the process.

Thus, we can make an assumption about the possibility of using for analysis of processes the information obtained when evaluating the properties of the formed reacted (RS) and unreacted substance.

The absolute values of the distribution of RS and the heights of the roughness of the gap (RG) in a complex way depending on the conditions of formation of the connection, and therefore they can only be given a relative estimate. Since the RG profile, specified in a certain direction, sufficiently characterizes its geometry, we can estimate the parameters of the correlation function of the RG profile in the direction of the axis x. The possibility of a linear approximation depending on the values of the RS distribution and the height of the RG irregularities during relative estimation give rise to the assumption of the identical behaviour of these quantities and the corresponding correlation functions when considering their dependence in the coordinate system of the RG profile. The expansion of a random function $W(x)$ in a Fourier series leads to the expression

$$W(x) = \int_{-\infty}^{+\infty} \varphi(\nu) e^{ix\nu} d\nu \, . \tag{1}$$

The spatial correlation function of the distribution of the RS concentration along the axis x will be determined by the expression

$$R_\tau = \overline{W(x)W(x+\tau)} = \int\int_{-\infty}^{+\infty} \overline{\varphi(\nu)\varphi^*(\nu')} e^{ix(\nu-\nu')} e^{i\nu\tau} d\nu d\nu' \, . \tag{2}$$

If we assume that the value x is not allocated in relation to other values, then the spatial correlation should not depend on x and is only a function τ. But the right-hand side of expression (2) will not depend on x only if the integrand is nonzero only when $\nu = \nu'$, i.e. if the function $\overline{\varphi(\nu)\varphi^*(\nu')}$ has the form

$$\overline{\varphi(\nu)\varphi^*(\nu')} = \varphi^2(\nu)\delta(\nu - \nu'), \tag{3}$$

whence

$$R_\tau = \int_{-\infty}^{+\infty} \varphi^2(\nu) e^{i\tau\nu} d\nu. \tag{4}$$

Expression (4) is a spatial analogue of the well-known Wiener-Khinchin theorem that relates the temporal and spectral characteristics of random signals using the Fourier transform. The function $\varphi(\nu)$ is the spatial-spectral characteristic of the distribution of the RS along the axis x. The relationship between $\varphi(\nu)$ and R_τ is given by the relation

$$\varphi^2(\nu) = \int_{-\infty}^{+\infty} R(\tau) e^{i\tau\nu} d\tau. \tag{5}$$

To evaluate this characteristic, it is necessary to find the spatial correlation function of the distribution of the concentration of RS [4] along the axis x.

Distribution of the concentration of RS is carried out in accordance with the laws of statistical physics, the main provisions of which assume the presence of a fluctuation component in the description of phenomena and parameters that characterize the state of a thermodynamic medium consisting of microparticles of RS [5]. In the process of activation, these microparticles acquire greater mobility; this gives reason to use here the idea of the processes occurring in a liquid consisting of RS particles. From the point of view of statistical physics, the behaviour of such a system is characterized by:

– Hamiltonian $H(X)$ as a function of variables X defining the microscopic state of the system;

– the module of the canonical distribution Θ that determines the average energy that falls on one degree of freedom (for a statistical mechanical system $\Theta = kT$, where k is the Boltzmann constant, T is the absolute temperature);

– forces a acting in the direction of the generalized coordinates of the system $q(X)$.

According to the main provisions of the Gibbs theory for generalized coordinates of the system

$$\frac{\partial \bar{q}}{\partial a}-\overline{\frac{\partial q}{\partial a}}=-\overline{\frac{1}{\Theta}(\frac{\partial H}{\partial a}-\frac{\partial \overline{H}}{\partial a})(q-\bar{q})}. \qquad (6)$$

If we distinguish two generalized coordinates $q_1(X)$ and $q_2(X)$, and forces a_1, a_2, acting in the direction of these coordinates, respectively, then we can introduce the Hamiltonian function

$$H(X,a_1,a_2)=H_0(X)+a_1q_1(X)+a_2q_2(X). \qquad (7)$$

Since the concentration RS is a macroscopic quantity characterizing the state of the medium and a function of the coordinates of the particles RS, it can be considered as a generalized coordinate, and for two points of the medium having a concentration, respectively W_1 and W_2 from expressions (6) and (7), putting in them

$$q\ (X)=q_1(X)=W_1(X), \qquad q_2(X)=W_2(X), \qquad \overline{\frac{\partial W_1}{\partial a_2}}=0,$$

receive

$$\overline{(W_2-\overline{W_2})(W_1-\overline{W_1})}=-\Theta\frac{\partial \overline{W_1}}{\partial a_2}. \qquad (8)$$

If the considered medium points are located at a distance τ from each other, then the left-hand side of (8), which, by definition, is the correlation moment of random variables W_1 and W_2, is equal to R_τ then

$$R_\tau=-\Theta\frac{\partial \overline{W_1}}{\partial a_2}. \qquad (9)$$

For the system under consideration, the role of additional terms of the type $aq(X)$ in the Hamiltonian function can be performed by the quantity PV, where P is the pressure, and V is the volume. Because

$$V=\frac{N}{W}, \quad PV=\frac{PN}{W^2}W, \qquad (10)$$

where N is the number of particles; force a will be determined by the expression

$$a=\frac{PN}{W^2}, \qquad (11)$$

then

$$a_2\overline{W_2} - P_2 N_2 = 0 \tag{12}$$

and for a function $\phi = a_2\overline{W_2} = P_2 N_2$, according to the rules of differentiation of implicit functions

$$\frac{\partial \phi}{\partial P_2}\frac{\partial \overline{W_1}}{\partial a_2} = \frac{\partial \phi}{\partial a_2}\frac{\partial \overline{W_1}}{\partial P_2}, \tag{13}$$

receive

$$\frac{\partial \overline{W_1}}{\partial a_2} = \frac{1}{N_2}\overline{W_2}^2 \frac{\partial \overline{W_1}}{\partial P_2} \tag{14}$$

Thus, from (9) and (14) it follows

$$R_\tau = -\frac{\Theta}{N_2}\overline{W_2}^2 \frac{\partial \overline{W_1}}{\partial P_2} \tag{15}$$

Expression (15) reflects the fact that the correlation function is determined by the sensitivity of the process of changes in concentration at one point to pressure changes at another point. Pressure P_2 arises due to intermolecular interaction forces, the change of which affects the concentration of particles in the medium. The derivative $\partial \overline{W_1} / \partial P_2$ reflects the action of forces, the sources of which are molecules located at point 2, on molecules located at point 1 [6], therefore, the radius of action of these forces determines the correlation interval of the distribution of the RS and the resulting RG profile.

The interaction energy of two molecules is extrapolated by the empirical potential of Lennard-Jones

$$\Phi(\tau) = \frac{c_1}{\tau^{12}} - \frac{c_2}{\tau^6}. \tag{16}$$

The second term of this formula corresponds to the van der Waals forces, the extent of which is several molecular radii r. The behaviour of the Lennard – Jones potential makes it possible to estimate the dependence R_τ for a real medium and conclude that the correlation function decreases significantly at distances reaching several molecule radii, according to accepted estimates, more than 10^{-7} m.

In fig. 1 – 2, the process of forming the spatial frequency spectrum of the RG image is displayed. Figure 1 shows the estimated graphs of functions that reflect the above relationships between the Lennard-Jones potential $\Phi(\tau)$ and the correlation function R_τ, in Fig. 2 its Fourier image $\varphi^2(\nu)$ characterizing the spectrum of spatial frequencies of the image RG.

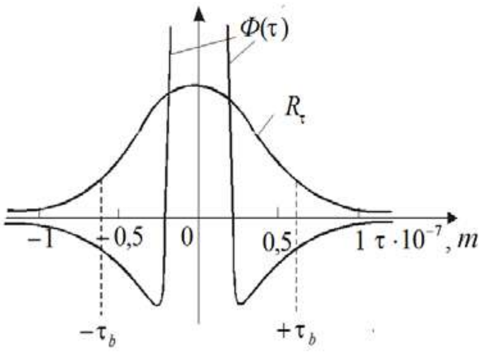

Fig. 1. The correlation function of the RG profile

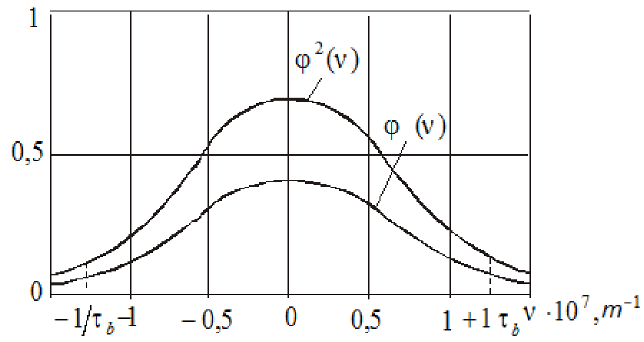

Fig. 2. The formation of the spectrum of spatial frequencies of the image RG

Considering that, by analogy with time signals, the width of the spectrum of spatial frequencies is inversely proportional to the width of the correlation function; we can conclude that there is white spatial noise in a wide range, from zero to $10^{-7}m^{-1}$ spatial frequency range.

The idea of the profile of RG can be obtained in the result of a mechanical simulation of the proposed mechanism for the formation of RG [7]. The simulation result is shown in Fig. 3. The initial data for the simulation was the dispersion of the distribution of irregularities along the axes x and z linked in a linear approximation with variance proportional to the concentration of RS. In view of the statistical independence of the processes of formation of RG on the distances, given estimates that more than 10^{-7}m, the choice of the variance, much larger, equal to 10^{-6}m, should not lead to significant errors in simulation results [8]. The presence of white spatial noise in the image RG gives grounds to conclude that when it is lighting it is possible to observe the diffuse dispersion of light and this can be used as a feature for recognition of RG in the analysis of the image.

Currently, technical vision systems (TVS) are used to solve such problems. The principle of operation here involves obtaining an image of the analyzed surface using the reflected light flux and the use of software that allows you to quantify the area of diffusely reflecting areas.

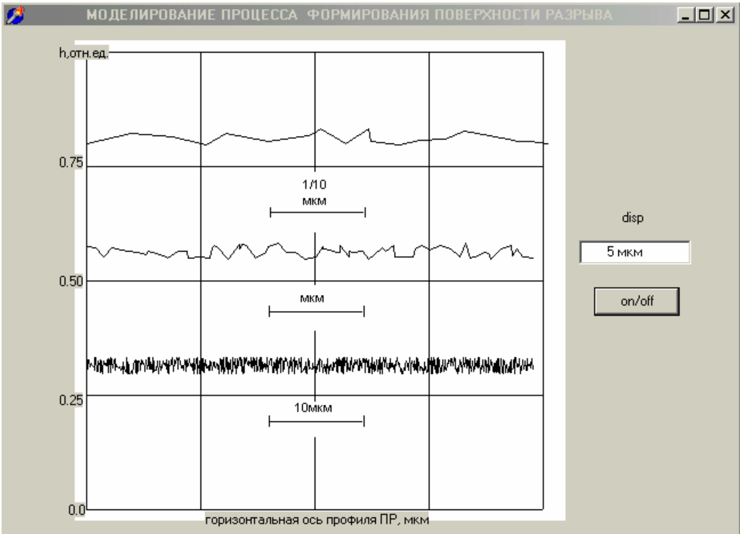

Fig. 3. RG profile modelling

It seems that an improvement in the detectability of RG can be achieved through a rational choice of the optical scheme of TVS and the use of optical filtering methods. Thus, the main objective of further research is to verify the theoretical positions obtained on diffuse light scattering RG by experimental studies of the spatial frequency spectrum of the RG image, which will make it possible to propose the optimal optical control scheme RG in order to evaluate the properties of the material forming the layer (MFL).

The analysis of the spectrum of spatial frequencies of the image of the initial surface. The complete separation of the light flux reflected by the analyzed surface into the mirror and diffuse components is fundamentally impossible, and the presence of the diffuse component in the spectrum of the initial surface can lead to deterioration in the detection of RG.

Thus, the use of a low-pass spatial filter makes it possible to increase the signal-to-noise ratio in a circuit where the mirror component reflected from RG light is used as a useful signal.

Experimental estimation of the spatial frequency spectrum of the RG image is presented. The experimental setup is shown in Fig. 4. The controlled surface of sample *1* was placed in the object plane of the optical circuit, which was aligned with the focal point of lens *2*. The parameters of the spatial low-pass filter *3*, mounted on the optical axis of the system in the focal plane of the lenses 2 and 4, were changed due to a change in the size of the light-transmitting square part.

The use of a video camera (cam), where a charge-coupled device (CCD) matrix combined with a PC personal computer was used as a photo converter, it was possible to implement an information processing system (IPS), and information output to the monitor. The use of a PC made it possible to implement a mode for measuring the illumination of the surface of a CCD by summing the

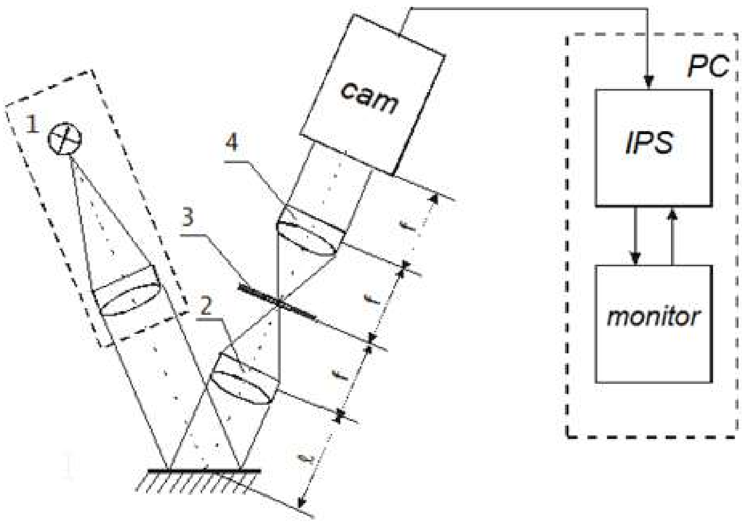

Fig. 4. The experimental setup

levels of signals received from each element of the matrix and normalizing the sum. The program developed for this provided for the transfer of the resulting image to the Image Editor of the Delphi software environment, digitization of the resulting pixel array, and further processing of the converted array in order to calculate and normalize the sum of its components. The image of the analyzed surface after inserting the image from the monitor screen into the Delphi project is shown in Fig. 5.

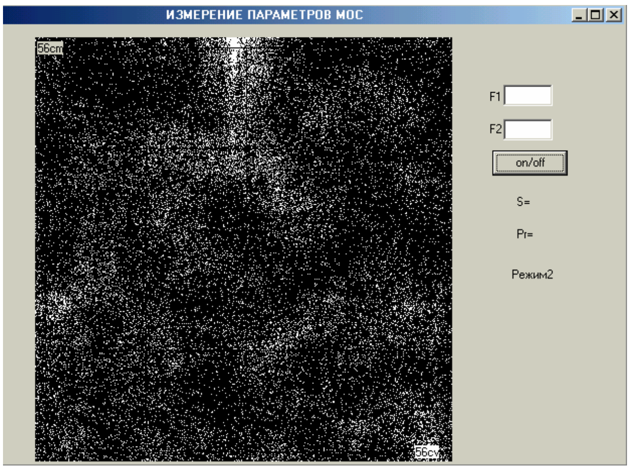

Fig. 5. Image of the analyzed surface of the gap

Having marked $F(x, y)$ the distribution of the complex amplitude of light in the plane of the object, we can obtain an expression for the distribution of the complex amplitude of light in the plane of the optical filter $f(\eta, \xi)$

$$f(\eta,\xi) = \frac{\exp[j\frac{k}{2f}(1-\frac{l}{f})(\eta^2+\xi^2)]}{j\lambda f}\int_{-\infty}^{\infty}\int F(x,y)\times\exp[-j\frac{k}{f}(\eta x+\xi y)]dxdy\,, \quad (17)$$

where k, l, f, λ – wave number, distance to the subject plane, focal length, wavelength of light, respectively.

When $l = f$ the image in the filter plane corresponds to the Fourier transform of the original image of the object. Assuming that spatial frequencies $F(x, y)$ occupy a range $\pm 1/\tau_b$, it can be approximated $F(x, y) = A$ in a rectangular region with sides $2\tau_b \times 2\tau_b$ and $F(x, y) = 0$ outside this region.

Designating $k / f \cdot \eta\tau = \alpha$, considering that when placing an object in the focal plane

$$f(\eta, \xi) = \frac{1}{j\lambda f} \int_{-\infty}^{\infty} \int F(x, y) \times \exp[-j\frac{k}{f}(\eta x + \xi y)] dxdy = \frac{1}{j\lambda f} A \left(\frac{\sin\alpha}{\alpha} \right)^2 \quad (18)$$

is a periodic function of α, and its period is equal to $\pm n\pi$, $n = (1,2,3,...)$ we can come to the equality

$$\frac{k}{f}\eta_b\tau_b = \pi \, . \quad (19)$$

Assuming that the main part of the spectrum is at its first maximum, this equality makes it possible to calculate the value of the upper spatial frequency η_b, and, consequently, the corresponding coordinate in the filter plane. Thus, the pattern that can be used to construct the spatial filter is a rectangular region transmitting light with the dimensions of the sides $2\eta_b \times 2\eta_b$ determined from equality (19). Calculation according to the formula (18) for $\lambda = 5 \cdot 10^{-7} m$, $f = 5 \cdot 10^{-2} m$, $\tau_b = 1/\nu_b = 15 \cdot 10^{-6} m$ leads to the result $2\eta_b = 1{,}7 \cdot 10^{-3} m$.

The energy of the radiation detected by the photo transducer can be determined by the formula $E = E_1 + E_2$, where E_1 the illumination due to the energy of light waves reflected from the analyzed surface, E_2 the additional surface illuminance of the CCD due to the reflected from the examined surface radiation caused by the beam divergence in the absence of a perfectly coherent source, and the presence of scattered radiation from the surfaces of the parts included in the installation design. Illuminance E_2 is essentially a source of error in the measurement of the useful signal caused E_1. To reduce uncertainty, to carry out the preliminary alignment of the illuminator. Thus, in the image plane was set perfectly reflecting surface, which gives the opportunity for coherent source to a wave of zero-order with a minimum value of the amplitudes of the harmonics. The axis system in the plane of the placement of the filter, install an opaque screen is rectangular in shape with dimensions $1{,}7 \cdot 10^{-3}$m $\times$ $1{,}7 \cdot 10^{-3}$m, that is guaranteed to have no effect on the results of the rays of the illuminator with the angle of divergence less than 1,7·10^{-2} rad. As shown by subsequent experiments, was able to pick up the illuminator, the divergence angle of the beam was less than 1, 3·10^{-2} rad. With a maximum window size of the filter achieved the minimum readings while measuring the light level of the surface of the CCD. Here were recorded the light levels at different filter settings and set the brightness of the light source. This level is then subtracted from the measurement results, thereby adjusting the above errors.

The well-known Parseval equality gives reason to use the expression

$$E_1 = \int_0^{\nu_b} \varphi^2(\nu) d\nu \tag{20}$$

and hence the calculation of spectral density by the formula

$$\varphi^2(\nu) = \frac{dE_1}{d\nu}. \tag{21}$$

The boundary frequency of the filter was determined by the dimensions of the sides of the square in accordance with expression (19) and varied from $2\eta_b = 1{,}7 \cdot 10^{-3}$ m to $2\eta_b = 20 \cdot 10^{-3}$, which corresponds to the interval of change τ from 15·10^{-6}m to 1,28·10^{-6}m. The correspondence between η_b and ν_b from (26) was determined by the formula $\nu_b = 2\eta_b / \lambda f$ and for the parameters of the given circuit $\nu_b = 8\eta_в \cdot 10^7 m^{-1}$.

Experimental studies were carried out on samples of soldered and adhesive joints, the design of which made it possible to carry out typical technological processes of surface preparation, to implement the necessary operations and modes, and to provide tensile testing and subsequent visual inspection of RG.

Figure 6 shows the dependence of the photoconverter illumination on the filter window area, measured at the above interval of change η_b, the scale of the corresponding filter pass band is also shown here.

To determine the function $\varphi^2(\nu)$ from discrete samples of the values of the derivatives (20), the least-squares method was used. For a given type of dependence $y = f(x)$, it allows to select its numerical parameters in the best way so that it reflects experimental data. The method is applicable for linear and nonlinear $y = f(x)$. Given the possibility of using a quadratic model in a limited frequency range, as an equation that allows you to determine the function $\varphi^2(\nu)$ from discrete samples, we can take the expression

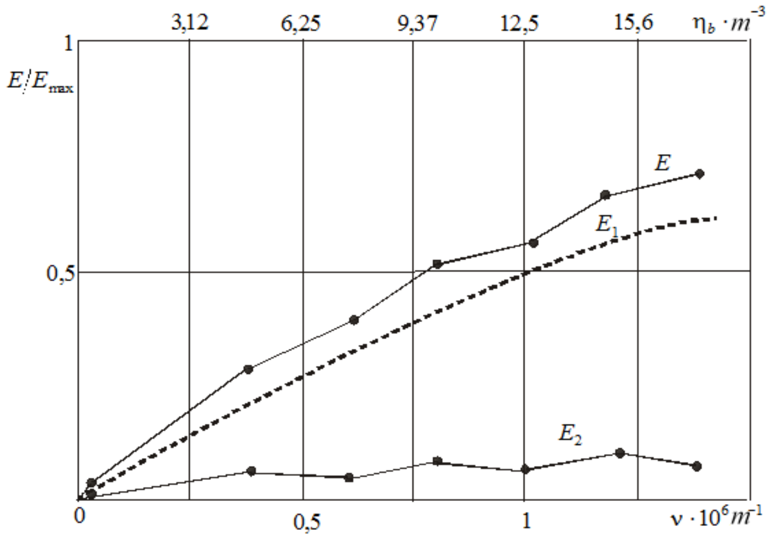

Fig. 6. The dependence of the illumination of the photoconverter on the area of the filter window

$$y = ax^2 + bx + c, \tag{22}$$

a, b and c can be determined by solving a system of normal equations. The calculations can be greatly simplified if the quadratic function is presented in the following form:

$$y = a_1\left(\frac{x-\bar{x}}{h}\right)^2 + b_1\left(\frac{x-\bar{x}}{h}\right) + c_1 \tag{23}$$

The values of the argument of this function are chosen equally spaced, i.e. $x_{k+1} - x_k = const = h(k = 1,2,\ldots,N-1)$, and its counting is carried out from the average value $\bar{x} = (x_1 + x_N)/2$ in integer parts of the step h for odd $N = 2M-1$ and in integer parts of the half step $h/2$ for even $N = 2M$. The parameters a_1, b_1 and c_1 functions (23) are calculated by the following formulas:

With odd $N = 2M-1$

$$a_1 = \frac{1}{3H_2(N)}\left[3\sum_{k=1}^{N} y_k (k-M)^2 - \frac{N^2-1}{4}\sum_{k=1}^{N} y_k\right], \tag{24}$$

$$b_1 = \frac{1}{H_1(N)}\sum_{k=1}^{N} y_k (k-M), \tag{25}$$

$$c_1 = \bar{y} - \frac{H_1(N)}{N} a_1, \tag{26}$$

where $H_1(N) = N(N^2-1)/12$; $H_2(N) = N(N^2-1)(N^2-4)/180$.

With even $N = 2M$

$$a_1 = \frac{1}{12H_2(N)}\left[3\sum_{k=1}^{N} y_k(2k-N-1)^2 - (N^2-1)\sum_{k=1}^{N} y_k\right], \quad (27)$$

$$b_1 = \frac{1}{2H_1(N)}\sum_{k=1}^{N} y_k(2k-N-1), \quad (28)$$

$$c_1 = \bar{y} - \frac{H_1(N)}{N}a_1. \quad (29)$$

Figure 7 shows the observed spectral density of spatial harmonics of the RG image for several samples of compounds calculated from (22). The average non-uniformity of the spectrum in the frequency band $0,07\cdot10^6 \ldots 0,8\cdot10^6$ m^{-1} was 4.1%.

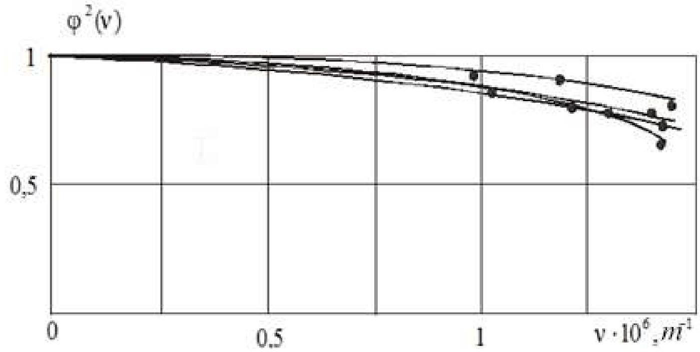

Fig. 7. Spectral density of spatial harmonics of the RG image

Noteworthy is the increase in spectrum non-uniformity with an increase in the upper limit of the range, which is a consequence of the limited size of the numerical aperture of the applied optical scheme, and the resulting attenuation of high-order harmonics that deviate significantly from the optical axis. This was confirmed by assessing the effect of misalignment of the optical and geometric axis of the lens system on the measurement results. A misalignment value of 5 mm led to a change in the results and significantly distorted the results for filters having a cutoff frequency of more than $1\cdot10^6 m^{-1}$.

Conclusions

Thus, the obtained results confirm the basic theoretical provisions on the diffuse light scattering RG, which confirms the proposed mechanism of RG formation, which provides a justification for the ability to evaluate the physicochemical activity of the MFL and the voltage corresponding to the true tensile strength of the MFL in a specific technological assembly and installation processes of electronic equipment.

The conducted studies made it possible to confirm the effectiveness of figurative analysis in some areas and to develop its main provisions that can be used to solve urgent problems of monitoring the production and operation of EE.

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23. JOINT EDUCATION PROGRAMS - A PROSPECTIVE DIRECTION OF HIGHER EDUCATION DEVELOPMENT IN UKRAINE

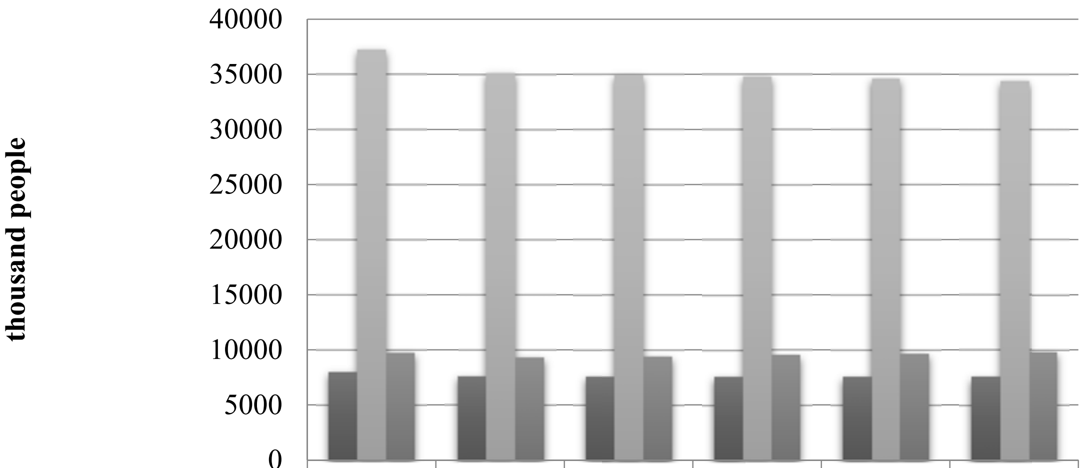
Kovtun T., Brashovetska G., Petrova O.

