

# Formalization of Typical Problems of Decision Making on the Basis of Expert Knowledge in the Priority Personnel Training System for Monotowns

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## ABSTRACT

The study object is the system of priority training of personnel of a monotown, which is one of the most important components that ensure the dynamic socio-economic development of special economic territories. The study subject is the decision-making problems arising from the main subjects of the system of priority training of personnel of a monotown, acting on the basis of network interaction. The study objective is to identify and formalize typical decision-making tasks based on the use of expert knowledge in order to reduce the variety of these tasks, and, accordingly, reduce the number of decision-making models that need to be developed to create an integrated methodological base and a modern digital environment for information support of the priority personnel training system of monotowns.

**Keywords:** *monotown, advanced training system, decision support, decision problem model, expert knowledge*

## 1. INTRODUCTION

Since 2014, Russia has been implementing measures of state support for individual territories - priority development areas (PDA) - in order to create prerequisites for improving the socio-economic state and development of monotowns. The main task of such PDAs is to create more favorable conditions for doing business, attracting investment in the city's economy, and creating a competitive environment. At the same time, the economic development of monotowns is associated with the diversification of the city's economy, the expansion of the range of products and services of the city's enterprises, the reorientation of sales markets, the creation of new innovative industries and an increase in the efficiency of existing ones through the implementation of new innovative technologies. In this regard, for the regional authorities and municipalities of PDA monotowns, along with the task of attracting investors to the PDA, the task is to create a system of priority training, which will ensure the formation of the town's personnel potential meeting the requirements of innovative production, capable of meeting not only current, but the prospective needs of the monotown labor market as well.

We also note that the problem of migration of the working-age population to other regions and cities with a more developed economy, and, accordingly, the potential for the implementation of professional competencies and career goals is often inherent in monotowns. In this regard, an understanding of the decision-making process by an individual when choosing his educational and career path is of particular importance [1]. At the same time, the task should be set to harmonize the interests of all subjects

associated with the education and labor markets of a monotown [2].

In the digital economy, effective practical implementation of a system of priority training of engineering and technical personnel, as well as the processes of making managerial decisions by all subjects of the system, are not possible without the use of information technologies that provide monitoring and decision-making processes and network interaction of participants in the training process. In this regard, the task of developing methodological foundations for creating information support for decision-making processes in the system of priority training of personnel in a monotown is urgent.

In [3], an analytical review of individual studies related to the above problem in five main areas is carried out:

- Approaches and organizational models for organizing network interaction in the training process;
- Specificity, approaches, and organizational models of personnel training in monotowns;
- Methods for forecasting the need for personnel;
- Models and methods of decision support in the implementation of educational programs;
- Means of information support for personnel training processes.

The conducted analytical review allowed us to draw a number of conclusions, here we will give only those that are directly related to the topic of the article:

1) In modern studies, practically no attention is paid to the problems of creating a system of methods and means of information support for the process of choosing an educational trajectory, assessing, choosing options to priority training from the point of view of various decision-making subjects in an integrated environment that provides

justification for decisions taking into account the interests of all interested subjects of a monotown. Most often, specific decision-making models are developed for practical tasks, for example: comparison of vacancies and resumes in the labor market [4], evaluation and planning of educational programs by educational institutions [5,6], the choice of an individual educational trajectory [7,8], information market models labor and vacancies [9,10]. As for the creation of means of information support for network interaction in the process of training professional personnel, it should be noted that today there is no single platform that provides information for making a decision on training personnel for all stakeholders.

2) specifics of digital support for monitoring and decision-making of the personnel training system for monotowns - priority development areas is expressed in the following requirements:

- A comprehensive methodological base and a modern instrumental environment for organizing and monitoring the quality of the implementation of network interaction of all stakeholders in the priority training of personnel for a PDA monotown should be developed;
- The main subjects of network interaction of the participants in the priority training of personnel in PDA monotowns are educational organizations, municipal and regional authorities, employer enterprises (consumers and customers of personnel), individuals (potential employees);
- Due to the high uncertainty of the decision-making environment, incompleteness and possible unreliability of information, the information support system should provide methods for organizing and conducting examinations, ensuring the collection, formalization, and aggregation of opinions and judgments of experts in various spheres of the

monotown economy, labor market and educational activities [2,3,10].

This article examines those decision-making tasks in the system of priority training of personnel of a monotown (SPTPM) that require the involvement of experts. The terms "monotown" and "PDA" are synonymous in this article.

## 2. METHODS FOR FORMALIZING TYPICAL DECISION-MAKING PROBLEMS BASED ON EXPERT KNOWLEDGE IN SPTPM

Despite the large number and heterogeneity of decision-making tasks in the system of priority training of personnel in monotowns, which is due to its complex network structure, some features can be identified that make it possible to combine tasks into several groups, which will reduce the number of decision-making models.