Annotation. Joint educational programs - a promising solution for higher education, which in the best traditions of the win-win strategy gives benefits to each of the participants of the program: Ukrainian students, Ukrainian and foreign partner institutions of higher education (HEI), as well as countries whose HEIs are participants. Students will have the opportunity to study in two HEIs from different countries at the same time, without leaving their homeland for a long period, and to receive two diplomas of state samples of higher education: Ukrainian and partner HEI countries. This is both an interesting experience of studying in a foreign HEI, and enhancing the competitiveness of graduates in future employment. Mutual integration contributes to the provision of up-to-date educational services in partner HEIs, through the use of innovative forms of learning, joint research, language courses for students and teachers, summer science schools and study visits to students, teachers and staff of the partners. Dissemination of joint educational programs will reduce the rate of departure of young people from Ukraine, increase the attractiveness of national higher education and increase the number of trained specialists for updating of personnel in the Ukrainian labour market. Promotion of own culture and language, European values, strengthening of the position of own HEI in the market of higher education services will be a gain for the partner country.

According to the UN projections, the population of Ukraine may decrease to 36 million by 2050. The annual outflow of human capital is becoming more threatening - the population of Ukraine, according to the State Statistics Committee as of June 1, 2019, amounted to 41 922 380 people, compared to last year it decreased by 187.6 thousand people [1]. There is an increasing trend of the elderly population and a decrease in the youth and working population (Fig. 1).

Among the major factors that lead to this condition are determined

- mass emigration,
- low birth rates,
- high mortality rate.



	2014	2015	2016	2017	2018	2019
0-17 years old	8009,9	7614,7	7614	7615,6	7609,3	7579,7
18 years old and older	37236	35145	34976,9	34799,3	34607,5	34403,9
60 years old and older	9753,3	9330,4	9417,2	9545,9	9679,8	9827,1

Fig. 1. Distribution of the permanent population of Ukraine by the specific age groups

According to Foreign Minister of Ukraine Pavel Klimkin, 100,000 Ukrainians leave the country every month. About 8 million of the working-age population is actually within labour migration. At a time when Ukrainian enterprises are suffering from a lack of skilled workers, it is precisely the lack of manpower that makes it difficult to carry out economic reforms in the country.

The purpose of education is to be one of the main factors in the growth of the quality of human capital. The current complex socio-economic situation of the state, unfortunately, has a negative impact on the institutions of higher education in Ukraine. Insufficient funding, deterioration of the material and technical base lead to a decrease in the total number of students (Table 1).

Table 1 - Dynamics of Higher Education in Ukraine

thousand people	2014	2015	2016	2017	2018	2019
Number of graduates of general secondary education institutions	304	247	229	211	203	195
Number of students admitted to universities, academies and institutes of Ukraine	291,6	259,9	253,2	264,4	256,8	-
Number of those who enrolled in foreign educational institutions	40		50	66	70	83*
Number of graduates of universities, academies and institutes of Ukraine	405,4	374,0	318,7	359,9	357,4	-

* predictive value [2]

The decrease in the total number of students and the lack of compliance with the modern quality requirements for the provision of educational services lead to a decrease in the number of HEIs in Ukraine and an increase in internal competition (Table 2).

Table 2 — Dynamics of decrease in the number of higher education institutions in Ukraine, 2010-2018

Indexes	2010	2011	2012	2013	2014	2015	2016	2017	2018
Higher education institutions, units.	861	854	846	823	803	664	659	657	652
The total number of students, thousands people	2599	2491	2312	2170	2053	1689	1605	1586	1522

Due to the economic crisis of Ukraine, one of the major educational problems faced by Ukrainian HEIs is the outflow of entrants abroad, where nearly 70,000 Ukrainian students (ie every 20 th) currently studying, and, according to the Institute of Public Relations (ISP), only 7% of Ukrainians studying abroad plan to return back [3]. According to the poll, 55% of respondents would like to study abroad. Only 29% intend to refrain from doing so [4]. Among the reasons for choosing a foreign education, the main, according to the research, is to receive a diploma of the European sample (about a third of Ukrainian students abroad plan to go to other EU countries after graduation).

Ukraine's active position in the world causes, among other things, to bring national educational standards in line with the norms of the world community. In order to improve the quality of education, its competitiveness and integration into the European and world educational space, Decree No. 344/2013 of June 25, 2013 “On the National Strategy for the Development of Education in Ukraine for the Period up to 2021” was signed, which states as a separate policy area in education - creation of joint educational programs by higher education institutions. It is the joint educational programs that enable the Defense Law Enforcement Agency of Ukraine to enter international educational markets and is one of the ways to solve the current problems of the Ukrainian higher education system.

Certain criteria distinguish joint educational programs among other educational tools:

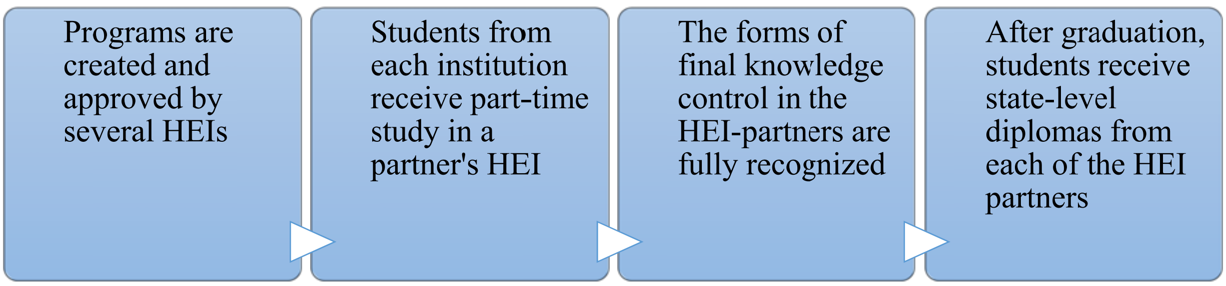


Fig. 2. Criteria to be met by joint educational programs

Joint educational programs follow a win-win strategy [5] where each participant has their own winnings and at the same time avoids the negative consequences of the winnings:

Benefits of joint educational programs for students:

- overcoming the dilemma of choosing education in Ukraine or in Europe;
- obtaining a recognized European University diploma while studying at a state HEI;
- Improvement of skills in different languages, both at home and at the professional level, because the program can be taught in Ukrainian, English, Polish and other languages.

Advantages of joint educational programs for partner universities:

- student and teacher mobility issues;
- formation of joint research topics of cooperation;
- modernization of curricula, materials and use of modern technologies;
- organization of inter-university language schools and centres.

Figure 3. - Benefits of participants in joint educational programs

At present, the following types of joint educational programs are distinguished: dual diplomas, joint diplomas, double diplomas, two diplomas, etc. (Table 3).

Table 3 - Types of joint educational programs

Types	Characteristics
Dual Diplomas	*Higher education institution and enterprise. *Educational program of the HEI, writing of which is possible with the participation of representatives of the partner enterprise. *State diploma of higher education institution.
Joint Diplomas	*Two or more higher education institutions. * The only educational programme that is taught by representatives of all HEI-partners. * One state diploma indicating the partners.
Double Diplomas	*One higher education institution. *Simultaneous education in two specialities (specializations). *One state diploma with a list of all specialities (specializations) that the applicant received.
Two Diplomas	*Two higher education institutions. * An educational programme consisting of most of the disciplines that are the same and some of the disciplines that are different for the HEI-partners. * Two separate diplomas provided by each of the HEI-partners.

Among the Ukrainian flagships of common education should be noted Kharkiv National Economic University named after S. Kuznets, which has been cooperating with the program since 2005. Sumy State University, Lviv Polytechnic, Odessa National Polytechnic University offer the largest number of joint programs (Table 4).

Table 4 - Characteristics of Ukrainian HEIs working under joint educational programs

Foreign partner HEI	Specialities
NATIONAL UNIVERSITY LVIV POLYTECHNIC	
1. Bialystok University of Technology (Poland) **2.** Wrocław University of Economics (Poland) **3.** Rzeszów School of Engineering and Economics **4.** AGH University of Science and Technology, (Poland, Krakov) **5.** Higher School of Regional Economy in Kutno **6.** University of Social Sciences, (Poland, Lodz) **7.** Lublin University of Technology **8.** University of Warmia and Mazury, (Poland, Olshtyn) **9.** Ilmenau Technical University (Germany) **10.** Neubrandenburg University of Applied Sciences (Germany) **11.** Le Mans University (France) **12.** Slovak University of Agriculture in Nitra (Slovakia)	Heating and ventilation Finance and accounting Management Geodesy and cartography Enterprise management Financial management Geodesy and cartography All specialities Restoration of architectural and urban monuments, reconstruction of architectural objects Chemical engineering Chemical technologies of high-molecular compounds International political and economic relations Metrology and information-measuring equipment Geoinformatics and geodesy, energy Chemistry Business economics
VINNITSA SOCIO-ECONOMIC INSTITUTE OF THE UNIVERSITY "UKRAINE"	
1. Deutsche Psychologische Akademie (Germany) 2. University of Siauliai (Lithuania) 3. University of Vistula (Republic of Poland) 4. Higher Linguistic School in Częstochowa (Republic of Poland)	Psychology Management Design Psychodiagnostics Social work Finance Economy Computer science International economics Rehabilitation pedagogy
VASYL' STUS DONETSK NATIONAL UNIVERSITY	
1. Vytautas The Great University (Kaunas, Lithuania) **2.** Economic Academy named after D. A. Tsenov (Bulgaria)	Biology / Molecular biology (molecular biology and biotechnology programme) Ecology and environmental protection / Environmental science (environmental

	management Program) - Biology / biology (biology and genetics programme) - Ecology / Ecological science (natural science and ecology program) - International financial management
KYIV INTERNATIONAL UNIVERSITY	
1. University of Dabrow Gurniczy (WSB University, Poland); 2. Sopot High School (SSW, Poland); 3. Upper Silesian Higher School of Trade named after Wojciech Corfanto (GWSH, Poland); 4. Kuyavian-Pomeranian Higher School in Bydgoszcz (KPSW, Poland); 5. Professional Institute of Business and Trade (IPAC, France); 6. Higher School of Information Systems Management (ISMA, Latvia); **7.** Klaipeda State University of Applied Sciences (KVK, Lithuania).	- Bachelor's courses: - Management - Information technology - Economy - Professionally-language competence in business - Business of languages - Architecture and urbanism - Interior design - Tourism (SP.: international tourism) - Right (SP.: international law; European law) - Construction: energy-saving construction - Business administration - Business administration in tourism - Information system - Business administration (Media business: management, PR communications and advertising) - Tourism - Communication and WEB marketing - International business and marketing - Psychology (SP.: clinical psychology; psychology of management.) - Civil engineering - Master's courses: - Management - Accounting and Finance - Tourism (SP.: international tourism) - Right (SP.: international law; European law) - Psychology (SP.: clinical psychology; psychology of management.) - Management of commercial development
UNIVERSITY OF ALFRED NOBEL	
1. Higher School of Management and Labor Protection, Katowice, Poland 2. University of Economics Bratislava, Slovakia 3. Cyprus Institute of Marketing (Nicosia, Cyprus) **4.** University of HUMANITAS (Wyższa Szkoła Humanitas University)	- English Philology - Management of international projects - International economic relations is economic diplomacy - Philology - Law (specialization - management, management of an international firm or management, social insurance)

ODESSA NATIONAL ACADEMY OF FOOD TECHNOLOGIES	
1. Politechnika Lubelska Lublin University of Technology (Poland, Lublin) 2. WSIU University of Informatics and Applied Knowledge (Poland, Lodz) 3. Angel Kanchev University of Ruse (Bulgaria, Ruse) **4.** University of Food Technology (Bulgaria, Plovdiv)	Food Technologies Automation and Computer Integrated Technologies Biotechnology and Bioengineering Electric Power Engineering, Electrical Engineering and Electromechanics” Grain storage and processing technologies (in Ukraine) Technology of grain, fodder, bakery and confectionery (in Bulgaria)
ODESSA NATIONAL ECONOMIC UNIVERSITY	
1. University of Applied Sciences, Mittweida (Germany) 2. School of Economics and Management (Zagreb, Croatia) 3. University (Angers, France) **4.** National University of Science, Technology and Management of France CNAM	Finances Personnel management and labor economics Marketing Accounting and Audit Business Economics Finance and Credit Management International Economics Tourism

Despite numerous international agreements on the mutual recognition of educational documents, scientific degrees and academic titles concluded with the participation of Ukraine, the total number of national HEIs that have implemented joint programs is only 3%. Effective work in the field of common education implies not only cooperation at the level of management between different universities, but also a concerted action between different units of each HEI-partner, which in turn leads to a synergistic effect.

Such cooperation has numerous advantages and has some difficulties (Table 5).

Table 5 - Advantages and difficulties of implementing a joint education program

Advantages	Difficulties
Defining common values	Complex system of coordination
Defining common goals	Internal competition
Development of communication skills	Lack of understanding of common goals of cooperation at a certain level
Raising teamwork	Delayed work
Creating a corporate culture	Discrepancy in work schedules
Improving the quality of education	

At Odessa National Maritime University (ONMU) the joint education program in the speciality "management" (educational program "project management") was launched in 2017.

The program provides for the simultaneous training of masters in project management at ONMU in the magistracy of the Polish Higher School of Occupational Safety Management in Katowice (WSZOP) in the specialities of "project management" or "strategic enterprise management". In the spring of 2019, the first graduates defended their diploma at ONMU and passed the master's exam at WSZOP. The presentation of diplomas of both HEIs was solemnly held at the ONMU Academic Council (Fig. 5).

Figure 5. Students - participants of the joint education program together with the Head of the Department "Management of logistic systems and projects" and the staff of the Center for Intercollegiate Education after the graduation ceremony

In January 2019, the Center for Inter-University Education (CIUE) was established, the main purpose of which is to create conditions for expanding cooperation between ONMU students and teachers with other educational institutions [6]. Proposals for ONMU students regarding new joint programs with Polish universities were prepared by 2019-2020 academic year of CIUE (Fig. 6).

Fig. 6. Polish HEIs are ONMU partners in joint education programs

Polish HEIs offer ONMU students' higher education in the following specialities:

- Management (enterprise management, marketing and sales, business management and psychology, quality management, project management, information security management, logistics management, financial management and stock market investments).
- Tourism.
- Translator from English.
- English in business.
- Teacher of English.

The implementation of joint educational programs is one of the priority areas of activity, which is in line with ONMU's internationalization strategy, which not only prevents outflow of potential students to foreign HEIs, but also allows to attract more students to study at the university, and also leads to indirect benefits such as competitiveness of the university in particular and attractiveness of the national higher education as a whole.

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24. RESEARCH OF THE ECONOMIC DEVELOPMENT STRUCTURE OF THE REGIONS OF UKRAINE WITH THE METHODS OF MULTI-DIMENSIONAL STATISTICAL ANALYSIS

Gybkina N., Sidorov M., Storozhenko O.

The classification problem of the regions of Ukraine on the main economic indicators in 2012 and 2017 is considered. The principal component method and cluster analysis methods were used for solving the problem. The obtained results graphically display the position of the regions of Ukraine on the plane of the first two main components grouped in selected clusters.

The economic situation of the regions of Ukraine. The variety of natural conditions, historically developed directions of development of certain areas and their economic orientation, which developed at the beginning of the 90-ies of the twentieth century, the difficulties associated with the shortcomings of planning and management of the political and economic system in the field for less than 30 years of independence of Ukraine have led to a significant imbalance in the levels of economic development of individual regions, which, in turn, significantly hinders the development of the whole country and requires constant increased attention to the allocation of funds and organization of management both locally and at the state level. In order to facilitate this task, it is necessary to clearly classify the individual regions in order to distinguish among them regions that are similar in economic terms. The problem here may be that funding in the social and economic spheres may require the distribution of funds between individuals in unequal proportions, since the level of development of the same entity may differ significantly in different directions.

The economy of the country and its individual parts is described by a large number of indicators, the values of which depend on the peculiarities of the geographical location and level of development and are constantly changing over time. Therefore, the issue of classification of economic objects is one of the tasks that can be considered as an initial issue when developing short and long-term programs for managing the economic development of the country. A comprehensive study of the issue in recent years has received increasing attention. In [9, 16, 21] the classification of regions of Ukraine according to the direction of their economic development is given, taking into account historical peculiarities and real existing natural conditions. Accordingly, four macro-regions are usually distinguished: Kyiv, industrial regions of Eastern Ukraine, coastal regions of the South, agrarian regions of the West and the Center.

In addition to using geographic considerations to solve the classification problem, you can use multidimensional statistical analysis methods, such as cluster analysis [1, 5, 8, 12, 14, 15]. In [10], the clustering of regions of Ukraine by the complete set of socio-economic features (41 socio-economic indicators) was performed, which allowed dividing the set of regions into eight clusters. The Kohonen network algorithm was used for clustering. On the basis of the results obtained in [10] in [11], an applied estimation of the growth potential of individual socio-economic indicators of the regions of Ukraine was carried out. The issue of grouping regions of Ukraine by the level of economic security is devoted to the work [3]. For classification, the author uses groups of socio-economic indicators characterizing socio-demographic, resource-energy, ecological-economic and financial-economic security of each region of Ukraine, and applies the k-means method. In [7], it is proposed to use the results of the cluster analysis to improve the budgeting potential of Ukrainian regions. The work [13] is devoted to the use of cluster analysis to assess the development of small business in the regions of Ukraine. It calculates a regional small business development index for each oblast, grouping the oblasts into separate clusters. In article [17], the different cluster analysis methods (hierarchical and iterative) to cluster regions by the level of economic potential are used. Three clusters were identified, the first of which consisted of Dnipropetrovsk, Donetsk, Zaporizhia, Kyiv, Lviv, Odesa and Kharkiv regions, the second cluster consists of Kyiv, and the third contains the rest of Ukraine's regions. The work [6] is devoted to the clustering of regions of Ukraine in order to identify disproportions in ensuring their financial security.

From the conducted review of works, it can be concluded that the authors use different groups of socio-economic indicators for classification, based on the purpose of their research. The desire to take into account as many indicators as possible in the selection of groups can lead to computational complications despite the use of electronic computing facilities. Therefore, it is promising to use cluster analysis methods in combination with dimension-reduction methods that will significantly reduce the amount of input information and present the results in an obvious way. So, let's look at methods that allow us to formalize and solve this problem.

Basic approaches to dimensionality reduction and classification of multidimensional observations. The economic status of an entity (business, city, region, country, etc.) can be described by a large number of indicators, different in nature, origin, and possibly stochastically related. As a result, the direct analysis and comparison (classification) of objects by all indicators is impossible and the additional task of reducing the dimensionality of many characteristics of the object. These problems can be solved with modern data analysis methods, including component and cluster analysis [1, 2, 5, 8, 12, 14, 15].

Component analysis (principal component method) allows for the formation of several integral indicators over the whole set of indicators (usually two indicators for the sake of clarity of interpretation of the results), which thus solves the problem of reducing the dimensionality of the initial set of indicators, and such compression of information ensures its minimum compression. This method is based on the study of the structure of a covariance (or correlation) matrix of a system of random variables and allows to distinguish linear combinations of initial features with the largest contribution to the total variance. Among the advantages of component analysis, it should be noted that no statistical assumptions are made to realize the probabilistic distributions of the system of economic indicators under consideration for its implementation.

Cluster analysis, in turn, solves the problem of splitting a given set of objects into groups (clusters) consisting of similar objects. The output for cluster analysis is presented as, for example, a matrix of distances between objects in the selected metric. The most common methods of cluster analysis are probabilistic (k-means, k-median, etc.) and hierarchical (agglomerative and di-visa algorithms) approaches.

Component and cluster analysis procedures and their application to solving the object classification problem. Consider the scheme of the method of principal components [1, 2, 5]. Let the economic system consist of n objects, each characterized by a vector of p metrics $x^{(1)}, x^{(2)}, ..., x^{(p)}$. Then the result of observing the system will be an array consisting of n p-dimensional vectors

$$X_1 = (x_1^{(1)}, x_1^{(2)}, ..., x_1^{(p)})^T,\ X_2 = (x_2^{(1)}, x_2^{(2)}, ..., x_2^{(p)})^T,\ \ldots,\ X_n = (x_n^{(1)}, x_n^{(2)}, ..., x_n^{(p)})^T.$$

Because indicators $x^{(1)}, x^{(2)}, \ldots, x^{(p)}$ can be measured in different scales, we assume that before applying the component analysis method, we make the transition to observations

$$\tilde{X}_1 = (\tilde{x}_1^{(1)}, \tilde{x}_1^{(2)}, ..., \tilde{x}_1^{(p)})^T,\ \tilde{X}_2 = (\tilde{x}_2^{(1)}, \tilde{x}_2^{(2)}, ..., \tilde{x}_2^{(p)})^T,\ \ldots,\ \tilde{X}_n = (\tilde{x}_n^{(1)}, \tilde{x}_n^{(2)}, ..., \tilde{x}_n^{(p)})^T$$

normalized values $\tilde{x}^{(1)}, \tilde{x}^{(2)}, \ldots, \tilde{x}^{(p)}$ by formulas

$$\tilde{x}_i^{(j)} = \frac{x_i^{(j)} - \overline{x}^{(j)}}{\hat{\sigma}^{(j)}},\ i = 1, 2, ..., n,\ j = 1, 2, ..., p, \tag{1}$$

where $\overline{x}^{(j)} = \frac{1}{n}\sum_{k=1}^{n} x_k^{(j)}$ and $\hat{\sigma}^{(j)} = \sqrt{\frac{1}{n}\sum_{k=1}^{n}(x_k^{(j)} - \overline{x}^{(j)})^2}$ – accordingly, the sample mean and standard deviation of the j-th indicator, $j = 1, 2, ..., p$.

Then, by normalized observations $\tilde{X}_1, \tilde{X}_2, ..., \tilde{X}_n$ we find a sample correlation matrix $\Sigma = [\hat{\sigma}_{ij}]_{p\times p}$ of indicators $\tilde{x}^{(1)}, \tilde{x}^{(2)}, \ldots, \tilde{x}^{(p)}$, where

$$\hat{\sigma}_{ij} = \frac{1}{n}\sum_{k=1}^{n} \tilde{x}_k^{(i)} \tilde{x}_k^{(j)}\ ,\ i,\ j = 1, 2, ..., p\ . \qquad (2)$$

The first selective main component $y^{(1)}$ is the normalized linear combination of indicators $\tilde{x}^{(1)}, \tilde{x}^{(2)}, \ldots,\ \tilde{x}^{(p)}$ which, among other normalized linear combinations of indicators $\tilde{x}^{(1)},\ \tilde{x}^{(2)},\ \ldots,\ \tilde{x}^{(p)}$ has the largest variance.

The second selective main component $y^{(2)}$ is the normalized linear combination of indicators $\tilde{x}^{(1)},\ \tilde{x}^{(2)},\ \ldots,\ \tilde{x}^{(p)}$ which, among other normalized linear combinations of indicators $\tilde{x}^{(1)},\ \tilde{x}^{(2)},\ \ldots,\ \tilde{x}^{(p)}$ uncorrelated with $y^{(1)}$, has the largest dispersion. And so on.

The task of component analysis is to construct a linear transformation

$$y^{(1)} = l_{11}\tilde{x}^{(1)} + l_{12}\tilde{x}^{(2)} + ... + l_{1p}\tilde{x}^{(p)}\ ,$$

$$y^{(2)} = l_{21}\tilde{x}^{(1)} + l_{22}\tilde{x}^{(2)} + ... + l_{2p}\tilde{x}^{(p)}\ ,$$

$$\ldots\ \ldots\ \ldots\ \ldots\ \ldots\ \ldots\ \ldots\ \ldots$$

$$y^{(p)} = l_{p1}\tilde{x}^{(1)} + l_{p2}\tilde{x}^{(2)} + ... + l_{pp}\tilde{x}^{(p)}\ ,$$

for which

$$l_{j1}^2 + l_{j2}^2 + ... + l_{jp}^2 = 1\ ,\ j = 1, 2, ..., p\ ,$$

$$\mathrm{cov}(y^{(i)},\ y^{(j)}) = 0\ ,\ \text{if}\ j < i\ ,$$

$$\mathsf{D}y^{(1)} \geq \mathsf{D}y^{(2)} \geq ... \geq \mathsf{D}y^{(p)}\ .$$

Thus, the selective principal components $y^{(1)},\ y^{(2)},\ \ldots,\ y^{(p)}$, formed as linear combinations of the initial normalized features $\tilde{x}^{(1)},\ \tilde{x}^{(2)},\ \ldots,\ \tilde{x}^{(p)}$, give a new set of features (generalized integral indicators) to the set of economic objects under consideration. In this case, the sample principal components are ordered by the degree of dispersion (by the magnitude of the variance).

It was obtained [1, 2, 5] that the vector $\mathbf{L}^{(j)} = (l_{j1}, l_{j2}, ..., l_{jp})^T$ is the j th normalized eigenvector of the sample correlation matrix Σ, which corresponds to the j th in size eigenvalue λ_j, that is λ_j is the j -th root of the characteristic equation $\det(\Sigma - \lambda E) = 0$ (E is the unit matrix of the p th order), and $\mathbf{L}^{(j)}$ is normalized by the condition $l_{j1}^2 + l_{j2}^2 + ... + l_{jp}^2 = 1$ of the solution of a homogeneous system $(\Sigma - \lambda_j E)\mathbf{L}^{(j)} = \mathbf{0}$, $j = 1, 2, ..., p$, with $\mathsf{D}y^{(j)} = \lambda_j$ and

$$\mathsf{D}\tilde{x}^{(1)} + \mathsf{D}\tilde{x}^{(2)} + ... + \mathsf{D}\tilde{x}^{(p)} = \mathsf{D}y^{(1)} + \mathsf{D}y^{(2)} + ... + \mathsf{D}y^{(p)} = \lambda_1 + \lambda_2 + ... + \lambda_p\ .$$

The contribution of the first p' main components ($1 \leq p' \leq p$) to the total variance is characterized by a value

$$q(p') = \frac{\mathsf{D}y^{(1)} + \mathsf{D}y^{(2)} + \ldots + \mathsf{D}y^{(p')}}{\mathsf{D}\tilde{x}^{(1)} + \mathsf{D}\tilde{x}^{(2)} + \ldots + \mathsf{D}\tilde{x}^{(p)}} = \frac{\lambda_1 + \lambda_2 + \ldots + \lambda_{p'}}{\lambda_1 + \lambda_2 + \ldots + \lambda_p},$$

analyzing which one can conclude how much is enough to allocate the first principal components to reduce the dimension of the space of output indicators of a given economic system.

Therefore, in order to get a clear idea of the structure of the economic system in question using the principal component method, it is necessary to design observation points $\tilde{X}_1$, $\tilde{X}_2$, …, $\tilde{X}_n$, from the original p-dimensional feature space into a one-dimensional (two-dimensional or three-dimensional) subspace stretched over the principal component $y^{(1)}$ (or major components $y^{(1)}$, $y^{(2)}$, or $y^{(1)}$, $y^{(2)}$, $y^{(3)}$), that is, each of the n objects of the economic system is represented by dots $(y_k^{(1)})$ ($(y_k^{(1)}, y_k^{(2)})$ or $(y_k^{(1)}, y_k^{(2)}, y_k^{(3)})$), $k = 1, 2, ..., n$, where

$$y_k^{(1)} = l_{11}\tilde{x}_k^{(1)} + l_{12}\tilde{x}_k^{(2)} + \ldots + l_{1p}\tilde{x}_k^{(p)},$$

$$y_k^{(2)} = l_{21}\tilde{x}_k^{(1)} + l_{22}\tilde{x}_k^{(2)} + \ldots + l_{2p}\tilde{x}_k^{(p)}, \tag{3}$$

$$y_k^{(3)} = l_{31}\tilde{x}_k^{(1)} + l_{32}\tilde{x}_k^{(2)} + \ldots + l_{3p}\tilde{x}_k^{(p)},\ k = 1, 2, ..., n.$$

The dimensionality of the p' subspace to which observations $\tilde{X}_1$, $\tilde{X}_2$, …, $\tilde{X}_n$, are designed, is determined based on the analysis of the behavior of the magnitude $q(p')$.

For the sake of certainty, let us assume that the design of the observations is made on a two-dimensional space, and, therefore, the observations are given as points $(y_k^{(1)}, y_k^{(2)})$, $k = 1, 2, ..., n$. To apply the cluster analysis procedure, you must select a metric by which the distances between objects will be measured. Since the initial observations were measured at interval scales, it is natural to use the Euclidean distance, which for points $(y_i^{(1)}, y_i^{(2)})$ and $(y_j^{(1)}, y_j^{(2)})$ is given by the formula

$$d_{ij} = \sqrt{(y_i^{(1)} - y_j^{(1)})^2 + (y_i^{(2)} - y_j^{(2)})^2}.$$

One of the hierarchical methods of cluster analysis is the method of minimizing Ward dispersion [8, 14]. This method allows obtaining the highest density clusters. Accordingly, in the first step of the algorithm, each cluster consists of a single object. The distance between the clusters is calculated as the increment of the sum of the squares of missing objects to the centre of the cluster resulting from their merging. This then combines the objects or clusters that give the smallest increase in the sum of squares. The results of hierarchical methods are usually presented in the form of a dendrogram - a treelike structure based on a measure of distance.

One of the most common non-hierarchical methods of cluster analysis is the k-means method, as well as its modification, which is more stable in the use of emission-observers, the k-median method [8, 14]. The essence of these methods is as follows. Upstream assumptions are made about the presence of clusters and on the plane randomly selected points (cluster centres) around which clusters are formed on the principle of minimizing the distance from the object to the centre of the cluster. Next, for the created clusters, the new centres are calculated as the arithmetic mean of the objects (or median signs) that formed the cluster, and several refinement iterations occur.

Comprehensive application of component and cluster analyses to the classification of regions of Ukraine in the 21st century. Consider the consistent application of component and cluster analysis methods to classify regions of Ukraine by their economic situation. To do this, consider the following socio-economic indicators traditionally used to characterize the economic situation:

$x^{(1)}$ – Gross regional product in actual prices, million UAH.;

$x^{(2)}$ – Gross regional product per capita, in actual prices, million UAH.;

$x^{(3)}$ – Consumer price index by region, % to the previous year;

$x^{(4)}$ – Industrial production index by region, % to the previous year;

$x^{(5)}$ – Index of agricultural production by regions, % to the previous year;

$x^{(6)}$ – Exports of goods by region, value, mln. US$;

$x^{(7)}$ – Imports of goods by region, value, mln. US$;

$x^{(8)}$ – Exports of services by region, cost, mln. US$;

$x^{(9)}$ – Imports of services by region, value, mln. US$;

$x^{(10)}$ – Wholesale turnover by regions, mln UAH.;

$x^{(11)}$ – Retail turnover in actual prices, mln UAH.;

$x^{(12)}$ – Registered unemployed, by region, % of the working-age population;

$x^{(13)}$ – Demand for labour, number of vacancies, thousand;

$x^{(14)}$ – Average monthly nominal salary by regions, UAH.

The values of the selected indicators for the regions of Ukraine are taken from [4, 18-20].

Let us consider the application of the clustering procedure with the previous reduction of the dimension by the principal component method according to 2012 data. We have $n = 27$ - number of regions (24 regions of Ukraine, Autonomous Republic of Crimea, Kyiv and Sevastopol); $p = 14$ - the number of indicators to be analyzed.

The preliminary stage of the statistical analysis is the normalization of the considered economic indicators in accordance with (1) since the raw data are given in different units (US dollars, interest, UAH, etc.). The basis for the application of the principal component method is the correlation matrix Σ, which is constructed by the formula (2) on the basis of the normalized input information (Table 1).

Table 1 – Correlation matrix of indicators Σ according to the 2012 data

	$x^{(1)}$	$x^{(2)}$	$x^{(3)}$	$x^{(4)}$	$x^{(5)}$	$x^{(6)}$	$x^{(7)}$	$x^{(8)}$	$x^{(9)}$	$x^{(10)}$	$x^{(11)}$	$x^{(12)}$	$x^{(13)}$	$x^{(14)}$
$x^{(1)}$	1	0,923	0,650	–0,157	–0,754	0,422	0,899	0,852	0,906	0,952	0,962	–0,557	0,889	0,914
$x^{(2)}$		1	0,636	–0,155	–0,844	0,325	0,952	0,902	0,956	0,917	0,823	–0,506	0,823	0,937
$x^{(3)}$			1	–0,267	–0,540	0,447	0,580	0,570	0,583	0,641	0,641	–0,716	0,488	0,752
$x^{(4)}$				1	0,111	–0,284	–0,147	–0,180	–0,159	–0,175	–0,181	0,458	–0,007	–0,287
$x^{(5)}$					1	–0,200	–0,857	–0,884	–0,862	–0,787	–0,691	0,425	–0,723	–0,777
$x^{(6)}$						1	0,294	0,256	0,283	0,329	0,437	–0,362	0,254	0,505
$x^{(7)}$							1	0,965	0,985	0,934	0,815	–0,552	0,820	0,869
$x^{(8)}$								1	0,964	0,915	0,808	–0,578	0,750	0,842
$x^{(9)}$									1	0,965	0,814	–0,526	0,797	0,884
$x^{(10)}$										1	0,890	–0,558	0,800	0,891
$x^{(11)}$											1	–0,611	0,848	0,859
$x^{(12)}$												1	–0,490	–0,627
$x^{(13)}$													1	0,745
$x^{(14)}$														1

Since the combination of the clustering method with a visual presentation of the results of grouping is chosen as a method of study, then we will use the two main components obtained by the method of component analysis. They make 81.15% of the contribution to the total variance. So, here are the first two maximal eigenvalues of the correlation matrix:

$$\lambda_1 = 9{,}85041,\ \lambda_2 = 1{,}51092$$

(note that the following eigenvalues λ_3 – λ_{14} do not exceed 1) and the corresponding eigenvectors:

$$\mathbf{L}^{(1)} = (0{,}306733;\ 0{,}304837;\ 0{,}230243; -0{,}0749314; -0{,}270995;\ 0{,}133939; 0{,}304549;\\ 0{,}298144;\ 0{,}305175;\ 0{,}305669;\ 0{,}291656; -0{,}210277; 0{,}271502;\ 0{,}302963)^T;$$

$$\mathbf{L}^{(2)} = (0{,}0493388;\ 0{,}114377;\ -0{,}313895;\ 0{,}601219; -0{,}187837; -0{,}45862; 0{,}141146;\\ 0{,}122458;\ 0{,}145224;\ 0{,}0819298;\ -0{,}0198077;\ 0{,}412784;\ 0{,}189012; -0{,}0982057)^T.$$

Using the above values, we use the formula (3) to calculate the values of the first two principal components:

$$y^{(1)} = 0,306733\,x_1 + 0,304837\,x_2 + 0,230243\,x_3 - 0,0749314\,x_4 -$$
$$-0,270995\,x_5 + 0,133939\,x_6 + 0,304549\,x_7 + 0,298144\,x_8 + 0,305175\,x_9 +$$
$$+0,305669\,x_{10} + 0,291656\,x_{11} - 0,210277\,x_{12} + 0,271502\,x_{13} + 0,302963\,x_{14};$$
$$y^{(2)} = 0,0493388x_1 + 0,114377x_2 - 0,313895x_3 + 0,601219x_4 - 0,187837x_5 -$$
$$-0,45862x_6 + 0,141146x_7 + 0,122458x_8 + 0,145224x_9 + 0,0819298x_{10} -$$
$$-0,0198077x_{11} + 0,412784x_{12} + 0,189012x_{13} - 0,0982057x_{14}.$$

By these ratios, we will determine the coordinates of regions of Ukraine in the coordinate system $(y^{(1)}, y^{(2)})$ in 2012:

Vinnytsya Region: $(-1,822;\ 1,451)$;
Volyn region: $(-1,680;\ -0,520)$;
Dnipropetrovsk Region: $(3,320;\ 0,543)$;
Donetsk Region: $(4,259;\ -1,61842)$;
Zhytomyr Region: $(-2,130;\ 2,490)$;
Zakarpattya Region: $(-1,479;\ 0,046)$;
Zaporizhzhya Region: $(0,034;\ -0,376)$;
Ivano-Frankivsk Region: $(-1,418;\ 0,091)$;
Kyiv Region: $(1,015;\ -0,445)$;
Kirovograd Region: $(-1,857;\ 1,705)$;
Luhansk Region: $(0,919;\ -3,847)$;
Lviv Region: $(-0,034;\ -0,066)$;
Mykolayiv Region: $(-0,855;\ 0,468)$;
Odesa Region: $(1,330;\ -0,264)$;
Poltava Region: $(-0,402;\ 0,747315)$;
Rivne Region: $(-1,816;\ 0,185)$;
Sumy Region: $(-1,428;\ -0,402)$;
Ternopil Region: $(-2,124;\ 0,666)$;
Kharkiv Region: $(1,045;\ -0,0855)$;
Kherson Region: $(-1,503;\ 0,762)$;
Khmelnytsky Region: $(-1,710;\ -0,129)$;
Cherkasy Region: $(-1,477;\ -0,025)$;
Chernivtsi Region: $(-1,860;\ -1,243)$;
Chernihiv Region: $(-1,988;\ 0,413)$;
Kyiv City: $(13,719;\ 1,545)$;
Sevastopol City: $(-0,025;\ -2,242)$;
Autonomous Republic of Crimea: $(-0,033;\ 0,147)$.

Note that these coordinates can be considered as the values of the integral indicators obtained by the method of principal components that characterize the economic situation of each region of the country as a whole.

The final stage of the analysis is the clustering of the data obtained. In Fig. Figures 1 and 2 show the results of cluster analysis using non-hierarchical and hierarchical approaches.

In particular, Figure 1 shows the graphical location of Ukraine's regions by principal components $y^{(1)}$, $y^{(2)}$, using the k-median cluster analysis method (6 clusters). Fig. 2 shows a dendrogram (cluster tree) constructed by the Ward method. In both cases, the Euclidean distance was used as the metric.

Analyzing the results, we can draw several conclusions. Both methods distinguish Kyiv into a separate cluster, which is explained by the peculiarities of its political position as the capital of Ukraine and, as a consequence, by the values of economic indicators. The other 5 clusters from fig. 1, obtained by the k-median method, contains the following regions:

- Dnipropetrovsk, Donetsk, Kyiv, Odesa, Kharkiv;
- Lugansk, Sevastopol;
- Volyn, Chernivtsi;
- Vinnytsya, Zhytomyr, Kirovograd;
- AR of Crimea, Zakarpattya, Zaporizhzhya, Ivano-Frankivsk, Lviv, Mykolayiv, Poltava, Rivne, Sumy, Ternopil, Kherson, Khmelnytsky, Cherkasy, Chernihiv.

On the basis of the dendrogram (Fig. 2), it is natural to distinguish (except Kyiv City) clusters consisting of the following regions:

- Vinnytsya, Zhytomyr, Kirovograd;
- Volyn, Zakarpattya, Ivano-Frankivsk, Rivne, Sumy, Ternopil, Kherson, Khmelnytsky, Cherkasy, Chernivtsi, Chernihiv;
- Dnipropetrovsk, Donetsk, Lugansk, Sevastopol;
- AR of Crimea, Zaporizhzhya, Kyiv, Lviv, Mykolayiv, Odesa, Poltava, Kharkiv.

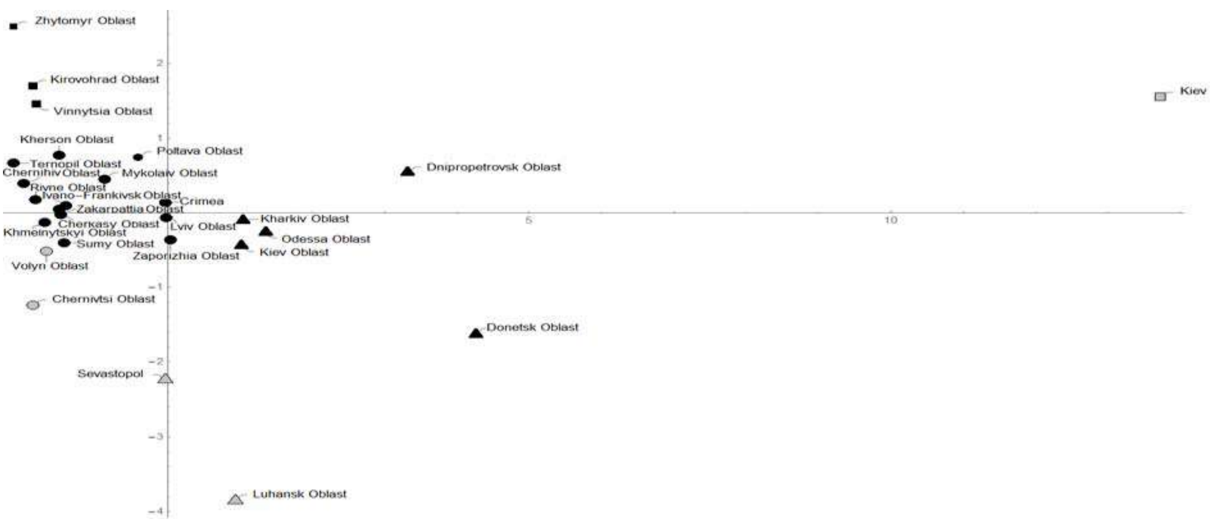

Fig. 1. k-median clustering, 2012

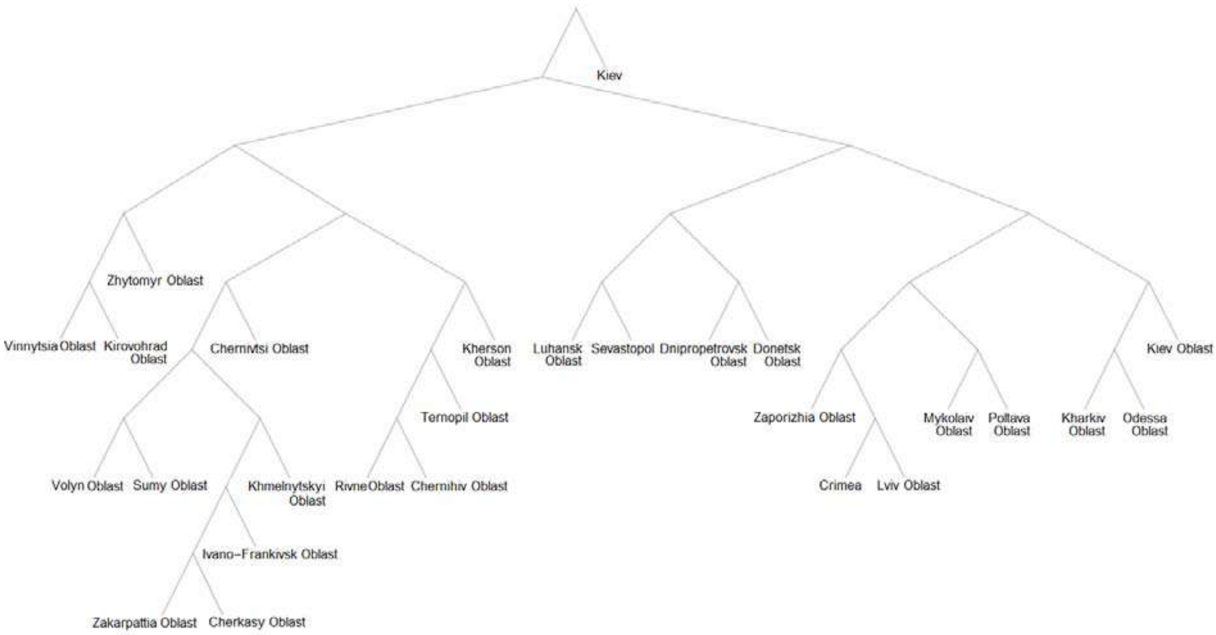

Fig. 2 Dendrogram of Ukrainian regions, 2012

As can be seen, in both cases the structure of the clusters is in good agreement (with some exceptions). The grouping differences that follow in Figs. 1 and 2 are explained by different mathematical approaches that use different clustering methods. By increasing or decreasing the number of clusters in the k-median method, it is possible to obtain other clusters (more detailed or more general) that are more suited to the purposes of the analysis. The use of hierarchical methods allows you to choose the right number of clusters of output from the appearance of the dendrogram.

Let us consider further what changes have taken place in the economic situation of Ukraine's regions in recent years. To do this, we apply the above approach for clustering according to 2017 data. As a result of component analysis, the following values of the first two components were obtained:

$$y^{(1)} = 0,322749x_1 + 0,311181x_2 + 0,137372x_3 - 0,045178x_4 -$$
$$-0,304181x_5 + 0,292846x_6 + 0,326835x_7 + 0,314691x_8 + 0,312756x_9 +$$
$$+0,324434x_{10} + 0,147145x_{11} - 0,114256x_{12} + 0,235248x_{13} + 0,317537x_{14};$$
$$y^{(2)} = 0,031930x_1 + 0,209915x_2 - 0,041099x_3 + 0,735189x_4 +$$
$$+0,013171x_5 - 0,030827x_6 - 0,034352x_7 - 0,014739x_8 - 0,060335x_9 -$$
$$-0,024382x_{10} + 0,318432x_{11} + 0,511370x_{12} + 0,200729x_{13} - 0,052707x_{14},$$

which make up 74.78% of the total variance.

The results of clustering by the k-median method provided that 6 clusters are shown in

Fig. 3. The dendrogram, constructed by the Ward method, is shown in Fig. 4.

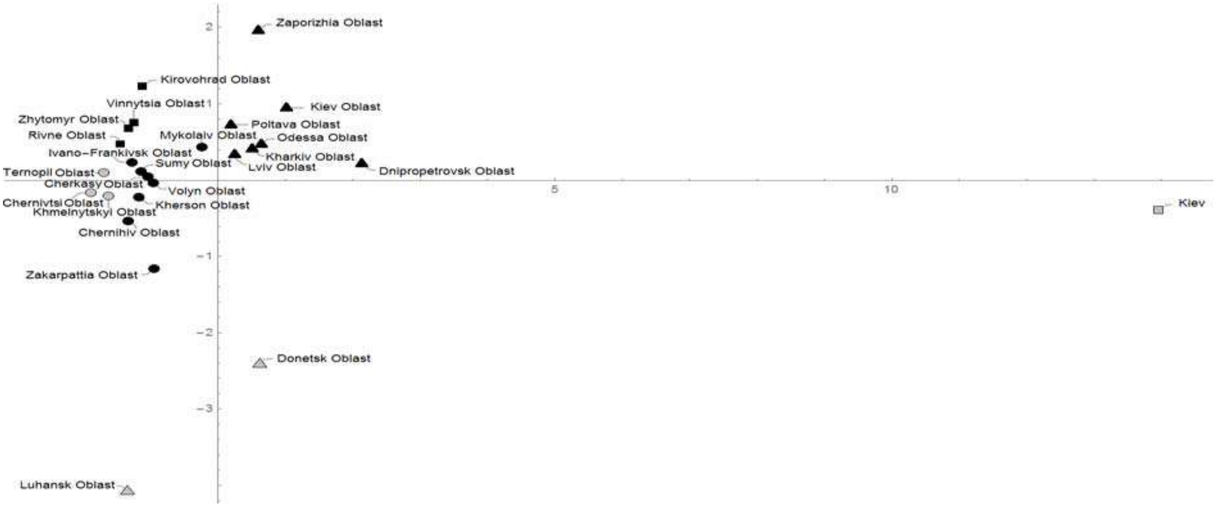

Fig. 3. k-median Clustering, 2017

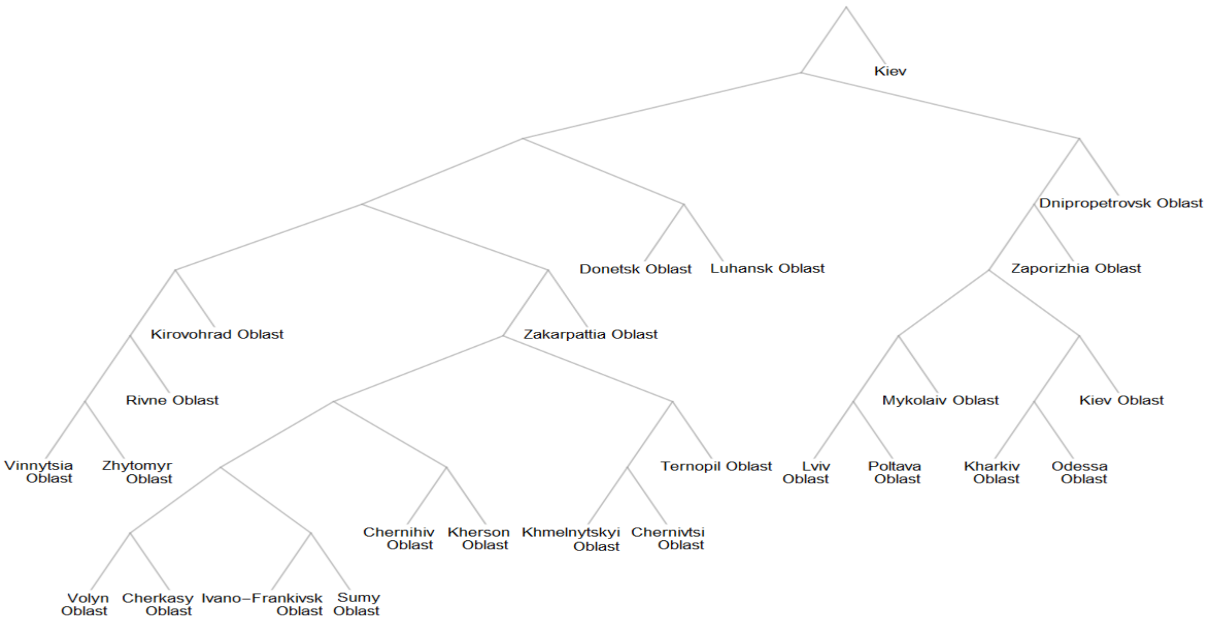

Fig. 4. Dendrogram of regions of Ukraine, 2017

As can be seen from the above figures, the special position of Kyiv as a separate cluster is preserved. Other clusters obtained by the k-median method (Fig. 3) consist of the following domains:

- Donetsk, Lugansk;
- Dnipropetrovsk, Zaporizhzhya, Kyiv, Lviv, Odesa, Poltava, Kharkiv;
- Ternopil, Chernivtsi, Khmelnytsky;
- Vinnytsya, Zhytomyr, Kirovograd, Rivne;

- Volyn, Zakarpattya, Ivano-Frankivsk, Mykolayiv, Sumy, Kherson, Cherkassy, Chernihiv.

The dendrogram (Fig. 4) allows you to group the areas into the following clusters (Kyiv is still allocated to a separate cluster):

- Vinnytsya, Zhytomyr, Kirovograd, Rivne;
- Donetsk, Lugansk;
- Dnipropetrovsk, Zaporizhzhya, Kyiv, Lviv, Mykolayiv, Odesa, Poltava, Kharkiv;
- Volyn, Zakarpattya, Ivano-Frankivsk, Sumy, Ternopil, Kherson, Khmelnytsky, Cherkasy, Chernivtsi, Chernihiv.

As before, overall, with some exceptions, the structure of clusters is maintained when using the k-median and Ward method.

Comparing the clustering results obtained by the same method for 2012 and 2017, we can conclude what changes have occurred in the economic situation of individual regions of Ukraine in the considered period of time.

Analysis of the received results. This procedure allows to group the regions with similar values obtained by the method of the main components of the integral indicators. Its advantage is that due to the large variety of natural economic characteristics we cannot only move to two or three summaries and merge the objects into homogeneous groups but also visually arrange the grouped objects in two-dimensional or three-dimensional space.

It should be noted that, unlike the traditional classification of regions of Ukraine as industrial, agricultural, resource, etc. [16, 21], the method of clustering proposed by the authors in combination with the method of principal components allows to integrate a large number of different economic indicators and perform groupings by the relevance of the general economic situation of the regions, not their economic profile. It should be noted that despite this peculiarity of the applied approach, the two cluster analysis methods used have allowed distinguishing groups that generally coincide with some traditionally considered ones: in particular, a group of large regions of eastern and southern Ukraine with great industrial potential; a group of regions mainly in western Ukraine, small in size and population; Kyiv as a separate cluster; the separation of Lugansk and Donetsk regions into a separate group because of the peculiarities of their current economic and political situation. It should be expected that the methodology discussed in this paper will also be useful for obtaining the classifications cited in general economic studies, for example, [21]. If the researcher is to obtain the grouping of regions by specific criteria (for example, breakdown into industrial/agricultural regions, etc., or classification by the level of development of social services), then indicators of this aspect of socio-economic status will have to be used as initial information. The selection of the required indicators and methods of cluster analysis is the prospect of applying the methodology in practice to obtain classifications that meet different economic research objectives.

Summarizing the results of the study, we can conclude that the consistent use of the principal component method and cluster analysis methods can help solve the problems of classification of elements of the economic system by a large set of indicators and significantly simplify the visual analysis. However, it should be noted that the use of component analysis procedure, which allows moving to a small number of integral indicators, at the same time leads to some loss of informativeness of the initial economic data that characterize the studied objects. For this reason, it is necessary to carefully consider the number and appearance of the indicators selected as initial when describing the economic status of the objects and to ensure that the compression of information does not become excessive. Taking into account the above comments allows us to consider this approach promising for visual statistical analysis of complex, in particular, economic, systems.

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25. UNDERSTANDING GLOBAL TRENDS OF GENDER INEQUALITY: KEY GLOBAL RATINGS CORRELATION ANALYSIS

Momot T.V., Tumietto D., Chekh N.O.

Over the past decade, gender equality and women's empowerment have been explicitly recognized as key not only to the health of nations, but also to social and economic development.

Research shows gender discrimination mostly in favour of men in many realms including the workplace. Discrimination affects many aspects in the lives of women from career development and progress to mental health disorders.

What's the goal here? To achieve gender equality and empower all women and girls.

Why? Women and girls represent half of the world's population and therefore also half of its potential. But today gender inequality persists everywhere and stagnates social progress. As of 2014, 143 countries have guaranteed equality between men and women in their Constitutions but 52 have yet to take this step.

What happens if gender equality is not ensured? Inequalities faced by girls can begin right at birth and follow them all their lives. In some countries, girls are deprived of access to health care or proper nutrition, leading to a higher mortality rate.

How does gender inequality affect women? Disadvantages in education translate into lack of access to skills and limited opportunities in the labour market. Women's and girls' empowerment is essential to expand economic growth and promote social development.

But, why should gender equality matter to me? Regardless of where you live in, gender equality is a fundamental human right. Advancing gender equality is critical to all areas of a healthy society, from reducing poverty to promoting the health, education, protection and the well-being of girls and boys.

The Global Gender Gap Report

The ***Global Gender Gap report*** from World Economic Forum sets a benchmark for gender parity. The Global Gender Gap Report benchmarks 149 countries on their progress towards gender parity across four thematic dimensions:

- Economic participation and opportunity – outcomes on salaries, participation levels and access to high-skilled employment
- Educational attainment – outcomes on access to basic and higher level education

- Political empowerment – outcomes on representation in decision-making structures
- Health and survival – outcomes on life expectancy and sex ratio. In this case parity is not assumed, there are assumed to be fewer female births than male (944 female for every 1,000 males), and men are assumed to die younger. Provided that women live at least six percent longer than men, parity is assumed. But if it is less than six percent it counts as a gender gap.

Thirteen out of the fourteen variables used to create the index are from publicly available "hard data" indicators from international organizations, such as the International Labour Organization, the United Nations Development Programme and the World Health Organization.

India

India made no improvement in the overall gender gap ranking by the World Economic Forum “India maintains a stable ranking this year, but its gap is directionally larger this year, with a 33 per cent gap yet to be bridged,” says the report, titled Measuring the Global Gender Gap.

Meanwhile, the country also recorded improvements in wage equality for similar work, succeeds in fully closing its tertiary education gender gap for the first time, and keeps primary and secondary education gaps closed for the third year running.

Interestingly, India has the second-largest artificial intelligence (AI) workforce, but one of the largest AI gender gaps, with only 22 per cent of roles filled by women.

According to the report, the world has closed 68 per cent of its gender gap and at the current rate of change; it will take 108 years to close the overall gender gap and 202 years to bring about parity in the workplace. “The economies that will succeed in the fourth industrial revolution will be those that are best able to harness all their available talent. Proactive measures that support gender parity and social inclusion and address historical imbalances are therefore essential for the health of the global economy as well as for the good of society as a whole,” said Klaus Schwab, founder and executive chairman of the WEF.

CUT A SORRY FIGURE

India's ranking in gender-gap report

	2017	2018
Overall ranking	108	108
Economic participation & opportunity ranking	139	142
Educational attainment ranking	112	114
Health and survival ranking	141	147
Political empowerment ranking	15	19

Source: World Economic Forum

India

COUNTRY SCORE CARD

	rank	score	avg	female	male	f/m
Economic participation and opportunity	**142**	**0.385**	**0.586**			
Labour force participation	138	0.351	0.669	28.7	81.7	0.35
Wage equality for similar work (survey)	72	0.646	0.645			0.65
Estimated earned income (PPP, US$)	138	0.232	0.510	2,602	11,195	0.23
Legislators, senior officials and managers	130	0.148	0.329	12.9	87.1	0.15
Professional and technical workers	133	0.338	0.753	25.3	74.7	0.34
Educational attainment	**114**	**0.953**	**0.949**			
Literacy rate	121	0.752	0.882	59.3	78.9	0.75
Enrolment in primary education	1	1.000	0.978	92.9	91.7	1.01
Enrolment in secondary education	1	1.000	0.967	62.2	61.4	1.01
Enrolment in tertiary education	1	1.000	0.939	27.0	26.9	1.00
Health and survival	**147**	**0.940**	**0.955**			
Sex ratio at birth	146	0.904	0.921			0.90
Healthy life expectancy	130	1.020	1.034	59.9	58.7	1.02
Political empowerment	**19**	**0.382**	**0.223**			
Women in parliament	123	0.134	0.284	11.8	88.2	0.13
Women in ministerial positions	77	0.227	0.208	18.5	81.5	0.23
Years with female head of state (last 50)	4	0.642	0.189	19.5	30.5	0.64

India (108) maintains a stable ranking this year and Ukraine (65) sees itself overtaken by a number of faster-rising countries this year.

Ukraine

COUNTRY SCORE CARD

	rank	score	avg	female	male	f/m
Economic participation and opportunity	**28**	**0.747**	**0.586**			
Labour force participation	65	0.829	0.669	60.4	72.9	0.83
Wage equality for similar work (survey)	39	0.703	0.645			0.70
Estimated earned income (PPP, US$)	66	0.631	0.510	6.822	10.813	0.63
Legislators, senior officials and managers	23	0.697	0.329	41.1	58.9	0.70
Professional and technical workers	1	1.000	0.753	62.7	37.3	1.68
Educational attainment	**26**	**1.000**	**0.949**			
Literacy rate	44	1.000	0.882	100.0	100.0	1.00
Enrolment in primary education	1	1.000	0.978	93.4	91.5	1.02
Enrolment in secondary education	1	1.000	0.967	86.7	86.1	1.01
Enrolment in tertiary education	1	1.000	0.939	89.5	77.6	1.15
Health and survival	**56**	**0.978**	**0.995**			
Sex ratio at birth	129	0.942	0.921			0.94
Healthy life expectancy	1	1.060	1.034	67.6	60.3	1.12
Political empowerment	**105**	**0.107**	**0.223**			
Women in parliament	121	0.140	0.284	12.3	87.7	0.14
Women in ministerial positions	102	0.150	0.208	13.0	87.0	0.15
Years with female head of state (last 50)	38	0.060	0.189	2.8	47.2	0.06

Comparison of Ukraine and India

	Economic participation and opportunity; rank*	Educational attainment; rank	Health and survival; rank	Political empowerment; rank
India	142	114	147	19
Ukraine	28	26	56	105

*rankout of 149 countries

Women leaders

Could the key to closing the gender gap be though putting more women in charge? While women worldwide are closing the gap in critical areas such as health and education, significant gender inequality persists in the workforce and in politics. The rate of progress for women has been slow over the past decade with the proportion of female leaders increasing by an average of just over 2 per cent across 12 industries studied by the World Economic Forum (WEF).

WEF's data shows that when women are more present and participating in leadership roles, more women are hired right across the board at all levels. This detail holds true even when taking into consideration the disparities in the size of female talent pools across various industry sectors. If the proportion of women in leadership is not increasing fast enough, yet we know that diversity in leadership positions is a critical factor in closing the economic opportunity gap, then it is clear that women's participation at the most senior levels of leadership and management swiftly need to increase and accelerate.

Ranking	The gender gap index ranking	The happiness index ranking
1	Iceland	Finland
2	Norway	Norway
3	Sweden	Denmark (13)
4	Finland	Iceland
5	Nicaragua (45)	Switzerland (20)
6	Rwanda (152)	Netherlands (27)
7	New Zealand	Canada (16)
8	Philippines (69)	New Zealand
9	Ireland (16)	Sweden
10	Namibia (113)	Australia (39)
65/133	Ukraine	Ukraine
108/140	India	India

We analyzed the correlation between the gender gap index ranking and the happiness index ranking from the WEF 2018/2019 reports. And we found that the countries that are leading in the gender gap ranking are at the forefront of the happiness rating.

Next, we analyzed changes WHR and GGGR of Sweden, Ukraine and India during 2013-2019.

	2013	2015	2016	2017	2018	2019
Sweden						
WHR(1-10)	7,48	7,36	7,29	7,28	7,31	7,34
GGGR(0-1)	0,81	0,82	0,85	0,82	0,82	
Ukraine						
WHR	5,06	4,68	4,32	4,1	4,1	4,33
GGGR	0,69	0,702	0,7	0,706	0,708	
India						
WHR	4,77	4,57	4,4	4,32	4,19	4,02
GGGR	0,65	0,66	0,68	0,67	0,66	

GGGR(SWE-UA-IND)=0,482+0,0459*WHR

Regression statistics	
Plural R	0,94
R-square	0,88
Standard error	0,02

The value of the multiple R = 0.94 tells us that this model has a high level of correlation.

The study of the influence of WHR on the GGGR model SWE-UA-IND shows us the direct dependence of WHR on the GGGR, that is, the larger the WHR, the greater the GGGR.

The number 0.482 means the share of the influence of other factors on the GGGR. For example, such as economic participation and opportunities, educational attainment, health and survival, political empowerment.

The more women in government, the lower the corruption in the country, American economists have figured out. Also, the presence of women in power has a positive effect on health and education. At the same time, however, even in the most progressive countries, their number in politically significant positions does not reach 50%

American economists from Le Moyne College and the Polytechnic University of Virginia have found out. “This study underscores the importance of empowering women, the importance of their presence in leadership positions and in government,” said economist Sudypta Sarangi. “This is especially important in light of the fact that women are still underrepresented in the authorities of most countries, including the United States.” Thus, among the members of the US Senate there are less than a quarter of women; in the US House of Representatives (the House of Congress, in which each state is represented in proportion to the population), it is only 19%. The woman did not become a US president once. In Sweden, Belgium, Finland, Iceland, Norway, meanwhile, 40-44% of women in parliament.

The relationship between the number of women in power and corruption has attracted the attention of researchers only recently, the authors note. In 2001, several studies emerged that showed that there is a negative relationship between the percentage of women in power and corruption: the more it is, the less corruption is. Subsequently, however, doubts arose - perhaps it was not women, but other factors that were unaccounted for. It was not even ruled out that lower corruption contributes to the influx of women into power, and not vice versa.

Data on corruption was provided by the World Bank, an organization dedicated to organizing financial and technical assistance to developing countries. Information on the number of women in power was provided by the International Labor Organization.

As it turned out, it is the presence of women in politics-related positions that affects the reduction of the country's corruption.

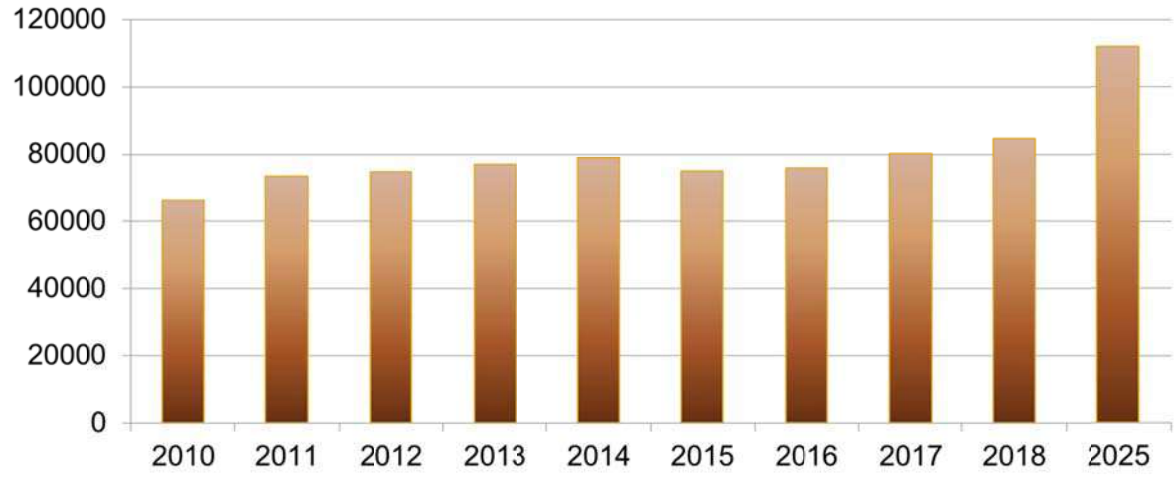
The number of women in office work was not related to corruption.

According to an analysis of earlier works, the researchers note, the whole matter may be in the management strategies that women and men choose. So, in particular, women are more policy-oriented, contributing to the well-being of women, children and families.

For example, in India, women in local governments allocate a large share of the budget for public goods and infrastructure issues, as well as more carefully ensure that certain subsidies do not fall into the hands of corrupt officials.

In addition, the presence of women in the legislature often correlates with higher spending on health and education. At the same time, education, in turn, also contributes to reducing corruption - the higher the quality of education in a given state, the less corrupt politicians there are.

Some researchers suggest that the link between gender of politicians and corruption may disappear as women acquire a social status equal to that of men. They attribute this possibility to the fact that, by gaining access to power, women gain access to the possibility of abuse of their powers. However, the results of the study show the opposite: the higher the status of a woman in a particular country, the stronger the link between the sex of politicians and the level of corruption. “Women are an integral part of society and at the same time an underestimated workforce,” comments Anu Madgavkar, a senior research associate. Ideally, if women are equal to men in the labor market around the world, global GDP will increase by $ 28 trillion in 2025, which will be the total GDP of the United States and China.



Fortune 500 companies spend $8 billion a year on diversity initiatives, much of it aimed at advancing women. This kind of investment suggests an awareness of the potential benefit in having more balanced leadership teams.

Lack of progress in this area is especially astonishing when you consider the research.

Companies with more women in leadership roles are more profitable. A Pepperdine University study showed that twenty-five Fortune 500 firms with the best record of promoting women into high positions were 18 to 69 percent more profitable than the median firms in their industries.

Companies with more women in leadership roles are more competitive than their peers. One USA Today report found the stocks of 13 Fortune 500 companies led by a woman for all of 2009 outperformed the S&P 500 (companies primarily led by men) by 25%.

Companies with more women in leadership roles reflect the marketplace. Women are responsible for 83 percent of all consumer purchases in the U.S. and control nearly $20 trillion of the world’s spending power.

Conclusions

Ways to bridge the gender gap:

1. There is a need for greater integration of gender aspects both in the general policies of countries and in sectoral policies;
2. Essential changes are needed in the collection of statistical information, including both an increase in the quantity and quality of data from a gender perspective;
3. Discrimination must be effectively eliminated, including by ensuring equal pay for work of equal value;
4. Effective would be a system of economic support and incentives aimed at non-discrimination against women. Improving the infrastructure that facilitates the upbringing of children could free up the time and resources of women and allow them to participate more actively in the economy;
5. Much can be done by private business. It is necessary to create a new corporate culture and working methods aimed at achieving gender balance.

Bridging the gender gap helps to improve the standard of living in the country. This can be done by integrating gender issues, eliminating discrimination, including pay, creating a system of economic support and incentives for women. The involvement of women in the political and economic spheres of the country leads to a positive dynamic, increasing GDP, a fierce fight against corruption and new trends in various fields.

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Suggested citation: Sunita Kishor and Kamla Gupta. 2009. Gender Equality and Women's Empowerment in India. National Family Health Survey (NFHS-3), India, 2005-06. Mumbai: International Institute for Population Sciences; Calverton, Maryland, USA: ICF Macro.

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26. HYBRID INTELLIGENT INFORMATION SYSTEM FOR DECISION-MAKING IN MULTI-CONNECTED OBJECTS

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Abstract

To date, an urgent problem is the creation of information systems in all areas of human activity, especially during the transition to the digital economy. Modern information systems must have a high level of intelligence and prompt decision makers, regardless of their qualifications, the right management decisions.

There are a number of approaches for solving such problems [1-5]. However, their disadvantage is the focus on solving a specific problem, which is embedded in the information system at the stage of its development.

Today, the development of intelligent information systems is mainly based on expert judgment, on the formation of a database (DB) based on previous experience. But in this case, the database is formed only to solve a specific problem. Consideration of a wider range of knowledge, use of modern mathematical apparatus is a great opportunity in creation of intelligent information systems.

Thus, creating unified approaches using the latest advances in the development of computer facilities, modern information technology and mathematical modeling methods is an urgent task.

Analysis of recent research and publications

A sufficiently large number of definitions of decision support systems (DSS) are known, reflecting virtually all stages of their development, the achievements of the relevant scientific schools, domain specific features, etc.

For a long time, the design of the DSS was determined by the type of tasks for which it was developed. As a result, there are five sustainable types of DSS [6]: Knowledge-oriented DSS provide specialized solutions to problems in the form of facts, rules, procedures; model-oriented DSS, characterized mainly by access to and manipulation of mathematical models (statistical, financial, optimization, imitation); Data-driven DSS mainly use access and data manipulation (not only internal but also external); Communications-based DSSs, Document-based DSSs that manage, search, and manipulate unstructured information given in various formats. However, new risk factors are often the impetus for the emergence of problems in such complex systems, which are large corporate structures. In this regard, traditional DSSs focused on the management of specific tasks become ineffective.

Each technology has both advantages and disadvantages. Only in a combination of methods and models can a systemic effect occur when additions and collaborations minimize private shortcomings and allow the complex challenges of managerial decision-making to be automated. This class of tasks include advanced, self-organizing, higher-level systems. In this case, self-organization means a purposeful process during which the organization of a complex dynamic system is created, reproduced or improved [7].

The concept of self-organization in the last decades is used in almost all scientific areas, explaining the mysterious phenomenon of the emergence of complex macrostructure results from the interaction of relatively simple entities, including the housekeeper. "Self-organization" reveals the following General properties of self-organizing systems [8]: a system that organizes itself moves from one stable state to another, and the final state is determined by the internal processes of the system; due to internal interactions between the elements arises the phenomenon of integrity; the overall complex system performance based on simple local rules of operation of its elements; to describe the local rules of functioning of the items requires less information than to describe the functions of the system as a whole; information on the operation of the elements describes the mechanism of formation of global system functions, not the function itself; instability, i.e., systems exhibiting instability, which are characterized by nonlinear dynamics where small changes in the environment lead to significant changes in the functioning of the system; in the time of instability, there are many equilibrium States, which may move the system; a critical state, that is, the presence in self-assembled systems, threshold effects and phase transitions; self-organization characteristic of systems that are in a state far from equilibrium.

If in the classical approach to the creation of intelligent systems it is necessary to determine for each specific problem its method of solution, then within the synergistic approach it requires the construction of a system capable of independently constructing the method of solving the problem. Synergetic artificial intelligence (AI) technologies include: 1) evolutionary computations, (genetic algorithms); 2) neural networks; 3) cellular automata; 4) hybrid intellectual systems; 5) multi-agent systems.

In general, a hybrid intelligent system (HIS) is a system in which more than one method of simulating human intellectual activity is used to solve a problem [9, 10, 11], each element of which implements a specific AI technology capable of performing many functions and processing a certain class of variables. To solve the complex, heterogeneous problems of one AI technology is not enough, and requires a variety of elements that implement different AI technologies. Such a task can be broken down into many isolated simple sub-tasks, and the relationships between them must be taken into account when modeling them in the HIS. The complex behavior of the HIS is due to the interaction of the elements.

For each HIS task, a method of its solution is synthesized based on the analysis of the properties of the task and the available prototype methods. As a result, HIS chooses one of many variants of its structure that can be considered as equilibrium states of HIS. The results of the analysis of modern models, methods and IT for decision-making in multiconnected objects (MO) have shown that all common features characteristic of self-organizing systems are modeled in HIS. The disadvantages of existing systems that solve the problem can be attributed to the fact that they are based on a single knowledge representation model (KRM), not allowing a qualitative assessment and prediction of the state of the object.

The analysis showed the need to develop a new integrated multi-level approach, taking into account the specifics of complex multi-connected systems, which makes it possible to increase the effectiveness of management decisions by developing a hybrid intelligent information system for decision-making in MO.

Purpose.

The issues of MO management are solved well enough, while the issues of structural, model and information integration, namely the development of hybrid intellectual DSS, which would combine the elements of the MO with the elements of the expert system under uncertainty, are not considered enough.

The solution of this problem is possible with the help of modern information technologies and automated information systems, which would include in their knowledge base with elements of intelligence that provide research and timely solution of a number of problems: preliminary analysis of the state of MO and prediction of behavior in space states.

Thus, the purpose of the work is to increase the effectiveness of decision-making in MO.

Research into existing information technologies of decision support systems has shown that they do not allow to assess the state of the MO sufficiently effectively. Therefore, in order to solve the problem of increasing the effectiveness of decision-making in complex MO, it is advisable to develop information technology on intelligent models of knowledge bases and relational data.

It is advisable to address structural, model and information integration issues, namely, the development of hybrid intelligent decision support systems that would combine a multi-connected entity with elements of the expert system in the face of uncertainty. At the same time, it is necessary to solve the issue of organization of system components such as databases, output subsystems and models of knowledge representation.

Results.

Development of a structure of intelligent information for decision making in multi-connected objects. To solve the decision-making problem in MO, we propose a general structure of HIS for managerial decision-making in MO (Fig. 1), which makes it possible to carry out a preliminary assessment of the state of an object and to predict its behavior in the state space.

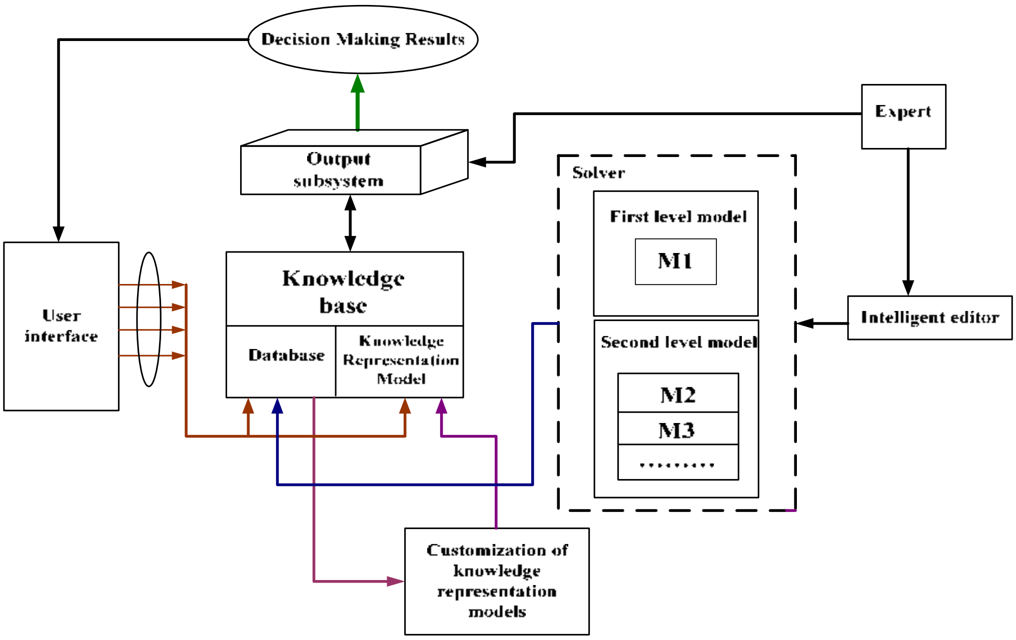

Fig. 1. General structure of a hybrid intelligent information system to support decision-making in multi-connected objects

The structure of the intellectual DSS is the following: there is a multilevel domain model, the development of first-level (M1) models, on which the knowledge base is developed, which includes a database and a knowledge representation model (KRM), resulting in a preliminary diagnosis. On the basis of the basic model M1, a fragment of the expert system was developed, that is, KRM in the form of products "IF…, THEN…". On the basis of the models of the second level (M2, M3), on the same data with additional indicators, the further forecast and recommendations concerning the studied object are determined. The results of the first and second level models are combined in the output subsystem for more results on the object's state. The timely application of decisions and recommendations received through intellectual DSS prevents the occurrence of complications of the condition of the MO, provides timely application of the necessary measures for their prevention, preventive measures and helps to increase the reliability of the decision made regarding the condition of the object, the choice of tactics for further actions and the formation of the prognosis for the development of complications. the background of the possible negative risks affecting the quality of decision-making in multi-connected objects under uncertainty.

Formalization of the terminology arrangement in the information system in the form of an ontology. An ontology is an exact specification of a field that contains a vocabulary of the terms of that field and many logical relationships (element-class, part-whole) that describe how these terms relate to each other [12] and allows you to introduce concepts in such a way that they become suitable for machining. Ontology (O) is defined by (1) [13]:

$$O = \langle T, A, R, C \rangle, \tag{1}$$

where T – a set of terms that denote objects and concepts of the domain, A – a set of attributes of concepts, R – a set of relations between terms, C – a set of definitions of concepts and relationships.

All O ontology classes are built into the "common - part" hierarchy, through which the inheritance of properties (including attributes, relationships, and constraints) of upper classes is subclassed. Ontology allows you to integrate information, link information provided for computer processing with information presented in a human-readable form. The task ontology is focused on solving specific problems and includes all the concepts that are necessary to describe the process of logical inference. The presentation of knowledge about the subject area of the information system and the problems it solves is provided by the applied ontology.

Based on the developed ontology, models of knowledge representation in the form of rules and precedents of decision making are being built. Ontologies and production rules form the knowledge base.

Developing a knowledge base for intelligent decision support information systems for decision making in multi-connected entities. Presentation of production model for management.

To date, research into the development of intelligent systems, which act as an expert and consultant, lie on the main line of development of computer IT. At the same time, there are undoubtedly topical issues related to the formation and presentation of knowledge, the identification of patterns in knowledge, the formation of decisive rules, decision-making and justification.

A distinctive feature of intellectual information systems is the availability of a knowledge base. Knowledge Base (KB) is a special kind of database that is designed to manage knowledge (metadata), that is, the collection, storage, retrieval and delivery of knowledge. KB is understood as a set of facts and rules of inference that allow a logical conclusion and meaningful processing of information. There are three strategies for knowledge acquisition [14, 15]: 1) knowledge acquisition; 2) knowledge extraction; 3) knowledge discovery.

Knowledge acquisition means a method of automatically filling the knowledge base with the help of expert dialogue and a special program.

The extraction of knowledge is called the procedure of interaction of a knowledge engineer with a source of knowledge (expert, source of knowledge, etc.).

The terms "knowledge discovery" and Data Mining are associated with the creation of computer systems that implement methods of automatic knowledge discovery. The process of extracting knowledge in the early stages of designing intelligent expert systems is one of the most complex and time consuming, and it does not always end successfully, as databases in subject areas that are poorly structured contain incomplete, fuzzy, mixed, and conflicting information.

Data mining is defined as "the process of non-trivial extraction of implicit, previously unknown and potentially useful information from data stored in a database." Data extraction is a multidisciplinary field that has emerged and evolves based on the achievements of applied statistics, pattern recognition, artificial intelligence methods, database theory, and more. Hence the large number of methods and algorithms implemented in various existing data extraction systems.

Therefore, one of the promising approaches to solving these problems is the use of intelligent Data Mining methods - modern embodiments of the basic ideas of artificial intelligence, whose main tasks are the search for functional dependencies and logical patterns in the accumulated information, the construction of models and rules that explain the found patterns.

According to the classification proposed by the authors M. Kiselev and V.O. Duke, the key methods and algorithms used in data extraction systems are: statistical methods; neural networks; decision trees; systems of reasoning based on similar cases; fuzzy logic; genetic algorithms; evolutionary programming; limited search algorithms; combined methods.

The process of retrieving knowledge in the early stages of intelligent system design is one of the most complex and time consuming, and it does not always end successfully, as databases in poorly structured subject areas contain incomplete, fuzzy, mixed, and conflicting information. Therefore, one of the most promising approaches to solving these problems is the use of intelligent Data Mining methods as a modern embodiment of the basic ideas of artificial intelligence, whose main tasks are the search for functional dependencies and logical patterns in the accumulated information, the construction of models and rules that explain the found patterns.

A KB is presented as a set of rules on the basis of which the logical inference algorithm determines the output. Based on the set objectives, we propose an approach to the development of DSS, which is based on the rules of logical inference.

WizWhy was used to process and analyze data contained in MySQL DBMS formats [16].

The WizWhy system of WizSoft is a modern representative of an approach that implements a limited batch. In this system, limited busting is used in a modified version with the use of an additional algorithm "Apriori", which eliminates the logic events with low frequency.

Method of limited bust was first proposed in the mid 60-ies of XX century by M. M. Bongard. Since then, such algorithms have demonstrated their effectiveness in many applications from different industries. Examples of simple logical events: $X = a$; $X < a$; $X > a$; $a < X < b$, etc., where X is any parameter, and a and b are constants. A limitation is the length of the combination of simple logical events. The maximum length of the combinations in the rule if-then in the system WizWhy is equal to 6. From the beginning of the algorithm is a heuristic search simple Boolean events, which then built the whole further analysis. Based on the analysis of the calculated frequencies is a conclusion about the usefulness of a particular combination (a combination is the conjunction of elementary events representing the penetration of the characteristic values in certain intervals) for the classification, recognition and prediction.

The production model, unlike others, attracts with its clarity, high modularity, ease of making additions and changes, simple mechanism of logical conclusion. Using WizWhy based on the first-level M1 model developed, a set of production rules was built to determine the status of a multifaceted object.

The WizWhy system is used as the module for setting up the knowledge representation model.

Formally, the PS production system is defined as follows:

$$PS = \langle E, B, I \rangle,$$

where E – data base; B – knowledge base that contains set products (condition-to-action rules); I – an interpreter (logical output machine) that implements the output process.

The process of constructing logical rules using the WizWhy system is the following: preparation of data for logical analysis: downloading the analyzed data, creating a storage structure (set the appropriate type of sign: quantitative (Number) and qualitative (Category), set the classification sign; parameters and launching the search procedure.

The initial parameters on the Rule Parameters tab are set:

– minimum confidence probability (accuracy) for the rule "If... Then" (if-then);

– minimal confidence probability "If ... Then Not" (if-then-Not) rules;

– the minimum number of objects on which the rule is confirmed;

– maximum number of events in a rule.

To determine the cost of errors (Error Costs), the values of two parameters are set, which are used for further forecasting:

– Cost of a miss - attribution to a class, with "No" diagnosed when actually there is a class that is diagnosed, as a rule is set equal to 1;

– Cost of a false alarm - attributed to the opposite class, which is diagnosed when in fact the correct recognition takes place, is also set equal to 1.

To minimize the number of errors in the data in the error analysis, the values of the error values are set equal.

Specifies the output options for the report: the number of rules in the report (Maximum number of rules), the method of sorting the rules (Sorting the rules), and also sets the output mode (Print rule report to) (report window, text, file, printer).

Analysis of the rules received.

The report with the revealed rules is provided by two divisions, such as:

1) General parameters of the rules;

2) list of rules.

Evaluation of informative features.

Evaluation of informative (useful) feature is carried out on the table "Field Index", which lists the features that are involved in the received rules, and a number of them is a list of numbers.

The resulting rules are visualized as a diagram illustrating the individual components of the rule.

Analysis of feature segmentation.

In the Trend report, the results of feature segmentation are displayed, indicating the informative nature of the selected segment. On the horizontal axis are possible values in the case of qualitative signs, and in the case of quantitative signs the segments for which the feature is selected, which is automatically broken by the WizWhy system.

As a measure of informativeness, the predicted possibility of value is used (the ratio of the number of correctly recognized objects to the total number of objects with a target value in a given interval).

Calculating the General information content of the characteristic for different variants of the partition, the most optimal is chosen, to be used for further classification and forecasting.

Analysis of unexpected rules.

Unexpected rules in WizWhy mean rules in the form of conjunctions of two or more simple statements, the combination of which gives accuracy and completeness of the forecast higher than would be expected with the independence of simple statements.

Using WizWhy based on the first-level M1 model developed, a set of production rules was built to determine the state of the object.

The DSS KB has been formed to determine and predict the status of MOs, which is represented by the production rules obtained using the data mining method, namely the method of limited search based on the developed model of the first level M1. This allowed us to establish the dependencies in the accumulated data and write the rules of inference that are applied in the software solution, since they depend on the adequacy and value of the output of the recommendations for the investigational MO and the result of the system.

Conclusions

Approaches to creating intelligent information support systems for decision support in multifaceted objects based on the combination of several models of complex semistructured problems are considered. The structure of a hybrid intelligent system for managerial decision-making in complex multi-connected systems is proposed, which integrates analytical and artificial intelligence methods. An ontological analysis of the decision support process is conducted. The proposed approach can be used to build decision support systems in different subject areas, enables the integration of different tools for managing heterogeneous data, and knowledge.

Research results can be used to create intelligent information systems in various industries.

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27. CRITERION OF REFERENCE DYNAMICS OF DEVELOPMENT OF INNOVATIVE PROJECT-ORIENTED ENTERPRISES

Rossoshanska O.V.

Abstract

In the era of the knowledge economy, the main type of enterprises that are most appropriate to the features of its functioning are innovative project-oriented enterprises. The work of such enterprises is associated with a high degree of uncertainty, which is synergistically enhanced by the main source of their development - the implementation of innovative projects. This makes it difficult to apply traditional parameters and evaluation criteria for their activities to effectively manage their functioning and development. Promising in this regard is the application of criteria developed on the basis of the holistic application of the concepts of temporal indicators, value approach and intellectual capital. The article describes the approach to the construction of the criterion of reference dynamics, which takes into account the accumulated experience of applying the criterion previously developed by us in real enterprises and the practice of its application by other researchers. The developed eight-component reference criterion for assessing the development process fully meets the proposed management principles. For its application, the values of the coefficients of inversion significance for the actual time series, as well as the weight coefficients for the components of the coefficient of decrease in the integral development indicator, are calculated. The latter takes into account the deviation of the actual values of the rates of growth of indicators from 100% in the direction of decrease. Taking into account the proposed two coefficients showed that for real IPOE the values of the integral development indicator can differ by four or more times in the direction of decrease compared with the calculations without taking them into account.

Introduction

Modern economy has a lot of associative characteristics. It is called global, creative, innovative, open, informational, design, knowledge economy, etc. And each of these characteristics is objective, because we feel their constant manifestation in everyday life. There is a change in the stages of development of civilization, which leads to a change in the organization of activities of all types and forms of business entities (from small to large enterprises, firms and corporations). But regardless of the size and type of activity, a common trend for all business entities is the transition to managing their business activity through projects [1]. The basis of most projects today is innovation and new technology. Business entities that switched to management through innovative projects were called innovative project-oriented enterprises (IPOE) [2]. Practice shows that innovative projects play a priority role in corporate changes, growth and development of such companies. Moreover, innovative projects for top management present a major problem due to the high degree of their uncertainty [3]. To solve these problems, new IPOE management methods are being developed, for example, based on the concept of harmonization of design and innovation activities [4]. However, the constant external changes in the environment of enterprises, the emergence and manifestation of a variety of local and global economic and financial crises do not remove the task of effective management of IPOE in such conditions. Therefore, there is a need for criteria for assessing the correctness of the management of IPOE as a holistic entity. Today, the search for such criteria lies in the intersection of the concepts of temporal indicators, value approach and intellectual capital. The practice of working with the previously proposed indicators of reference dynamics for IPOE, which contained four components [5], showed the feasibility of increasing their number by introducing components that detail the design and innovation activities. In this case, it is advisable to develop general principles of IPOE management based on indicators of reference dynamics. In the development process, it is necessary to focus on the emerging new family of temporal indicators, which is used to assess the impact of innovation and entrepreneurship on the economy of socio-economic systems of various sizes [6].

Conceptual provisions

The concept of proper enterprise management is a subjective category. This is due to the fact that enterprises independently develop systems of key indicators, which, in their opinion, characterize them as successfully developing. Correspondence of the actual course of the functioning and development of the enterprise to the management principles adopted by them can serve as a criterion for the correctness of management. The principles should be considered as a measure, from the position of which the management decisions made are evaluated, the products obtained as a result of their implementation, and the consequences of using these products (result).

For IPOE, the basic principles of management should be presented in the form of the following statements.

1. The principle of comparability and subordination of indicators of stakeholders. All indicators that take into account the diverse interests of IPOE stakeholders should be dynamically comparable and dynamically related.

2. The principle of maximizing the growth of the market value of the enterprise. Management decisions should be aimed at maximizing the growth of the market value of the

company in the long term, which is determined by the duration of the change of innovation in the subject area of the enterprise.

3. The principle of priority of the growth rate of the intangible component of market value. The prevailing indicator in a dynamically subordinate criterion series is the growth rate of the intangible component of the market value of the enterprise.

4. The principle of consistency of growth rates. The model of the integral criterion of management effectiveness should be built on the basis of the consistency of growth rates indicators that describe the design and innovation activities of IPOE.

5. The principle of Miller. The number of growth rate indicators in the integral criterion model should correspond to the Miller principle (7 + -2).

These principles are a modification of the well-known provisions that are used in management. The modification was aimed at strengthening the practical aspect of the principle, which allows them to be applied at all levels of IPOE management without additional refinement.

The described principles make it possible to determine the structure of the criterion for the integrated assessment of IPPO activities. As the basis of the criterion, we use a four-component time series, which has the following form:

$$TV_{t_i} > TR_{t_i} > TS_{t_i} > TL_{t_i} > 100\%, \quad \text{for } t=t_1, t_2, \ldots, t_j, \tag{1}$$

where t_j – time points for which indicators are measured;

T(.)- indicates that the growth rate is used *(.)*.

Consider in more detail the performance of the time series. Indicator *V* is the specific weight of the added market value of the enterprise in its market value from the use of the most important intellectual property objects, which provide it with market competitive advantages and, first of all, in the long-term strategic perspective. The calculation of the added market value of VIC - Value of Intangible Component was proposed by N. Lyashenko in [7]. For IPOE, the rate of change should be greatest compared to the growth rate of other indicators. This indicator meets the requirements of the third management principle.

The second indicator of the time series is the growth rate of profitability *R*. Today, profitability is the most commonly used indicator of economic efficiency, because holistically reflects the degree of efficient use of all resources of the enterprise and the success of its work. It is essentially relative, and, in contrast to the profit indicator, takes into account the value of those assets, the use of which made it possible to make a profit. Indicators *V* and *R* are specific. This meets the requirement of comparability of indicators arising from the first principle.

Today, almost all IPOEs, regardless of their size, conduct research and development (*R&D*), their competitiveness largely depends on the amount of costs for these types of work.

Therefore, it is advisable to use the growth rate of the specific share of costs *S* on *R&D* in the total cost as the third indicator of the time series. This indicator is also specific.

As the fourth indicator, the growth rate of the specific share of labor costs *L* in the total cost was used.

The four-component time series (1) is essentially the same as the "golden rule of enterprise economics". But it does not have enough indicators that reflect the state of the main source of competitive advantages of IPOE - human capital. It can be considered as a source of energy for the implementation of interdependent activities of the individual - physical, creative, creative and intellectual (Fig. 1).

In [8] M. Sc. Dimov proposed to define an innovative enterprise as an enterprise that has a certain type of competencies or their correlation, as well as the correlation between categories of personnel with specific and functional competencies. Using different classifications, he divided the staff into: researchers and other research personnel; analytical, technical and other applied specialists; managers, administrative staff, researchers, technical staff and support staff. At the same time, the author emphasized that it is possible to determine specific competencies for production and executive personnel. But for researchers and innovation leaders, this is much more difficult.

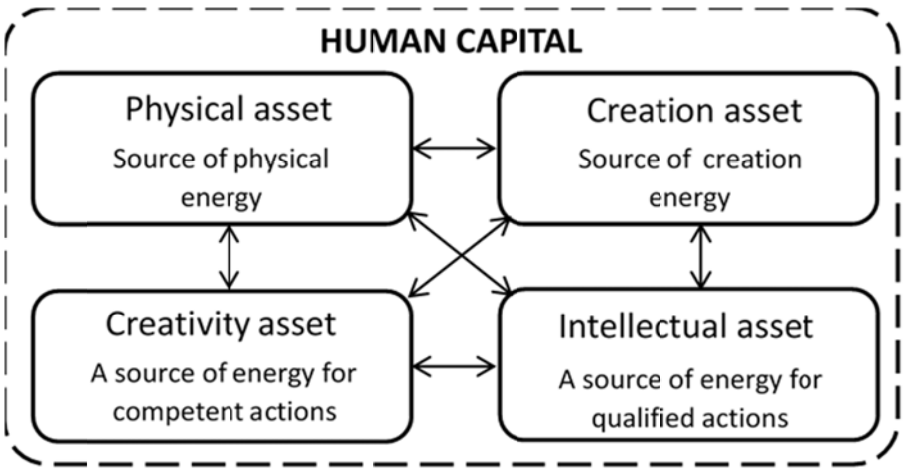

Fig. 1. The structure of human capital by energy sources

Source: developed by the author.

We previously defined IPOE as a company with a hybrid organizational structure, using flexible portfolio management, introducing innovations as separate businesses in order to create new values for consumers. The semantic combination of the model (Fig. 1) with the considered definitions of an innovative enterprise and IPOE, taking into account various classifications of personnel, allows us to propose considering personnel from the standpoint of innovation, design activity and the release of innovative products. With this consideration, the same employee could theoretically fall into all three categories. This does not contradict the system-holistic vision of activity. The category of "innovation" (*C*) will include employees who generate ideas for innovation (show creative activity), develop and launch them in production (show creative activity). To the category of project activity (*P*) - employees who are intellectually active, and for the release of innovative products (*B*) - physical activity.

For sustainable safe development of IPOE, it is necessary, in accordance with the fourth management principle, to agree on the growth rate of the proposed categories of employees. The higher growth rates of innovators *C* are logical as compared to the growth rates of those employed in projects *P*, which, in turn, should be higher than the growth rates of those engaged in innovative products *B*

$$TC_{t_i} > TP_{t_i} > TB_{t_i} > 100\%. \quad (2)$$

In the structure of time series (1), this time line should be located in front of the growth rate of the specific share of labor costs *L*. Otherwise, the incentive factor for increasing wages to employees who exhibit great, creative, creative and intellectual activity will be lost.

One of the main conditions for the successful operation of IPOE is also its ability to constantly innovate faster than existing and potential competitors. Therefore, the company must track the pace of innovation (*M*) through an individual, flexible approach to the organization of project activities, which should take into account the features of the innovation being introduced. Moreover, these rates should be higher than the growth rate of the specific share of costs *S* on $R\&D$.

Given the foregoing, we have proposed a time series that reflects the reference dynamics of the development of IPOE:

$$TV_{t_i} > TR_{t_i} > TM_{t_i} > TS_{t_i} > TC_{t_i} > TP_{t_i} > TB_{t_i} > TL_{t_i} > 100\%. \quad (3)$$

From the point of view of sustainable, safe development, this is the most preferable direction for changing the rates of growth of indicators, which should be sought to maintain throughout the entire period of IPOE operation. The coincidence of the actual time series with the reference one ensures that the enterprise is developing in the chosen direction, that all emerging threats and dangers are overcome without negative consequences. At its core (3) reflects the "strategic rational rule" of the IPOE and is a criterial dynamic model. The criterion displays the priority, most rational arrangement in descending order of its indicators - growth rates. Therefore, in a series of ranks, the first indicator will have the first rank, the second - the second, etc.

The mathematical model for calculating the criterion

We introduce the concept of the actual dynamic range of indicators. It is a series of indicators that are present in the reference series, and their sequence reflects the actual status of activities IPOE. Then to determine the degree of deviation of actual number from the reference you must have an integral indicator, which will characterize the degree of compliance of the actual state development plan (overall development). Will use to build the matrix method. Consider the method for simplicity, the example of dynamic lines consisting of the first four components of the rule (3). Three matrices are built. The first matrix, which reflects the strategic rational (3), i.e. the reference time series (Fig. 2a). The second matrix is the actual dynamic range (Fig. 2b), and the third matrix inversions, which are fixed to different values of the actual matrix compared to the reference (Fig. 2c).

Reference rank order		V	R	S	M
		1	**2**	**3**	**4**
V	**1**		1	1	1
R	**2**	-1		1	1
S	**3**	-1	-1		1
M	**4**	-1	-1	-1	

a)

Actual rank order		V	R	S	M
		3	**1**	**2**	**4**
V	**3**		-1	-1	1
R	**1**	1		1	1
S	**2**	1	-1		1
M	**4**	-1	-1	-1	

b)

Indicators, *j*	*i*				Inversion
	1	***2***	***3***	***4***	
	V	**R**	**S**	**M**	
V		1	1	0	2
R	1		0	0	1
S	1	0		0	1
M	0	0	0		
Inversion amount					4

c)

Fig. 2. Matrices for calculating the integral development indicator

a) - reference time series; b) - actual time series; c) - inversions.

Source: developed by the author.

The mismatch (proximity) of the first two matrices is usually characterized by the Kendall rank correlation coefficient. However, this coefficient does not take into account the removal of the indicator of the actual dynamic series from its location in the reference series. We have developed a method of accounting for this fact and obtained a working formula in the following form [5]:

$$IDI = \left(1 - \frac{2\sum_{i=1}^{n}\sum_{j=1}^{n}\left(\frac{\propto_{ij}}{2}\right)m_{ij}}{n(n-1)}\right)^2, \qquad (4)$$

where: n – number of indicators in the time series;

m_{ij} – the number of inversions for the indicator, which occupies the *i*-th place in the *j*-th row of the actual time series;

α_{ij} – inversion significance factor.

The values of the significance coefficient were experimentally selected for $n = 4$ from the conditions of the multiplicity of their values to 0.05; equality of the sum of all coefficients 12; finding the magnitude of the coefficients in the range of 0.5-1.5; the value of the coefficients for the cells that are on the periphery from the diagonal should be greater than one, and the difference between them should be greater than the difference between the coefficients that are in the cells adjacent to the diagonal.

In [9], the values of the inversion significance coefficients that we obtained were taken as basic and based on them; a method was developed for calculating such coefficients for any number of indicators of the time series. For the time series (3) of eight indicators, their values are given in table 1.

Table 1 - Inversion significance factors for a time series of eight indicators

№		*i*							
		1	2	3	4	5	6	7	8
j	1	0	**0,75***	0,95	1,15	**1,35**	1,4	1,45	**1,5**
	2	**0,75**	0	0,72	0,92	1,12	1,17	1,217	1,4
	3	0,95	0,72	0	0,68	0,88	0,93	1,117	1,3
	4	1,15	0,92	0,68	0	**0,65**	0,83	1,017	**1,2**
	5	1,35	1,12	0,88	**0,65**	0	0,62	0,8	0,98
	6	1,4	1,17	0,93	0,83	0,62	0	0,583	0,77
	7	1,45	1,22	1,12	1,02	0,8	0,58	0	**0,55**
	8	**1,5**	1,4	1,3	1,2	0,98	0,77	**0,55**	0

**- the basic values of the coefficients are highlighted in bold*

Source: developed by the author.

An analysis of the performance of real IPOEs (of which there are very few in Ukraine today compared with countries with a high human development index) showed that there are quite long periods in their activity, when part of the growth rate is less than 100%. Even if the reference rule is implemented in terms of the sequence of parameters, such a situation should be recognized as critically dangerous from the perspective of strategic development. To take this fact into account, we proposed to introduce an additional coefficient of decrease in the integral development indicator calculated by formula (4) in the following form

$$\beta = 1 - (0{,}21\check{V} + 0{,}186\check{R} + 0{,}161\check{M} + 0{,}137\check{S} + 0{,}113\check{C} + 0{,}089\check{P} + 0{,}064\check{B} + 0{,}04\check{L})\,, \qquad (5)$$

where: $(\check{R})$ – deviation of the actual values of the growth rates of the indicators of the reference dynamic series from 100% towards the decrease.

Then the formula (4) for calculating the decrease in the integral development indicator will take the following form

$$IDI = \beta \left(1 - \frac{2\sum_{i=1}^{n}\sum_{j=1}^{n}\left(\frac{\propto_{ij}}{2}\right)m_{ij}}{n(n-1)}\right)^2 . \quad (6)$$

The results of calculating the integral indicator using the Kendall formula, and taking into account the two coefficients we have introduced have shown that for real IPOE their values can differ by a factor of four or more.

Conclusions

Based on our study, we can make the following conclusions.

1. The general trend for all business entities is the transition to the management of business activity through the implementation of projects. Moreover, most projects are aimed at implementing innovations and new technologies. Therefore, such enterprises are called innovative project-oriented (IPOE). The high degree of uncertainty of innovative projects makes it difficult to find criteria for assessing the correctness of development management of such enterprises.

2. It is proposed to use five management principles as a conceptual basis for the development of criteria. Substantially they relate to the intersection of the concepts of temporal indicators, value approach and intellectual capital. As a basis for the criterion, a four-component dynamic series of temporal indicators previously developed by the author is used. It is supplemented by indicators that are associated with the main source of competitive advantages of IPOE - human capital. Human capital is considered as a source of energy for physical, creative, creative and intellectual activity. Each type of activity is inherent in a certain category of employees who are engaged in innovation, design activities or the release of innovative products.

3. For the extended reference dynamic series of temporal indicators of IPOE, a formula has been developed for calculating the integral indicator of its development. It is based on the formula for calculating the Kendoll rank correlation coefficient, which is supplemented by two coefficients: the significance of inversions and a decrease in development when the actual growth rate deviates from 100% downward.

4. Accounting for the entered coefficients and the presence of all the constants that are used in their calculation allows us to calculate the value of the integral development indicator, which more adequately reflects the actual state of affairs at IPOE.

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28. METHODOLOGY FOR ASSESSING INTEGRATION POTENTIAL OF THE PARTICIPANTS OF THE TRANSPORT AND LOGISTICS CENTER PROJECT

Kovtun T.A., Smokova T.N.

Abstract

In the course of the study, the concept of "integration project risk" is defined. And also, a sequence of qualitative analysis of integration risks in the project of creating a logistics center, which consists of using quality management methods, namely: Pareto analysis, ABC analysis and Ishikawa cause-and-effect analysis is developed. The application of methods of qualitative analysis is carried out in a logical sequence. The obtained results of a qualitative risk analysis allow at the initial stage of the project to increase the impact on its results by reducing the degree of integration risks.

Introduction

Integration in projects of creation logistics complexes is one of the system-building aspects, since logistics complexes as objects of logistic infrastructure arose due to the expansion of logistics integration and became an integral part of the logistics systems that provide the opportunity to implement logistics integration objects in the logistics network. Consequently, the logistics complex is a complex system, which includes a plurality of elements integrated by integration links, through which it is able to perform logistic functions.

A modern look at the creation of a logistics center is to present it as a project, one of the specific features of which is the large number of participants associated with integration links, which is dynamically changing throughout its life cycle. Preservation of integration links between the participants of the logistics complex project is one of the most important tasks, the implementation of which affects its viability. Therefore, in our opinion, we must pay special attention to the management of the integration of participants in the project, using modern methods and models of management.

A look at the integration processes between the participants in the logistics complex project through the risk management prism made it possible to identify a specific category of project risks - integration design risks that could lead to a breach of integration in the project (logistic or project). Logistic integration is a prerequisite for the full functioning of the logistics complex, and the project - to achieve success of the project implementation by all its participants.

At the moment, the issue of risk management and assessment of its impact on business efficiency occupies a leading position virtually in all spheres of economic activity. The lack of an unambiguous interpretation of the concept and characteristics of risk is explained by the multidimensional nature of this phenomenon, since risk is a system-wide concept, a complex category, an integral attribute of any sphere of human activity. The risk in those areas related to the decision-making under conditions of incomplete information, which include the project activity of the creation of logistics centers is of particular importance.

Despite the large number of scientific works devoted to the formation and organization of the activity of objects of logistic infrastructure and the use of tools for project management and risk management [1-5], a quality management in projection logistics systems, paid insufficient attention.

The successful implementation of large-scale and complex projects requires the availability of appropriate methodological support, which will take into account the features of the created complexes. A large number of participants in the project of creating a logistics center are the reason for the emergence of integration project risks, the occurrence of which can lead to very negative consequences, even before the project is completely closed. In work [5] the authors introduce the concept of "integration project risk", based on existing scientific concepts of logistics and design risks.

Explanation of basic material

Integration risks relate to the category of risks; which consequences can be catastrophic for the project - the rupture of integration links can lead to the destruction of the entire system. Consequently, integration risks in projects of logistics complexes form one of the most important risk groups, since in these projects the most clearly expressed integration links, both in the project and in logistics areas.

A large number of participants in the logistics complex project take into account the degree of their impact on the integrity of the project system, which is expressed by the indicator of "integration potential", that is, the ability of the element to subject the system to the impact of integration risks. The integration potential of each of the project participants may be determined due to the application of the "matrix of integration risks".

Particular attention should be paid to the analysis of integration risks, which is proposed to be implemented in five stages:

1) determine the propensity of project participants for integration risks,
2) qualitative assessment of the integration risks of each of the project participants,
3) calculation of the capacity of integration links between project participants,
4) assessment of the integration potential of project participants,

5) identification of the reasons for the integration risks of each of the participants in the project.

The proposed sequence of analysis of the integration risks of the logistics complex project allows, in the absence of reliable information on the conditions for the implementation of the project:

– to identify elements of the system - the participants of the project, the most exposed to the integration risks;

– to determine the integration potential of project participants - the degree of influence on the stability of the project system;

– to identify the main causes of the risk of breaking the integration links for each participant in the project.

Obtaining such information at the initial stages of the life cycle of the project will enable the development of preventive measures to reduce the probability of occurrence of integration risks in the project of creating a logistics center, this, in turn, will reduce the amount of funds needed to minimize their impact [6].

For example, we will form a system of twelve elements - partners in the project logistics complex (Fig. 1).

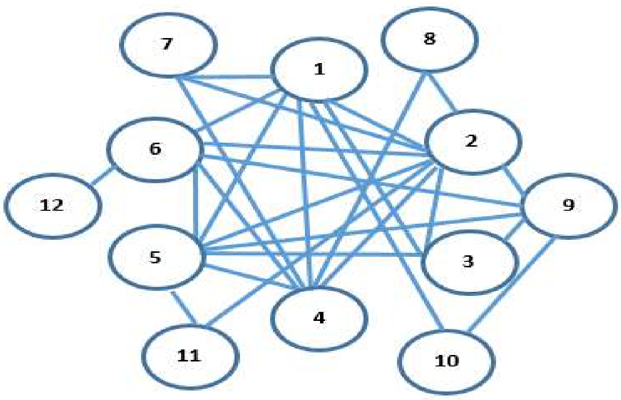

Fig. 1. Integration links between logistic complex project participants

Pareto analysis is proposed to be used to identify participants' inclination to an integration risk. The input for analysis is the set of integration links between the project participants graphically depicted as a network structure, and at the output we get a Pareto chart.

A qualitative analysis of the integration risks of the project using the Pareto chart consists of the following steps:

1) creation of a matrix of contiguity, reflecting the presence (1), or the absence (0) of the integration links between the elements,

2) analysis of the significance of the results obtained, shown in the table of aggregated data,

3) construction of the Pareto chart.

We construct the Pareto chart of integration partnerships, using the data of the analysis. On the axis of abscissas, we place elements on the degree of growth of the number of integration links, and along the axis of ordinates - the percentage of integration links of elements in the total amount and the cumulative percentage of integration ties (Fig. 2).

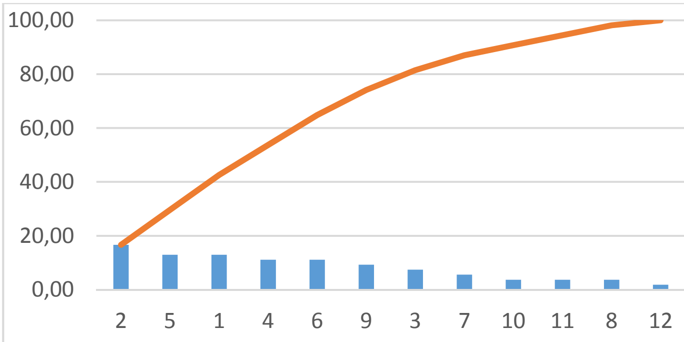

Fig.2. Pareto Chart of the integration links of the project participants

ABC analysis - a method of qualitative analysis, designed to group factors, phenomena, elements, in this case, the system "project", the degree of influence on the final result [4]. This grouping allows you to select project participants with the largest number of integration links. Hence, the output of such a participant from the project will bring the greatest violations of integration between the elements of the system. The input for the ABC analysis is the Pareto analysis data, and the output is the ABC analysis chart. Using the ABC analysis tools, we will identify the importance groups for integrating risk management:

– Group A - the most important elements of the system that have the largest number of integration links with other elements. The relative percentage of group A in the total number of elements is usually from 60 to 80%.

– Group B - elements that have a maximum of 20% in total.

– Group C - the least significant elements, which include participants with no more than two integration links (Fig.3).

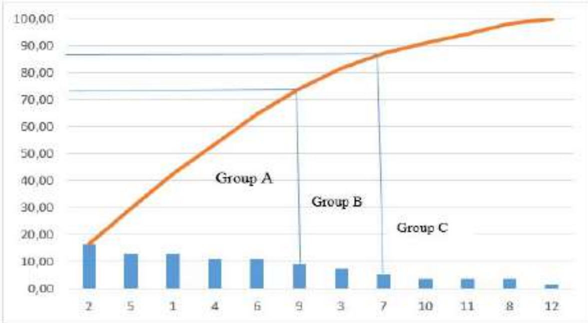

Fig. 3. ABC analysis of project participants

To determine the capacity of the integration communication we offer taking into account the number of realized relationships (transactions) using this link and the flow of cash (value) of the relevant transactions. But for the completeness of the idea of the importance of this or that integration, we suggest taking into account not only the quantity but also the cost of the operations performed. Their product will determine the cash flows between the elements of the system that create the integration link. This will determine the amount of work performed on the system that corresponds to a particular integration link.

$$CF_{ij} = q_{ij} \cdot c_{ij} \text{ , (1)}$$

where CF_{ij} - flows of money moving from the i-th to the j-th element, between which is established l_{ij} integration link,

q_{ij} - the number of operations between i-th and j-th elements l_{ij} integration link,

c_{ij} - the average cost of one transaction between i-th and j-th elements l_{ij} integration link.

Thus, there is an analogy with the indicator of "power" in physics, which corresponds to the amount of work performed over a period of time and is calculated by the formula:

$$N = \frac{A}{t} \text{ , (2)}$$

A - amount of performed work,

t - time spent on work.

To determine the power of the integration link between the elements of the system - the participants of the logistics center project - we apply the formula:

$$N_{ij} = \frac{CF_{ij}}{t_{ij}} \text{ , (3)}$$

where CF_{ij} - flows of money moving from the i-th to the j-th element, between which is established l_{ij} integration link,

t_{ij} - time spent on operations between i-th and j-th elements l_{ij} integration link.

Based on the obtained values of the capacities of integration links, it is possible to determine their rating.

To determine the total power of all integrative connections of the element possible by the formula

$$N_i = \sum_{j=1}^{m} N_{ij} \left(i = \overline{1,n}\right), (4)$$

Determination of the integration potential of project participants is carried out using the "matrix of integration risks". After calculating the total capacity of integration links for each of the elements of the system - participants in the project logistics complex - it is possible to allocate them in zones of "significant", "medium" and "insignificant" power of integration links of the element. In addition, in the second step of the given sequence of analysis of the integration risks of the project of the logistics center through the use of the ABC analysis tools, the project participants were divided into three zones by the number of integration links: "large" (group A), "medium" (group B) and "small" (group C). Using the results of the previous risk analysis, we will construct a "matrix of integration risks" and define the integration potential of each of the project participants (Table 3).

Table 1 - Matrix of integration risks of the project

Connections power	The importance of project participants (by the number of integration links)		
	Group A	Group B	Group C
significant	big	big	average
average	big	average	small
insignificant	big	small	small

Depending on which region of the matrix of integration risks one or another of the project participants will fall into, it is possible to determine its integration potential, i.e. the degree of influence on the stability of the integration links between the project participants: "big", "average" or "small".

The next step to analyze the risks of a logistics complex project is to identify the causes of the integration risks of the project participants proposed to be carried out using Ishikawa cause-and-effect analysis. The construction of the Ishikawa chart allows us to identify the cause-and-effect chains of the risk of break-up of integration links. For each project participant a "fish spine" is created, which clearly reflects its integration links with other participants and the possible reasons of breaking these links.

Ishikawa chart is constructed for each participant and consists of the following elements:

1. The first level ("spine") corresponds to the analyzed problem - the risk of the rupture of the integration links of the i-th participant of the project $\left(i=\overline{1,\mathrm{n}}\right)$.

2. The second level consists of "big bones" $j\left(j=\overline{1,\mathrm{n}_i}\right)$, which connects with the "spine" and reflects the integration of the i-th participant with other project participants.

3. Detailiation can continue to levels of "middle bones" $g\left(g=\overline{1,\mathrm{z}_{ij}}\right)$ or up to the level of "small bones" $h\left(h=\overline{1,\mathrm{k}_{ijl}}\right)$, which allows to analyze deeper the reasons of the risk of breaking the integration links between project participants.

Integration relationships between elements of the system may have different degrees of importance for maintaining the sustainability of the project. From the standpoint of the possibility of the risk of breaking the integration links between the project participants, the characteristic that is subject to thorough analysis is the strength of communication. An appropriate assumption is that the stronger the integration link, the lower the level of integration risk.

To make a rating assessment of integration links is possible by using the Saati pair coupling method [7]. It is expedient to investigate the integration links of the participants that, as a result of the ABC analysis, fell into group A or groups A and B, depending on the number of project participants and the required accuracy of the study.

The sequence of analysis using the Saati method is as follows:

1. Construction of matrix of pairwise comparison of integration links for the i-th participant of the project $\left(i=\overline{1,\mathrm{n}}\right)$, to be analyzed. A matrix of the size n_i x n_i, where n_i is the number of integration links $j\left(j=\overline{1,\mathrm{n}_i}\right)$ of analyzed participant.

2. Calculation of analytical indicators of the matrix, which includes: evaluation of components of the own vector, normalized estimates of the own vector. In doing so, use the following formulas:

3. Evaluation of the component of the own vector - the average geometric elements of the jth line of the matrix

$$a_j = \sqrt[n_i]{a_{j1} \cdot \ldots \cdot a_{jn_i}}\ , \tag{5}$$

normalized estimation of own vector

$$x_j = \frac{a_j}{\sum_{j=1}^{n_i} a_j}\ , \tag{6}$$

4. Checking the components of the matrix for consistency, which allows you to correct the mistakes that the expert could admit when filling the matrix of comparisons, involves the calculation of the index of consistency and the relation of consistency by the formulas:

- the index of coherence $\lambda_i = \dfrac{\sum_{j=1}^{n_i}(a_{1j} + \ldots + a_{n_1 j})x_j - n_i}{n_i - 1}$,

- coherence ratio - the ratio of the index of coherence to random coherence $\delta_i = \dfrac{\lambda_i}{\gamma_j}$.

Similar calculations will be made with other project participants who have been assigned to groups A and B of the ABC analysis. For each participant we get a set of normalized estimates of the own vector $X_j^i \left(i = \overline{1, n}\right)$, $\left(j = \overline{1, n_i}\right)$, where reflects the propensity to risk the rupture of the j integration integration of the i-th participant. Since the link between the project participants is two-way, X_j^i is a direct vector that reflects the participant's direct links. It is also formed X_i^j - Feedback vector of the participant links. On the basis of obtained data, it is possible to conduct a rating assessment of both the direct and the feedback of the participant, and to identify the most dangerous in terms of the risk of breaking the integration links.

Conclusions.

The need in creation modern logistics complexes in Ukraine as objects ensuring the integration of participants in logistics systems and networks is particularly acute in recent years and requires immediate solution. The successful implementation of such large-scale and complex projects requires the availability of appropriate methodological support, which will take into account the specific features of the objects being created. A large number of participants in the project of creating a logistics center is the reason for the emergence of integration project risks, the occurrence of which can lead to negative consequences. Therefore, it is necessary to pay special attention to this category of risks and to conduct constant analysis to prevent their occurrence. The lack of necessary methodological support revealed the need to create a methodology for analyzing the integration risk of a project for the creation of a logistics complex.

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29. DETECTOR ARTIFICIAL NEURAL NETWORK. NEUROBIOLOGICAL RATIONALE

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Abstract

On the basis of the formulated hypotheses the information model of a neuron-detector is suggested, the detector being one of the basic elements of a detector artificial neural network (DANN). The paper subjects the connectionist paradigm of ANN building to criticism and suggests a new presentation paradigm for ANN building and neuroelements (NE) learning. The adequacy of the suggested model is proved by the fact that is does not contradict the modern propositions of neuropsychology and neurophysiology.

Key words: artificial intelligence, neural code, artificial neural network, neuron-detector.

Relevance

Some modern research [1, 2] argued that ANN that are constructed on the basis of the known models of neural elements (NE) and use the connectionist paradigm of NE relationship establishing are just universal approximating devices that can simulate any continuous automatic machine to any given accuracy. Such ANN is rather mathematical abstraction than the model of perception and internal representation of the world made by the human brain.

Evidently, the adequate information models of neurons –NE of ANN and the approaches to ANN building should interpret and accumulate modern concepts of neuropsychology and neurophysiology about the mechanisms of information processing by neurons and brain modules.

The key point in the development of the given models can become the resolution of the problem of so-called 'neural code'. There exist a lot of approaches and a large number of scientific works devoted to this subject, but the mechanisms of coding and transformation of information in neurons and neural structures of the brain are still puzzling.

There is no sufficient experimental data to substantiate rigorously the information models of neurons in terms of neuropsychology and neurophysiology suggested in this paper. Therefore, we will use the hypotheses – assumptions about the neurophysiological mechanisms of certain information processes occurring in the neurons. The suggested hypotheses do not contradict the current views of neuropsychology and neurophysiology.

Neural code hypotheses

Based on the results of research [3, 4] it is possible to conclude that the morphological diversity of neurons, their functional difference depending on the position in the reflex arch point out different roles neurons play in the information processing. Thus, E.N. Sokolov, working out in his papers the detector approach suggested by D.H. Hubel, singled out specific roles of neuron-detectors, pre-detectors, neuron-modulators, command neurons, mnemonic and semantic neurons, neurons of newness and identity [5]. Experimental evidence of certain propositions of the specified approaches tells about the diversity of mechanisms (algorithms) of information processing in different types of neurons, which focus the necessity of building different information models of neurons at different steps and stages of information processing.

But what information does the 'visible' neuronal response contain? What information does it react to and how does it process this information? Numerous attempts to find an answer to these questions suggest the idea that neurophysiological isomorphism of neurons response lies just in the fact of making certain sequence of spikes. The impulse activity of a particular neuron seems to tell only about its excitation to a certain degree. D.H. Hubel took the same point of view; he considered that a particular neuron sends no information to other neurons except for the information about the fact of its excitation. D.O. Hebb considered the information coding as coding by the neuron ensemble [6].

Trying to answer the suggested questions, following D.H. Hubel, E.N. Sokolov and S. Sevuch [7], we will suggest the following statement that has neuropsychological grounds.

Statement 1. *Specific subjective perception of input image is connected with the excitation response of a single neuron or a group of specifically linked neurons. The excitation of a particular neuron is the essence of perception and the result of information processing.*

It is evident that subjective perception of the input image or its separate structural elements or characteristics (indicators of recognitions) is connected with the excitation of separate neurons-detectors. However, the entire 'picture' of the internal view of a complex image, for example a 'smiling grandmother', is connected with the simultaneous excitation of a group or ensemble of neurons [4].

A set of neuronal ensembles at all the stages of information processing is called the presentation of the input image.

In the given context presentation is not the way to submit information to someone, but the mode the brain tries to interpret internally a perceptive image.

Information system that makes presentations which all together create a subjective picture of the world is called a presentative system.

It is known that to excite a neuron at least two input information components are important – the fact of excitation of particular presynaptic neurons and the level of the excitation.

Thus, the following hypothesis can be formulated.

Hypothesis 1. *The main information components of any neuron response are:*

1) the location of the excited neuron in a certain structure (module) of the brain that is determined by its 'address' which is coded in the output signal;

2) the level of the neuron excitation that is coded by the frequency of generated impulses (spikes).

The question arises: why do the neurons send their 'address' as they are structurally interconnected by synaptic bindings?

It is necessary to take into account the fact that a neuron can receive excitatory signals from a great number of neurons, but only a part of these signals will play significant role in the process of its excitation.

According to the suggested hypothesis 'address' response of the excited neuron-detector is the basic information which is fed to subsequent neurons in the reflex arch, and the frequency response in this case plays a significant role in the process of 'competitive activity' of simultaneously excited neuron-detectors defending the right to participate in the further information processing.

The following hypothesis can be suggested.

Hypothesis 2.

a). A set of excitatory postsynaptic potentials (EPSP), the total value of which, enables getting over an excitation threshold (ET) of neuron is a set of necessary and sufficient conditions for its excitation.

b). As local EPSP is connected to the excitatory level of specific presynaptic neuron, to identify whether this particular EPSP belongs to the set of necessary and sufficient conditions of postsynaptic neuron excitation is possible on the basis of the excitatory neuron address.

c). A set of 'addresses' of presynaptic neurons, the excitation of which creates a set of necessary and sufficient conditions for exciting this specified postsynaptic neuron, is made in the process of neuron learning. In the process of learning the neuron memorizes only those 'addresses' of presynaptic neurons, the excitation of which with the specified excitatory level (the frequency of excitatory impulses) will become a necessary and sufficient condition for its own excitation.

We will state the following important definition.

A set of ‘addresses’ of presynaptic neurons, the excitation of which is a necessary and sufficient condition for exciting a postsynaptic neuron bound to it, is called the concept (Con) of this neuron.

Thus, to determine whether the ‘addresses’ of presynaptic neurons belong to Con of a postsynaptic neuron is possible while learning either with or without the ‘teacher’. ‘Teachers’ are the corresponding neurons of other subsystems, for example, a representative subsystem (RS). The importance and the role of RS are considered in the paper [8]. Evidently, the more often the ‘address’ of a particular presynaptic neuron appears in the process of learning in the vector of input signals, the greater the probability that this ‘address’ belongs to its Con.

This hypothesis absolutely agrees with Hebb's classical postulate.

Information model of neuron-detector

Grounding on the suggested hypotheses we can make an information model of neuron detector.

Let detector d has n number of synaptic inputs and one output. For simplification we assume that the detector does not have inhibitory input synapses. The synaptic input i can receive excitatory signal xi(a,b) from presynaptic neuron with the ‘address’ a and the level of excitation b.

When detector d is excited, the normalized signal y'(a',b') is generated in its output, where a' is its address component, b' is the level of excitation. Detector d also has control input z, where the control signal from the neurons of other systems, e.g. from RS, is fed.

The detector has the following characteristics:

- excitation threshold – et;
- resting potential – rp;
- shift in the membrane potential – smp;
- action potential – ap.

We introduce w_i function of membership of signal xi, that is fed to ith input of detector d, on its concept Con(d).

For learning ‘with teacher’ w_i looks like (1):

$$w_i = \frac{l_i(t_0)}{k(t_0)}, \tag{1}$$

where: - li(t0) is the total number of signals xi fed to a ith input of detector d during learning time t0. During learning time xi is fed synchronously with z;

- k(t0) is the general amount of cycles of feed of input signals $\overline{X}$ vectors to inputs d at the moments of learning time t0.

Then,

$$\text{if} \quad \begin{cases} w_i = 1, \text{ then } x_i(a) \in Con(d); \\ w_i < 1, \text{ then } x_i(a) \notin Con(d). \end{cases} \qquad (2)$$

Probably, detectors always learn 'with teacher', neurons of different brain systems acting like teachers.

In this case to determine the membership of x_i on concept $Con(d)$ it is necessary to introduce the statistical threshold of membership $q < 1$.

Then,

$$\text{if} \quad \begin{cases} w_i' < q, \text{ then } w_i = 0 \text{ and } x_i(a) \notin Con(d); \\ w_i' \geq q, \text{ then } w_i = 1 \text{ and } x_i(a) \in Con(d). \end{cases} \qquad (3)$$

When input excitatory signals are received, *smp* of detector *d* is:

$$smp(d) = \sum x_i(b) | x_i(a) \in Con(d) \qquad (4)$$

Then, if $rp(d) + smp(d) \geq et(d)$, then there exists $ap(d) = y(b')$,

where $y(b')$ is non-normalized component of output signal – non-normalized level of excitation of detector *d*.

In the suggested information models of NE it is convenient to use NE positive characteristics. Besides, to create ANN on the basis of these models it is reasonable to use NE interrelations in the module of information processing of 'common bus' type rather than radial structure of interrelations between pre- and postsynaptic neurons.

In the process of competition of simultaneously excited detectors value $y(b')$ is important to determine one leader in a module, signals from which will participate in the further information processing.

We call this process WTA- competition [8].

Actually, there cannot exist two similar concepts, but it is possible that $Con(d_1) \subset Con(d_2)$. Then detectors d_1 and d_2 will be excited simultaneously, but value $y_1(b')$ of detector d_1 will be less than value $y_2(b')$ of detector d_2.

In the context of WTA-competition output signals $y_i(b')$ of simultaneously excited NE-detectors are compared in comparators *C* of each detector, in case if any external signal $y_i(b')$ exceeds its own one, an internal control signal of inhibition *h* is generated. This signal 'drops' the excitation of detector switching it over into the state of 'pre-excitation'. Fig. 1 shows the diagram of generating *h* signal in d_1 detector under the condition of $y_2(b') > y_1(b')$.

In case if $y_1(b') > y_2(b')$, the detector d_2 is inhibited. Then *C* comparator of detector d_1 sends $y_1(b')$ signal further to unit *N*, where function $f(y_1(b'))=y_1'(b')$ is performed. This is the function of normalization of excitation level $y_1(b')$ and generation of output signal $y_1'(a',b')$ with the normalized component of excitation level $y_1'(b')$ and address component $y_1'(a')$ (Fig. 1).

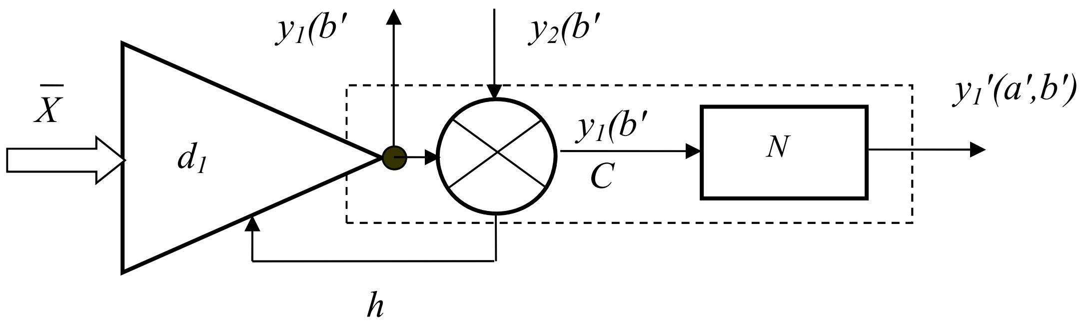

Fig. 1. Diagram of forming h and $y_1'(a',b')$ signals

The normalization of the detector excitation level in output signal yi'(b') is necessary to prevent the effect of its limitless increase in NE cycle of ANN, which corresponds to real processes of normalization (saturation) of an output neuron signal.

Control learning signal z is formed by NE-detector of other systems, for example, representative system. We will study the process of NE-detector of presentative system (PS) learning under the control of NE-detector of representative system (RS). To do this PS detector should establish relation with the corresponding RS detector. The diagram of establishing this interrelation is shown in Fig. 2.

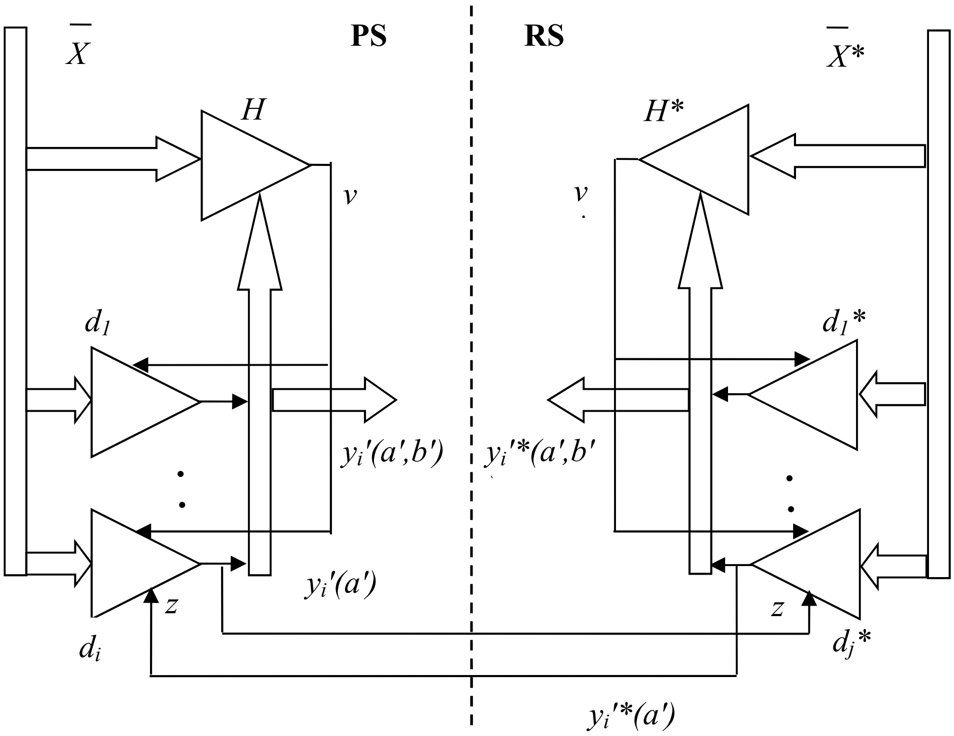

Fig. 2. Diagram of establishing interrelation between d_i and d_i^* detectors

We assume that at the initial moment of time detector d_i is not activated and is a 'free' state. This state is characterized by the fact that when any vector of $\overline{X}$ signals comes into its inputs it is not excited, since *Con(*d_i*)* is not formed. The detector also does not recognize the learning signals z since d_i is not bound to RS learning detector d_i^*. This binding is formed as a result of memorization of 'address' d_i^* by detector d_i.

To activate d_i detector, it must be 'captured'. To do this command neuron H that controls the process of activation of all the neurons of the module is required. All output signals of NE module and input vector of $\overline{X}$ signals come into H inputs. If $\overline{X}$ comes into the module, but no NE of the module is excited, then signal 'capturing' free NE is generated at the output of H. Therefore, command neuron H is the neuron of newness. When free detector d_i nearest to H receives control signal v, it interprets input vector $\overline{X}$ as the vector of identification and memorizes it as initial *Con(*d_i*)*. Thus, d_i becomes detector-identifier of $\overline{X}$ sample. In case if there is no further learning 'with teacher' of d_i detector, it will be excited only when vector $\overline{X}$ comes into its inputs or it will learn on its own.

We assume that d_i is activated, but its interrelation with d_i^* learning detector is not established yet. Then, $\overline{X}$ vector comes into d_i input it is excited and sends $y_i'(a')$ signal to the module of RS. If d_i^* detector is excited simultaneously with d_i in RS module, then d_i detector interprets its output signal $y_i'^*(a')$ as control learning signal z. In this case d_i detector memorizes the value of signal $y_i'^*(a')$ and thereby the interrelation between d_i and d_i^* is established. Similar process occurs in detector d_i^* when it memorizes output signal $y_i'(a')$ of detector d_i. Thus, detectors d_i and d_i^* learn from each other.

When vector $\overline{X}' \cap Con(d_i)$ comes into d_i input and if there exists control learning signal z, learning d_i takes place as a result of correction *Con(*d_i*)*.

If in z existence vector $\overline{X}'$, which does not intersect *Con(*d_i*)*, comes into d_i inputs, then d_i detector is nor excited. In this case 'capture' takes place as well as excitation of a new detector with the alternative for this signal z concept.

If vector $\overline{X}' \cap Con(d_i)$ comes into d_i, inputs, but learning signal z that occurs simultaneously does not coincide with the memorized value $y_i'^*(a')$, then d_i detector is not excited (it is inhibited). Then 'capture' takes place and excitation of new detector d'_i with $Con(d_i') = \overline{X}'$ by new value of z signal.

If input vector does not come into d_i inputs, but real z signal comes, then *associative excitation* of this detector takes place. The mechanism of this kind of excitation is not considered in this paper.

Conclusion

The diversity of neuron-detectors responses that determine our subjective perception of external images cannot be explained only by combinatoric character of their interrelation in irradiating paths of signal spreading. It is evident that to create the internal ‘world picture’, the information that comes only from the receptors of perceptual system is not sufficient. The process of internal presentation of external images (building presentations) should be the process of cognition. The meaning of this process lies in the synthesis of ‘knowledge’ based on the analysis of information. If the synthesis can be realized by NE-detectors, then to make analysis it is necessary to generate new characteristics that are not formed by the perceptual systems.

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30. NETWORK ANALYSIS AS A METHODOLOGY OF SCIENTIFIC RESEARCH OF BUSINESS NETWORK INTERACTIONS

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Annotation. The paper studies a network analysis as a method to research the processes of interactions among economic actors, business networks in particular. The preconditions, specific features, principles of formation of network analysis as an independent methodology of scientific researches at interaction of business structures for creation of a network are established. In order to organize interactions of business structures aimed at building a network, three aspects are deployed simultaneously, i.e. legal, economic and general scientific, which fully conforms to the principles of building a new network economy. The study estimates the potential of the network analysis and its universality, that help to model structural changes among network participants. It describes a step-by-step algorithm with which to research network connections within the framework of any business structure. While analyzing the threats connected with market monopolization during network building, the paper offers a method of assessing the efficiency of contacts among business network participants.

Introduction. The main trend in the development of modern society is the distribution of networks in all spheres of public life. Effective mechanisms of network development in politics, biology, sociology, and public administration have long been new products. External tendencies and patterns of economic development have allowed business structures to also begin to introduce elements of network interaction in business practice.

Networks can be formed both on the basis of technical possibilities of modern communication means, and with the use of a network approach in the formation of modern business associations. That is why the network economy gives more chances for the development of competitiveness for those enterprises, which, in addition to the traditional ones, implement network mechanisms in organizational and managerial, technological and other methods of implementing their own strategy in the market.

Today, despite the proliferation of the term "business networking", "network interaction", the only methodological approach to the interpretation of the concept of "network" in the domestic scientific literature is not formed. According to the authors, the reason for this is the plurality of criterion signs of the network [1], as well as a rapid change in the external environment, which causes constant mixing and new interpretations of economic concepts.

The universal nature of the network phenomenon attracts more researchers from different areas of theoretical and applied sciences, and the number of interpretations of the network is very difficult to be subjected to a detailed classification. The reason for this, as noted above, is the existence of different scientific schools, the emergence of new interpretations and their mixing in the process of parallel scientific research. Researchers offer different classifications of theories that underlie the research of networks. As it is known, the concept of "network" first appeared in the sociological studies of S. Berkowitz, S. Wassermann, B. Wellman, D. Knook, P. Marsden, K. Faust, L. Freeman at the end of the XX century. Hat is why the study of the methodology of network processes is based on works from sociology.

The main directions of research of business networks can be structured, taking as a basis the interaction between the individual elements:

1. General research of the firm at the macro level: we will include "structural holes" (R.S. Burt), network markets (H.C. White), economic actions and social structure (M. Granovetter) in this category.
2. Investigating of the integration of the firm into the environment through their interaction at the level of regions and states: this category includes the study of regional business networks (M.Casson) and aspects of interaction (P.R. Lawrence & J.W. Lorch).
3. Study of the internal structure of the company through the interaction between different levels of government, non-hierarchical formation of new structures (W.W. Powell, E. Jaques, T. McGuiness).
4. Study of the relationship between the organizational and individual levels of realization of managerial social capital (J. Coleman, R.D. Putman, P. Burdier).
5. Research of information intelligence networks and knowledge dissemination: this category will include the strategy and the theory of firms (R.M. Grant), the theory of evaluation of the multinational corporation (B. Kougt & U. Zander).

However, most researchers believe that the phenomenon of networks is formed solely as a result of inter-firm cooperation. At the same time, for the explanation and systematization of networks, a range of coordination mechanisms is used: they are considered to be informal communication, and an inter-firm information and planning system for alliances, and complex integration structures for joint ventures and franchising relations [2].

That is, inter-firm networks can be considered as a method of regulating the interdependence between firms that are different both from hierarchical regulation and from traditional market coordination as an appropriate response to market signals. But at the same time, the network process of coordination and the structure of the inter-firm coalition are unique characteristics, rather than simple repetitions of market or intra-firm analogues [3].

1. Principles of interaction of business entities for the formation of networks

Network structures are flexible forms of integration of business entities. Their effective interaction depends, at the same time, on the degree of realization of their own interests as members of the association, and on the degree of the interests of other partners in a specific network resource, which will enable them to obtain additional benefits.

As the business network it is understood the totality of subjects of entrepreneurship that unite their efforts and realize interests on the basis of certain criteria of optimality of functioning, which are connected with satisfaction of external and internal interests of the network structure itself. At the same time, the unification of efforts can take place for the construction of a technological chain, the promotion of goods to the market, the introduction of innovations, the use of experience for operational and strategic activities of the firm, etc.

The methodology of studying the processes of interaction of economic entities is based simultaneously on general economic laws, and on the specific laws of interaction. On the basis of them, a methodology is developed for the study of the processes of interaction between economic entities, principles are formed and requirements are defined, which are then formulated in the form of rules and recommendations. For business networks - this is the establishment of new rules that provide network participants with more effective functioning in the domestic business space and when entering the foreign markets.

For solving the problem of organizing the interaction of entrepreneurial structures in the formation of a network, it is necessary to consider at the same time three aspects: legal, economic and general scientific, which fully correspond to the principles of formation of a new network economy and a new business environment (Table 1).

The legal principle of the interaction of business structures is based on the possibility of free choice of partners in business, the equality of their rights, the mandatory implementation of the agreed arrangements by all the members of the association. At the same time, the agreements should not be in conflict with the current legislation, be as transparent as possible and accessible to all participants of the network.

The economic principle of the interaction of entrepreneurial structures to participate in the network is based on the sustainability of management and coordination of joint actions, mutual awareness and joint control of actions and their results, prioritizing the access of new network agents to explore their capabilities and permanent assessment of the potential of existing agent members.

Table 1 – Principles of interaction of business networks *

Principles	Components of the principles
Legal	- possibility of free choice of business partners;
	- equality of rights in the conduct of economic activity;
	- the availability and legality of contracts entered into for cooperation;
	- obligatory performance for all subjects of contracts, concluded for interaction.
Economic	- full account of existing opportunities;
	- Timeliness, priority and establishment of perspective in the organization of interaction;
	- sustainability of management and coordination of joint actions;
	- - the continuity and reciprocity of the flow of information from all members of the network and general control over the conduct of general business.
Scientific	- system approach;
	- adaptation;
	- - continuous improvement of systems and processes.

[compiled by the authors]

The scientific principle of interaction is based on the system approach and the adaptation of existing research methods to the needs of the network.

These principles are in line with the conditions of the new network economy, which transformed the relations between the participants in the production process, formed a special business environment, network business culture. For the success of the company network economy greatly depends on the efficiency of its interaction with business partners, each employer is necessary microenvironment regular monitoring activities to find and establish long-term partnerships. This leads to the formation of various integration structures, in particular, networks, alliances, coalitions, corporations, unions, blocs and others.

The main motivating factor for entering the network is the optimization of transaction costs or access to new resources, which ultimately leads to the strengthening of competitive advantages. The main factors that cause the effectiveness of the interaction of business structures are:

- high dynamism of development, which is manifested in the flexibility of interaction and its centralization;
- active competition, which is manifested in the stability of the interaction and the availability of forces and means;
- the uncertainty of the environment, which is manifested in the continuity and focus of interaction.

In the organization of interaction of business entities, the political, technical and social aspects remain as key, creating a multiplicity of levels of interaction. New structures use interaction as a process of coordinating actions in all areas of partnership in order to maximize the benefits of each participant interaction in particular, and from the shared network resource.

In international practice, a network approach is widely used to explore network environments in the business environment. The concept of interaction of entrepreneurial structures within the framework of a network approach is based on the postulates inherent in modern entrepreneurship:

- similarities of the target benchmarks for business entities;
- necessity of enhancing the innovative potential of entrepreneurship;
- development and application of information and communication technologies;
- desire to get a synergistic effect;
- development of partnership ideology.

Specific features of the network approach can include the integration of sectoral and territorial aspects, the possibility of widespread use of infrastructure capacity, as well as the ability to change the network configuration, that is, if necessary, the addition or replacement of partners.

2. Methodology for assessing the effectiveness of network operators' network connections

Over the past 30 years, a significant number of scientific works have been published in the fields of sociology, social psychology, economics, geography, political science, where scientists discuss the network structures, using the toolkit of analysis that is inherent in each of these sciences. Although these works are quite heterogeneous, the analytical toolkit used is based on common principles. Their universality consists in combining different mathematical methods for data analysis, in particular, system, statistical, cybernetic, imitation.

At the beginning of the research, the notions of networks were, more likely, intuitive, but now they are gradually translated into more stringent terms of algebra, probability theory, and graph theory [4]. On the basis of mathematical concepts, specific "network" methods have been developed, aimed at solving socio-economic problems, the possibility of widespread use of mathematical and computer algorithms, the use of quantitative methods.

The potential of network analysis as a theoretical approach is quite large, since it helps to simulate structural changes among network participants - individuals, teams, enterprises, and social institutions. Compared to other methods, network analysis has another significant advantage, since it allows data to be processed at different levels of research, from micro to macro level, providing a sequence of data acquisition, when smaller units are combined without loss of information.

Network analysis is the best choice of methodology and tools in the analysis of structures, including entrepreneurial The universality of the network approach is that it allows to consider any object under study from an interdisciplinary point of view, since one and the same object or its substructure can have many attributes that are studied through various studies. Also, networking methods allow better understanding and description of socio-economic processes by quantitative methods, which has always been a problem for most economic research. In addition, within the framework of network analysis, relationships and relationships between economic agents that are of fundamental importance are taken into account taking into account the dynamics and uncertainty of the external environment. The study of network connections within any business structure should be done step by step, highlighting the steps presented in Table 2.

At the first stage it is expedient to carry out research on the environment, in particular, the institutional, organizational principles of a particular business environment, formal and especially informal principles of interaction of economic agents, which are needed to develop an adequate strategy for network behaviour.

At the second stage, it is necessary to select and evaluate the potential of each potentially possible business partner, the effectiveness of their interaction, to analyze the advantages and disadvantages of forming the optimal network structure. Choosing network partners and conducting a detailed assessment of the economic efficiency of network communications will allow building such an organizational structure of interaction that corresponds to the existing market situation and will be able to quickly adapt to changes in the external environment. Network partners interact to reduce their own and aggregate network costs, increase their business value, level of competitiveness of goods / services, enterprises, region, industry. At the heart of the second stage are the principles of integration and globalization, reconciliation and unification, the unity of competition and general partnership, the principle of rational dialogue, which are the basis of network development of the business space.

Table 2 – Research of network connections of business structures*

Stage No.	The essence of the stage	Components of the stage
1st stage	Investigation of the environment	Political environment
		Economic environment
		Technological and technological environment
		Socio-cultural environment
2nd stage	Selection and evaluation of the potential of each of the participants in the network	Estimation of economic efficiency of network connections
3rd stage	Analysis of the interaction sequence on the basis of network links	Current (operational) connections
		Perspective (strategic) connections
4th stage	Permanent monitoring and correction of connections	Use of economic, legal, social adjustment tools

[compiled by the authors]

At the third stage, which involves the analysis of the interaction sequence on the basis of network links, it is necessary to establish the nature of these links - they are operational or they are formed on a strategic perspective. At this stage, it is important to involve a sufficient number of experts from the external environment for decision-making - representatives of government and administration, industry associations, related industries and the local business environment, specialists from specialized universities, as well as the internal environment - specialists of firms that can really evaluate the role of each network connection. In the case the effects of interaction on the basis of a particular network connection are assessed as negative, it is advisable to return to the second stage to select other potential network partners.

At the fourth stage it is advisable to adjust the quantity and composition of network participants, which is based on the continuous assessment of network connections taking into account threats of different levels. The system of entrepreneurship is not static, it undergoes constant changes, as a result of which the interaction process acquires new characteristics. There are new features, principles, conditions, as well as the forms and mechanisms of cooperation that generate organizational and managerial innovations. Therefore, on the basis of assessing the effectiveness of each network connection and the opportunities of each participant's influence, corrections are made to increase the effectiveness of the interaction as a whole.

The network form of business organization, besides the indisputable competitive advantages, can have negative sides, in particular, to create threats of monopolization of the market. Therefore, an antimonopoly policy and its tools should be an important element in the methodology of the networked form of entrepreneurship. For its practical implementation, a methodology for evaluating the effectiveness of network operators' network links is needed, which consists of the steps presented in Table 3.

At the second stage, the optimality of the overall structure of the interaction is determined by the coincidence or not the coincidence of intense and effective interactions.

Table 3 – Methodology for assessing the effectiveness of network communications*

Stage No.	The essence of the stage	The sequence of actions
1st stage	Selection of particular types of relationships	Each interaction is divided into: - internal; - external; - formal; - informal.
		Each interaction is evaluated according to the intensity and efficiency of the pre-set scale.
		Average estimates of each type of communication are calculated.
2nd stage	Assessment of the effectiveness of the structure of the links	By the coincidence or not the coincidence of intense and effective interactions, the optimality of the overall structure of the interaction is determined.
		It is calculated the probability coefficient, which allows to quantify the effectiveness of the organizational structure and is equal to the ratio of all ties-coincidences to the number of all relationships that are observed in the network.

3rd stage	Checking the structure of the interaction on compliance with the antimonopoly legislation	The newly created structure should be in line with the existing antimonopoly legislation, which limits the various manifestations of discrimination in the market and increases the competitiveness of the domestic business environment.
		The addition of new agents to the expansion of network connections of business structures should take place until it conflicts with the antitrust methodology of network interaction.
4th stage	Detection of the influence of network characteristics on the economic efficiency of a separate business unit	Construction of adequate mathematical models.

[compiled by the authors]

To do this, we use the probability p, which will allow to quantify the effectiveness of the organizational structure. Let n be the number of all bonds, c is the number of bonds-matches for the network agent (business units), e is the number of effective bonds, i - the number of intensive bonds. Then

$$n = c + i + e, \tag{1}$$

and the probability can be calculated by the formulas:

$$p_e = \frac{e}{n-c} * 100\% = \frac{e}{i+e} * 100\%; \; p_i = \frac{i}{n-c} * 100\% = \frac{i}{i+e} * 100\%. \tag{2}$$

For the implementation of the fourth stage, for example, a logistic regression model can be used:

$$p\,(Y) = \frac{1}{1+\exp[-(a+b_1X_1+b_2X_2+\cdots.+\,b_pX_p)]}\,, \tag{3}$$

$a, b_1, b_2, \ldots b_p$ - coefficients for independent variables in the equation (3);

$X_1, X_2, \ldots, X_p$ – independent variables (for example, the number of external and internal links);

Y – dependent variables that are responsible for belonging to the category of successful or unprofitable enterprises.

According to the proposed methodology, the introduction of a new participant in the network can be justified in two ways: through the evaluation of economic efficiency or in accordance with the conditions of anti-monopoly protectionism. This approach allows to significantly expand the practice of implementing a new competitive-oriented concept for the development of the regional business space structure.

Conclusions.

As it can be seen from the presented research, in today's scientific world, there is no unity between the theoretical and practical scientists about terminology, clear forms and methods of network organization of business structures. Ukrainian business practice successfully adapts foreign experience, but it should also take into account its own national peculiarities in the process of forming Ukrainian business networks. Arguments for introducing into the domestic business space network forms of doing business is given enough. The main of them is a truly multifaceted range of spheres of cooperation between companies spectrum, which may form a network of associations. In addition, being quite flexible forms of business organization, networks independently evolve internally, adapting not only to changes in external conditions, but also to increase internal efficiency. Therefore, it is important to form not only the scientific and theoretical, but also the methodological, methodological basis of research of network structures for maximizing the use of the network effect on the micro-, meso- and macro levels.

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31. THE MECHANISM OF CREWING COMPANY FINANCIAL RESULTS FORMATION

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The article studies the concept of an enterprise financial result and its correlation with profit. The financial results of the crewing company's work are defined and it has been proved that the company's effectiveness assessment in the crewing services market should be carried out not only on the basis of the profits study, but also by analyzing volume, structure and sources of income and expenses. The sources of income and items of expenditure of the crewing company were revealed for various types of crewing: pure crewing, full crew management, limited crew management and representation of the ship-owner. The analysis of the impact of such factors as the number of seafarers employed by the crewing company, their level of wages and the duration of the voyage on the income, expenses and profits of the crewing company with various types of crewing was made.

Introduction. Dynamic changes of the economic conditions of management in Ukraine, as well as the increase in the number of companies providing employment services for seafarers on the ships of the world navy, require crewing companies to introduce modern economic tools into management practice. At the same time, along with innovative methods of increasing the crewing company's efficiency, one should not ignore the traditional components of the enterprise's economy - financial results of the work.

The generally recognized financial result of an enterprise is profit. It is also the essential condition for the development of a business entity. Its growth provides the company with a certain freedom of action in the market, which necessitates the analysis of profit, the study of factors affecting it, and the search for ways of its growth.

At the same time, in the economy of a crewing company there are a number of financial indicators that also characterize the results of its work and can be attributed to the financial results of performance.

The specifics of crewing companies functioning are reflected in a particular pattern of formation of its financial results. Sometimes incomes are generated through commissions for employment, otherwise incomes include future payments of seafarers' wages. This determines the non-trivial dependencies of the crewing company's financial results on certain internal and external factors. It also has a decisive influence on the choice of areas to improve the efficiency of the company and on the establishment of its development projects. Therefore, the study of the peculiarities of the financial results of the crewing company and identifying the influence of various factors on them, taking into account the specifics of its functioning, is relevant for the study.

Literature review and problem statement. Financial results of a company are analyzed in many scientific works. However, there is no single definition of this concept. A significant part of scientists in their works [5, 6] equate the concepts of financial result with profit. First of all, it is connected with the accounting, where Form No. 2 “Report on financial results” [7] approved by the Ministry of Finance of Ukraine [7] reflects a profit as a financial result.

However, from an economic point of view, the concept of "financial result" and "profit" are not identical. This is proved in the work [8], where the author explores the evolution of approaches to the interpretation of the economic content of financial results by various economic schools and concludes that the modern interpretation of a financial result in an economic sense is much broader. He rightly argues that it is necessary to separate the understanding of the accounting and economic content of the company's financial results.

There are various approaches to the definition of financial results of economic activity and different concepts. For example, some researchers study and define the economic content of financial results through the prism of such functions as accumulation, incentives and distribution [1].

In another work [2] three main approaches are defined, according to which financial results are defined as:

– the difference between income and expenses;
– change in the value of the company's net assets during the reporting period;
– change in the value of the equity of an enterprise.

The first approach is the most common one. It correlates with the accounting approach.

Some authors [3], along with the profit, include cost-effectiveness in the financial results, as the indicator, which allows making a conclusion about the performance of the company and the efficiency of financial results of the company’s management.

One more work [4] emphasizes the need for a deeper understanding of the financial result of the company and its study in terms of structure, formation mechanism and management system.

The conducted research showed that the views of different authors on the definition of the essence of the "financial result" concept are diverse. However, the formation of financial results is influenced by various factors that are proposed to be divided into two groups: internal and external [9]. Significant influence is exercised by the branch of management, and in crewing activities, even the kind of crewing. The influence of conceptual approaches on the crewing business efficiency was investigated in the research [10], where the expediency of a seafarer's decision on employment based on an economic approach was justified. But this work reflects the interests of the seaman, which do not always coincide with the interests of the crewing company, and even opposite in certain types of crewing.

The interests of the crewing company concerning the formation of financial results were considered in [11], but it described the formation mechanism of financial results of a crewing company as a structural unit of a shipping company, that is, only when using the crewing type "representation of the ship-owner" that has significant differences from other crewing types.

The specifics of determining the crewing company’s financial results for various types of crewing based on calculation formulas are described in [12], but further study has shown that new crewing subtypes need to be introduced and the dependence of a crewing company’s financial results on its performance indicators should be provided, which will allow to determine the most appropriate type of crewing for a particular crewing company.

The relevance of the research is emphasized by the need to study the scheme of formation of the crewing company’s financial results with various types of crewing and to assess the impact of certain company’s indicators on the company’s profit, income and expenses.

The aim and objectives of the study. The purpose of this article is to study the peculiarities of the formation of the crewing company’s financial results and to identify the dependencies of the financial results of the crewing company on certain indicators of its work.

To achieve this goal it is necessary to solve the following objectives:

– study the sources and mechanism of formation of the crewing company’s income, expenses and profits for various types of crewing;

– to compare the levels of the crewing company’s financial results for various types of crewing;

– identify the dependence of the crewing company’s financial results on the number of seafarers employed by the crewing company, the level of their salary and the duration of the voyage.

The mechanism of formation of the crewing company's income, expenses and profits for various types of crewing. The main activity of the crewing company is employment services for seafarers on the ships of the world navy. The list of crewing company services varies depending on the peculiarities of its activities. Crewing companies are classified according to various criteria [2, 13]. In particular, the type of crewing distinguishes "pure crewing", "crew management" and "ship-owners representation". These three crewing types provide fundamentally different schemes for generating financial results, which are described in detail in [12].

The study of the peculiarities of the crewing company's income and expenses formation, as well as mutual settlements with the customer - the shipping company (vessel operator), necessitated the addition of the crewing company classification by the crewing type given in [13].

"Crew-management" is proposed to be divided into two subspecies: "full crew-management" (the shipping company transfers the full amount of funds to the crewing company, which independently distributes them by expenditure) and "limited crew-management" (the crewing company receives a certain percentage of the salary of each employed seaman, depending on his qualifications).

Each type of crewing has its own distinctive features, distinguishing it from the other ones: the conditions for entering the labor market of seafarers, the organizational and legal basis of work, the relationship with the shipping company (vessel operator), the list of crewing services, sources of income, expenditure items, etc.

As an economic category, the financial results of the crewing company should be studied in the context of the analysis of the formation sources and the structure of its income and expenses. Each crewing company, aware of its goals and relying on market analysis, can choose the most attractive type of crewing for it.

At this stage identifying the dependence of the financial results of the crewing company on the main production indicators of its work is essential for the crewing type selection.

We can perform calculating of the income and expenses volumes for various types of crewing by the example of the crewing company's work. **Table 1** shows the main sources of a crewing company's income formation for various types of crewing.

Table 1 – The main sources of a crewing company's income generation for various types of crewing

% - fixed percentage of seaman's salary

- share of the total amount allocated by the shipping company

The source of a crewing company's income	Pure crewing	Full crew mana-gement	Limited crew management	Represen-tation of the ship-owner
1. Commission fee for the employment of a seaman				
– from the seaman	%			
– from the shipping company	%	#	%	
2. The shipping company's payments		#	#	

It should be borne in mind that payments from the ship-owner have different nature and different sizes. Thus, payments and commissions from the ship-owner with full crew management are not obvious and are hidden in the total amount that the ship-owner allocates for remuneration of the seaman, search for the seaman, getting visa and insurance, forwarding the seaman on board the vessel and other procedures concerning the search, forwarding and maintenance of the seaman on board. And limited crew management allows to calculate this amount - this is a clearly defined percentage of the standard seafarer's salary of a certain qualification.

Table 2 shows the crewing company's aggregative types of expenses for various types of crewing. The expenses incurred by a crewing company with a certain type of crewing are highlighted.

Some large shipping companies even invest in training seafarers at their own expense. Training centres are being created in Ukraine, and the practice of investing in seafarers training at the expense of the company is gradually being introduced. But this is observed in most cases only when using the "ship-owners representation" crewing.

Table 2 – Crewing company's aggregative types of expenses for various types of crewing

Item of expenditure	Pure crewing	Crew management		Representation of the ship-owner
		Full	Limited	
Office maintenance				
Advertising and website				–
Salary of the crewing company personnel				
Salary of seafarers	–		–	
Other expenses on a seafarer	–			
Other expenses				

On the basis of the market analysis, average performance indicators of Ukrainian crewing companies were determined for different types of crewing. Let's consider the dependence of the crewing companies' financial results on certain company's performance indicators for different types of crewing, using the example of these average values.

In order to obtain objective results and to ensure the comparison of the companies' financial results, we will define certain basic terms of payment (Table 3).

Table 3 – Conventional performance indicators of a crewing company with various types of crewing

Name of the indicator	Pure crewing	Crew management	Representation of the ship-owner
Number of shipping companies - customers	10	2	1
Number of vessels in service	10	5	10
Number of crew members employed per vessel	12	25	25
Average duration of sea voyage, months	4		

On the basis of the analysis of vacancies in the labor market of Ukrainian seafarers, as at the beginning of 2018, the average salary level of seafarers was determined. Values may vary depending on the type of vessel, the duration of the voyage, the sailing area and other factors.

A crewing company may cooperate with a different number of companies and employ a different number of seafarers, using various types of crewing. Under the terms of the calculation, we have accepted that with pure crewing the crewing company cooperates with the largest number of shipping companies - 10. But all contacts of the company are of short duration. Pure crewing is most similar to the work of a recruitment agency. Therefore, the income of the crewing company with this type of crewing will be lump-sum payments for the entire contract period (one seafarer's voyage), but from two sides - from the seaman's side (a certain percentage of future salary determined by the market) and from the shipping company (a certain percentage of the seafarer's salary approved by the crewing and shipping company).

Crew management involves working with several companies. But their number cannot be large, since this type of crewing requires constant monitoring and changing the crew of a specific vessel within a clearly defined contract period.

In this study the condition for the calculation is the change of the entire crew.

However, there are cases when the ship-owner cooperates with a few crewing companies that provide one ship with the crew.

Taking into consideration the complex nature of seafarers' labor and considerable psychological stress during the voyage, most experts emphasize the need to consider not only qualifying factors when choosing a crew, but also psychological compatibility [10, 11]. This is very important to ensure the necessary level of safety of the vessel. Therefore, the search and selection of the crew should be entrusted to one crewing company, which will fully carry out the ship crew management. There are such opportunities in Ukraine, as sailors of all the necessary maritime professions are prepared here. Crewing companies have an opportunity to form a crew only from Ukrainian sailors at the request of the ship-owner.

We determined that the number of ships for a ship-owner's representation is 10. It should be emphasized that in Ukraine only a few large foreign shipping companies have their representative offices. The number of ships under their crew management may be significantly higher, but in order to compare the results in the future, and proceeding from the fact that not all ships of one shipping company will be staffed only by Ukrainian sailors, in this study, 10 ships are a realistic figure in our opinion.

Let's consider the mechanism for generating income of a crewing company with the help of real numbers. In some cases, the amount of commission is a certain percentage of the monthly salary of a seaman of a certain category. This situation is observed with pure crewing, when the crewing company receives an average of 3% of the seaman's salary from the shipping company, not taking into account the seaman's category. Besides the crewing company charges a one-time fee for sailor's employment. The percentage depends on the position. The highest percentage is charged not for the highest positions, but for the most popular ones. A crewing company may require up to 20% of a monthly salary for the employment of a second or third mate and a third engineer. But the most common rates are about 12%, which are the largest of all seafarers' positions reviewed.

The study showed that, usually while using the full crew management system, the fee for agency services is $ 250 per seaman after signing the employment contract. Besides, if the system of full crew management is used, the crewing company receives a total budget, which is on average 10-15% more than the seafarers' salary expenses necessary for the work on the company's ships. These funds are spent by the crewing company not only on the remuneration of seafarers, but also on all other expenses. The rates of payment for the services of the crewing company in search and employment of seamen were determined, and the crewing company’s income from the search and employment of seamen by category on one vessel was calculated for various types of crewing.

Seaman's salary is set by the shipping company. In the case of pure crewing and limited crew management, the seaman’s salary remains unchanged throughout the entire voyage and is paid directly to the seaman by the shipping company. In this case, the crewing company is interested in a large salary of a sailor.

In the case of full crew management, the seafarer's salary is determined by the crewing company, on the basis of the minimum salary amount according to ITF requirements, the average salary in the market and the allocated budget of the shipping company. That is, the maximum level of income in comparison with other types of crewing does not indicate an excessively high level of profitability of this type of crewing. The crewing company will have to use part of this income to make a lot of different payments, a consolidated list of which is given in **Table 2**.

An important source of income for a crewing company with this type of crewing is cost savings on seafarers’ salary, seafarers repatriation, visa support, insurance and others. They are paid by the shipping company from the general budget, without fundamental restrictions and considerable control.

Relying on the initial data and taking into account the defined number of vessels, the level of the crewing company’s income was calculated for various types of crewing.

The income of a crewing company with pure crewing depends on the number of partner shipping companies, the number of manned vessels and the number of crew members that this crewing company provides. Under modern conditions of crew management development, the demand for pure crewing services is being reduced. Companies that operate on a pure crewing basis are interested in finding the largest possible number of ship-owning customers. In this study, when calculating income for pure crewing, it is understood that the company has the ability to employ only 12 seafarers per ship. In the future, for a comparative monthly analysis of the work of crewing companies, the number of vessels in the service of pure crewing will equal 10. This is a high value for the crewing company, but it will provide comparable values.

Figure 1 shows the income levels of crew management companies servicing one ship per contract for various types of crewing.

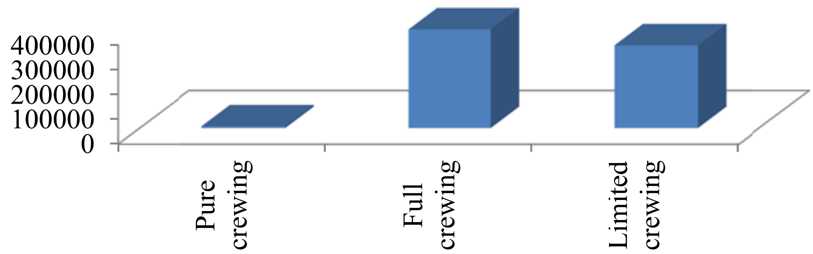

Fig. 1. Income levels of a crew management company for various crew management schemes, USD / month

As a result of using full crew management system, the income from one vessel manning is the highest. But it should be noted that it includes a sum of money for seafarers' salary payments.

The second largest income belongs to a company that uses limited crew management system.

Under the given conditions, the income from pure crewing will be the lowest.

The income from "ship-owners representation" type of crewing cannot be determined, as crewing in this case is only one of a large shipping company's areas of work. The next step is to determine the crewing company's expenses while using various types of crewing system.

A distinctive feature that has a great influence on the formation of outcome indicators of a company's expenses is that the salary level of seafarers in a crewing company with full crew management system is determined independently by the company, which can save on seafarers' payments to improve the financial results of its activities. In turn, the size of salaries will differ significantly from the salary in the representative office of the ship-owner.

To carry out the amount of work specified by the task conditions in this study, while taking into account the operating conditions of the crewing services market, the number of employees of a crewing company will be from 8 to 13 people.

Costs for the crewing company staff payments consist of the following expenses:

- salary;
- bonuses for achievements and impeccable work;
- accruals for salary - a single social contribution.

In the process of working, the crewing company bears the cost of maintaining the office.

According to the cost of utilities, housing services and other resources, the expenses for the maintenance of the office were determined, including the costs of electricity, heat, security, etc.

On the basis of the presented data, the total amount of expenses incurred by the crewing company for various types of crewing was calculated. A crewing company pays some expenses (for example, expenses for forwarding a seaman on board a vessel, medical insurance for a seaman and other expenses for a seaman) only once during the contract period. The duration of the contract period differs depending on a seafarer's category. The average duration of the contract period is 4 months. This value is used in the calculations.

The calculations show that the highest level of expenditures for providing crew ship management services is in the ship-owners representative offices and in companies using full crew management system. The obtained data provide an opportunity to see the distinctive features of each type of crewing (Fig. 2).

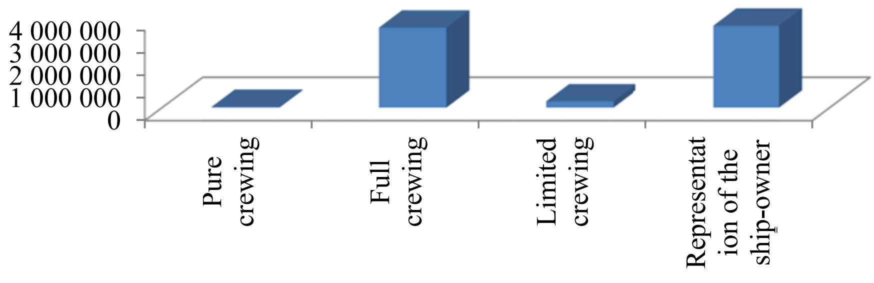

Fig. 2. The level of a crewing company's expenses for various types of crewing, uah./ the contract period.

The cost of seafarers' labor is paid by a ship-owner's representative office and by a crewing company using full crew management system.

Let's consider the crewing company's cost structure for different types of crewing. This will help to identify the ways of reducing costs to improve the efficiency of a crewing company.

The crewing company's cost structure for different types of crewing is shown in Table 4.

Table 4: The cost structure of a crewing company, %

Expenditure	Pure crewing	Full crewing	Limited crewing	Representation of the ship-owner
Office maintenance	14,0	0,2	2,7	0,2
Advertising and website	1,1	0,013	0,2	0,009
Remuneration of the crewing company personnel	83,6	1,3	16,1	1,1
Remuneration of seafarers		90,8		93,3
Other expenses for seafarers		7,7	80,8	5,5
Other expenses of the crewing company	1,4	0,021	0,3	0,017

If a crewing company uses pure crew management system, about 84% of its costs fall on the remuneration expenses for the crewing company personnel. The second group of expenses in terms of volume, though it is significantly smaller, is the cost of maintaining the office, which constitutes 14% in the company's cost structure. This type of crew management implies no costs associated with the salary payment or other costs for seafarers.

If a crewing company uses full crew management system, the expenses for seafarers make up the lion's share of its costs. The share of expenses for seafarers' remuneration is more than 90%. Other expenses for seafarers constitute about 8%. These costs are fully compensated by the shipping company.

While using the limited crew management system, most of a crewing company's costs (about 80%) are expenses for seafarers, which include transportation costs for shipping a sailor on board a ship, living expenses in hotels, medical insurance and other expenses associated with seafarers except for the payment of their salaries. For this reason, the main source of cost reduction is the optimization of the expenses for repatriation and getting the seafarers' documents ready for the voyage.

Almost 94% of expenses in a ship-owner’s representative office are accounted for labor costs. Another 5% are other expenses for a seafarer.

Relying on the stated level of income and expenses of a company, we are going to calculate the profit of each type of crewing per contract period.

The greatest amount of profit is obtained by companies using full crew management system. But under the stipulated conditions crewing companies using different types of crewing, employed a different number of sailors.

Figure 3 shows the specific income, specific costs and specific profit of a crewing company for different types of crewing.

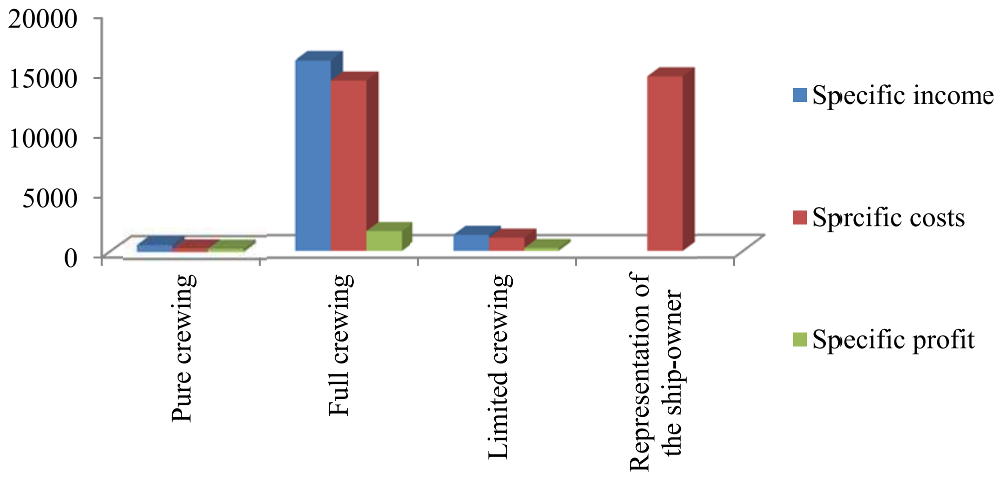

Fig. 3. The level of specific income, costs and profit of a crewing company for various types of crewing, USD USA / seafarer

The highest level of specific profit is observed in companies using full crew management system. The company's profit from a pure crew management system is lower than its profit from a limited crew management system. But the specific profit is higher in companies using pure crew management system than in companies using limited crew management system.

On the basis of the obtained results, we can conclude that when evaluating the effectiveness of the crewing company in order to select the most appropriate type of crewing, it is not always possible to use relative indicators. Under certain crewing schemes (in particular, the representation of the ship-owner), the only way to evaluate the effectiveness of the company is to estimate the company's costs.

Analysis of dependencies between some performance indicators of a crewing company using different types of crew management. We are going to analyze the dependence between some performance indicators of a crewing company using different types of crewing. Let's include the results of the crewing company's determined specific expenses in the calculation in order to take into account the stationary costs.

The correlation between income, expenses and profits of a crewing company and the level of an employed seafarer's salary depending on different types of crew management is shown in Figure 4.

The expenses of a crewing company using the pure crew management system does not depend on the salary of an employed seafarer. There is a linear relationship between income and profits, taking into account the fact that income is generated by a clearly defined percentage of the salary of an employed seafarer. When the salary is below 3,000 USD, the crewing company's work is unprofitable.

There is a linear relationship between the salary of a seaman and the financial results of a crewing company using full crew management system. When the salary is below 1325 USD, the crewing company's work is unprofitable.

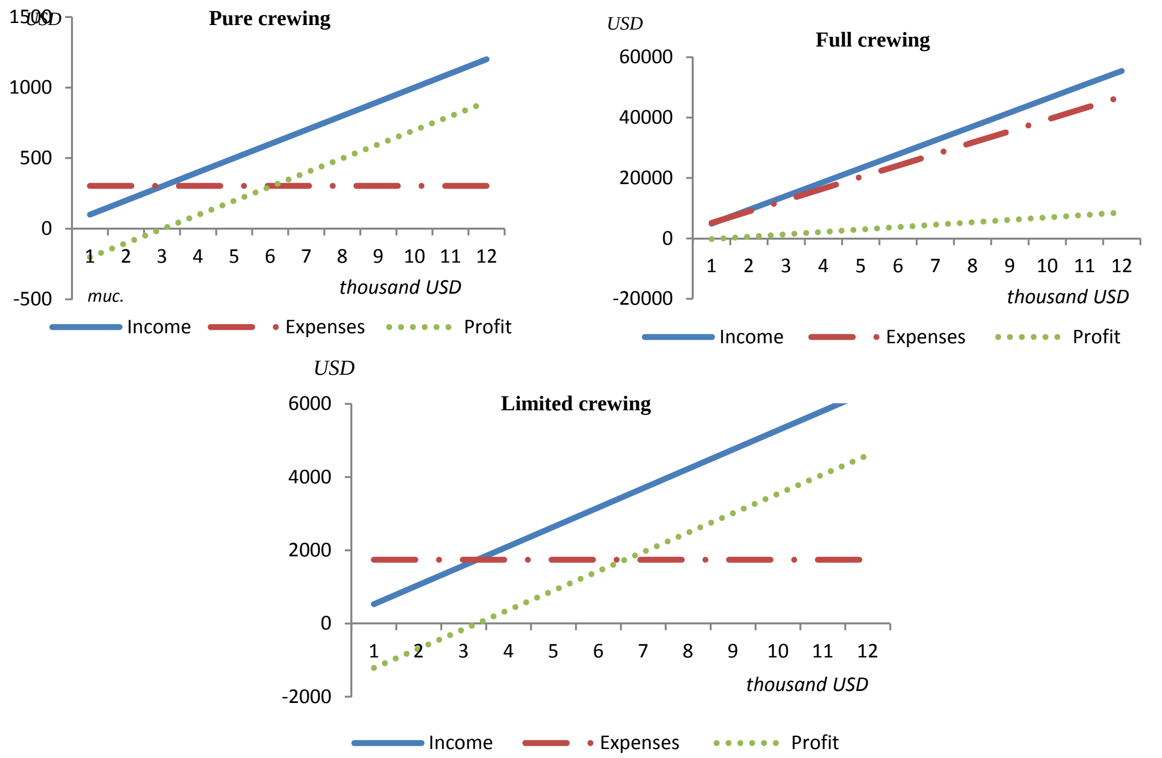

Fig. 4. Dependence of income, expenses and profit of a crewing company on the level of an employed seafarer's salary for different types of crewing

In crewing companies using limited crew management system, income and profits grow in proportion to the level of salary. The expenses do not depend on the salary level of a seaman, since with, the crewing company using limited crew management system pays the costs of transporting the seaman on board the ship, hotel accommodation, agency services and others. They depend on the choice of the route to the location of the vessel, the distance to the vessel and the frequency of crew change. That is why, the expenses of the crewing company using limited crew management system do not depend on the seaman's salary. When salary is below 3,000 USD, the crewing company's work is unprofitable.

We are going to study the dependence of income, expenses and profits of a crewing company with various types of crewing on the duration of the contract (voyage period) of the seaman. It can vary from 2 to 8 months. Although, according to international practice the duration of a seaman's voyage should not exceed 4 months. Let's define the dependencies on the condition of a chief engineer employment with a salary of 8,500 USD per month.

Dependence of income, expenses and profit of a crewing company using different types of crew management system on the duration of the contract (voyage period) of a seaman is shown in Figure 5.

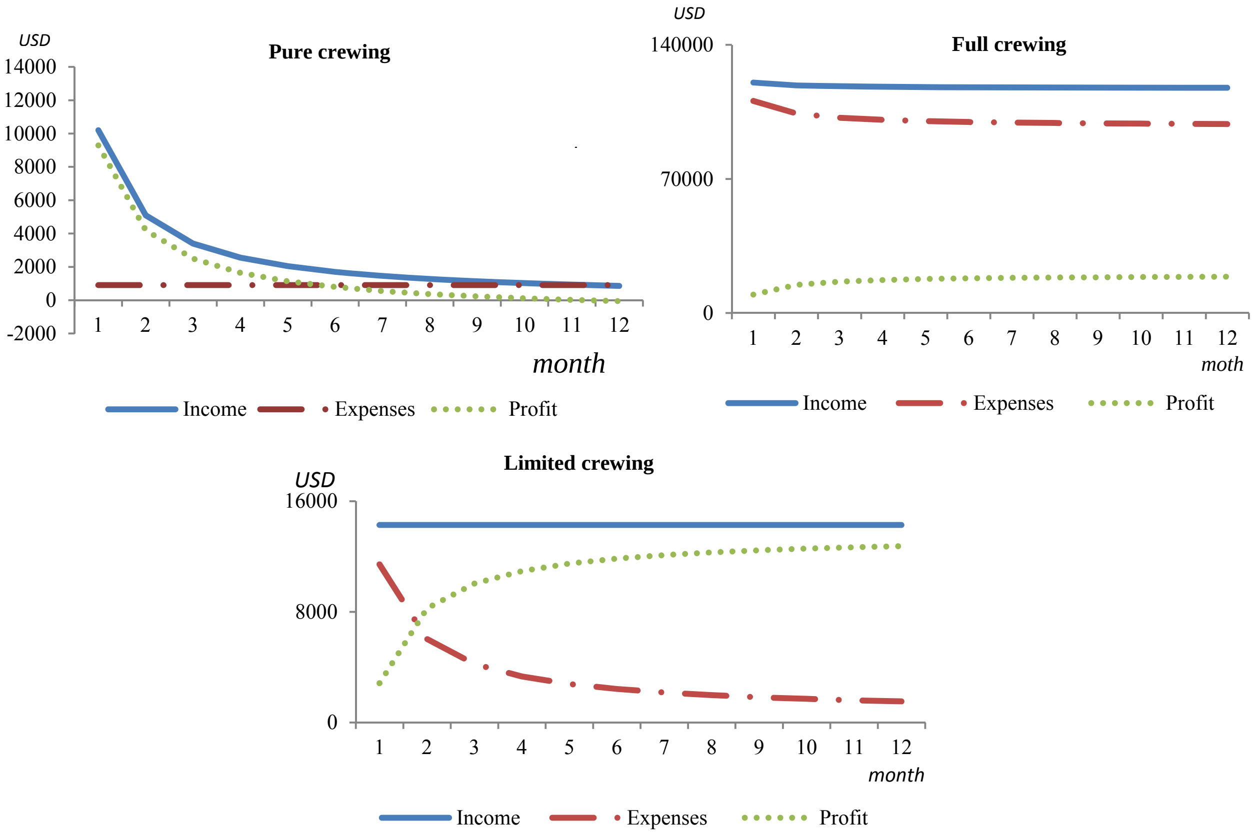

Fig. 5. Dependence of income, expenses and profit of the crewing company on the duration of the contract (voyage period) of a seaman for different types of crewing

A crewing company using pure crew management system receives income from employment of a seafarer at the time of contracting. Because of this, the crewing company is interested in reduced voyage period and in the frequent departure of a seaman to a sea voyage. The greatest profit is observed with the shortest duration of the sea voyage. Under these conditions, if the duration of the sea voyage is more than 11 months (i.e., 1 voyage per year), the crewing company's work is unprofitable.

The income of a crewing company using full crew management system is formed by the shipping company's monthly payment of a certain amount for each seafarer, depending on his category and single payment by the seafarer at the time of contracting, which amounts to 250 USD. The crewing company's income is growing by precisely this amount (250 USD), with the reduction of a sea voyage period and a corresponding increase in the number of sea voyages per year. Costs increase by the amount of expenses for documents preparation and sending a sailor to the sea voyage.

With limited crew management, the income of the crewing company is formed by paying the shipping company an appropriate share of the seafarer salary. Therefore, when a sailor is on a voyage, the crewing companies' income does not change according to the duration of the voyage. In its turn, with this type of crewing, the crewing company pays the expenses for documents preparation and forwarding the seaman on board the ship. Additional costs result from each sea voyage. Therefore, maximum expenses are observed at the shortest duration of a sea voyage.

The highest profitability is demonstrated with an increase in the duration of the voyage, and accordingly with a decrease in the number of sea voyages.

Let's consider the dependence of income, expenses and profit of a crewing company on the number of seamen employed by a crewing company depending on different types of crewing. Let's define the financial results for the year of the crewing company's work. It is assumed that every seafarer takes 3 sea voyages 4 months each per year.

The dependence of the income, expenses and profit of the crewing company on the number of seafarers employed by the crewing company with various types of crewing is shown in **Figure 6.**

All expenses of a crewing company using pure crew management system are fixed, that is, they do not depend on the amount of work performed. Therefore, the number of employed seafarers does not affect the level of expenses of the crewing company. Income grows in direct proportion to the increase in the number of employed seafarers, which corresponds to the mechanism for generating income by a company with this type of crewing: a percentage of employed seafarers salary. The more sailors, the more income.

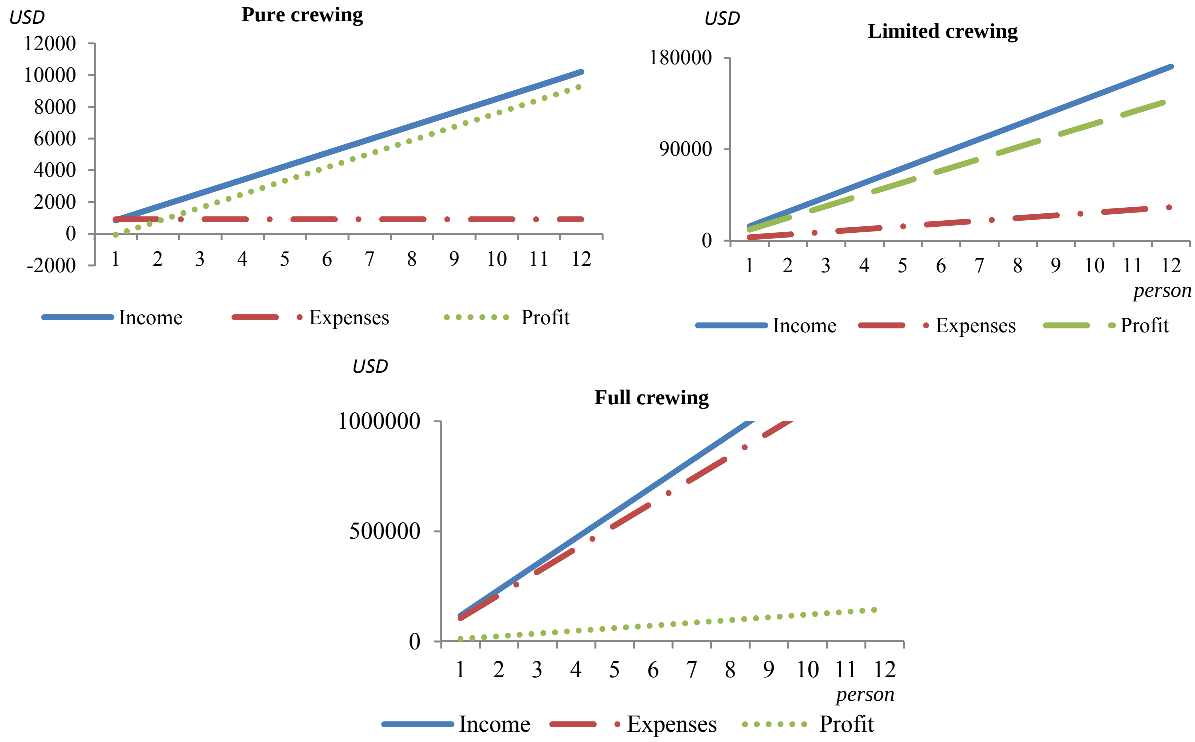

Fig. 6. Dependence of income, expenses and profit of the crewing company on the number of seafarers employed by the crewing company with various types of crewing

Profit grows with the increase in the number of seafarers. On the condition of the determined specific costs, payback begins with two employed chief engineers.

Income and expenses rise almost proportionally with the increase in the number of seafarers. This is due to the fact that almost 90% of expenses go to seafarer salary and all incomes are generated relying on the number of employed seamen and their categories on which their salary depend.

Profit of companies using full crew management system increases with the rise in the number of employed seafarers.

With limited crew management, all financial results of a crewing company grow with different types of crewing. Expenses will include fixed costs for the maintenance of the office and staff of the company, as well as the costs for documents preparation and forwarding the seafarer on board the ship. On the basis of a given number of sea voyages, the costs of a company using this type of crewing vary slightly. In this case, the crewing company receives a fixed amount from the shipping company during each month of the employed seafarer's voyage.

The conducted research made it possible to identify the factors for each type of crewing that affect the financial results of a crewing company, identify the ways to increase revenue, and define the spheres of reducing the costs of a crewing company (Table 5).

Table 5. Comparison of the factors influencing the financial results of a crewing company with different types of crewing

<table>
<tr><th>Elements of comparison</th><th>Pure crewing</th><th>Full crewing</th><th>Limited crewing</th><th>Represen–tation of the ship-owner</th></tr>
<tr><td>1. Nature of payments</td><td></td><td></td><td></td><td></td></tr>
<tr><td>−from a seafarer</td><td rowspan="2">single payment at the time of the contract conclusion</td><td>single payment at the time of the contract conclusion</td><td>–</td><td>–</td></tr>
<tr><td>−from a ship-owner</td><td>monthly payments during the cooperation with the shipping company</td><td>monthly payments during the sailor's voyage</td><td>constant payments for the implement–tation of activities</td></tr>
<tr><td>2. Factors affecting the financial results of the company</td><td>seaman's salary (which depends on his position and qualifi–cations)</td><td>−number of sailors;
−seafarers qualifications;
−number of ships</td><td>−number of sailors;
−seafarers qualifications;
−duration of sea voyage (number of sea voyages per year)</td><td>need for sailors for a shipping company fleet</td></tr>
<tr><td>3. Ways of income growth</td><td>attraction of new shipping companies</td><td>attraction of new shipping companies and more qualified seamen</td><td>attraction of new shipping companies and more qualified seamen</td><td>shipping company development</td></tr>
<tr><td>4. Spheres of reducing expenses</td><td>– improving seafarers databases;
– increasing the</td><td>– savings on seafarers salary;
– route optimization of a</td><td>– cost optimization of shipping a sailor on board;</td><td>– improving seafarers' databases;
– increasing</td></tr>
</table>

	efficiency of the crewing company personnel	sailor’s forwarding aboard a ship	– increase of the sea voyage period (reduction in the number of crew changes)	the efficiency of the crewing company personnel; – cost optimization of shipping a sailor on board

Conclusion. Crewing activity has specific features of functioning, which is reflected in the list and structure of the financial results of the company. The intermediary nature of the crewing company’s work makes it dependent on customers: shipping companies or ship operators. The amount and sources of income of a crewing company, as well as the list, structure and volume of its expenses are affected by the type of crewing. This fact determines the differences in the sources of savings and the directions of a crewing company development for various types of crewing. Different financial results dependencies on the production performance of a crewing company are observed. Therefore, the ways to improve the efficiency of a company will be different.

In the future, it is planned to substantiate the mechanism for choosing the type of crewing depending on the goals and development strategy of a crewing company and to develop a mechanism for managing the crewing company’s financial results.

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