To identify typical decision-making tasks that arise in the subjects of priority personnel training of the PDA and requiring the involvement of experts, we will decompose the area of decision-making tasks from the standpoint of system analysis on three grounds:

- Management stage (analysis, assessment and selection, control);
- Subjects of priority training, making this decision;
- Subjects about which the decision is made.

Table 1 shows the results of the decomposition of the decision-making tasks area in SPTPM for the management stage - analysis. Similar tables are developed for the selection and control stages.

**Table 1** Examples of decision-making tasks in SPTPM for the management stage - analysis

PDA subject who makes a decision	PDA subject, regarding which the decision is made			
	Town (region) administration (PDA)	Employer	Educational institution	Individual
City (region) administration	identification and assessment of social and economic factors affecting the PDA development	identification and assessment of factors in the formation of the necessary professional and qualification structure of the PDA labor market	identification and assessment of factors affecting the training of professional personnel	identification and assessment of factors influencing the implementation of an individual's professional career
Employer	identification and assessment of the factors that determine the PDA policy in relation to economic diversification	identification and assessment of the factors of development of the enterprise that affect the requirements for the professional and qualification structure of the personnel of the enterprise	identification and analysis of factors influencing the formation of the necessary professional and qualification structure of the PDA labor market	identification and analysis of factors influencing the choice of areas of professional activity and places of employment
Educational institution	identification and assessment of factors that determine the PDA policy in relation to economic diversification and the need for a professional and qualification structure of personnel	identification and assessment of factors influencing the requirements for the professional and qualification structure of graduates of educational programs	identification and analysis of factors affecting the demand and competitiveness of educational programs	identification and analysis of factors influencing the choice of an individual's educational trajectory
Individual	identification and assessment of factors affecting the demand for professional personnel in the PDA	identification and assessment of factors affecting the demand for professional competencies in the labor market	identification and assessment of factors affecting the demand for graduates of educational programs of educational institutions	identification and assessment of factors influencing the formation of an individual educational trajectory and professional career

The performed decomposition allows us to single out typical decision-making tasks for each of the stages of managing the activities of various subjects of the system of priority training of personnel in PDA monotowns. The presence of typical tasks makes it possible to reduce the number of decision-making models in the information system of priority training of personnel of a monotown (ISPTPM)

We will formalize typical tasks in accordance with the model (1).

$$\langle S_o, T, Q \mid S, A, B, Y, F(f), L, Y_{opt}, \rangle \quad (1)$$

where the first three elements are known parameters, the rest are sought ones;

So - problematic situation;

T and Q - respectively, the time and resources available to make a decision;

$S = (S_1, \dots, S_n)$  - elements detailing So;

$A = (A_1, \dots, A_k)$  - decision-making purposes;

$B = (B_1, \dots, B_l)$  - restrictions;

$Y = (Y_1, \dots, Y_m)$   $Y = (Y_1, \dots, Y_m)$  - alternative decisions;

f - decision maker's preference function;

K - optimality criterion;

F(f) - group preference function;

L - principle of group preference formation;

Yopt - optimal (recommended) decision.

### 3. RESULTS OF FORMALIZATION OF TYPICAL DECISION-MAKING PROBLEMS IN SPTPM

Let us present the results of formalization in accordance with (1) of typical decision-making problems based on expert knowledge for three stages. Under the decision-maker, we further understand the decision-maker for any of the subjects of the system of priority training of personnel in PDA monotowns.

#### 3.1. A typical model of the decision-making problem in ISPTPM at the analysis stage

At the stage of analysis, the decision-maker needs to form a set of external and internal factors, the influence of which is significant in the implementation of the goals of the subject in the system of priority training of personnel of a monotown (SPTPM). These factors and their combinations can serve as a basis for developing a list of options to achieve the goals of the subject. The decision-making problem model has the form (2).

$$\langle S_o, T, Q \mid S, A, B, V, C(V), X_d, X_c, K, F(f), L, X_{rd}, X_{rc} \rangle \quad (2)$$

where  $S_o$  is the problematic situation associated with the functioning and development of the subject in the SPTPM and the subject at the time of the analysis;

T - decision time;

Q- resources for decision-making: human (labor costs of decision-makers, analysts, experts, etc.), material

(organizational and technical means for collecting information and analysis, information (own knowledge bases, databases, external information resources, etc.);

$S = (S_1, S_2, \dots, S_n)$  - set of external and internal factors detailing the problem situation  $S_o$ , making it possible to specify and decompose certain aspects of the problem situation;

$A = \{A_1, A_2, \dots, A_k\}$  - multitude of goals sets by the decision-maker as the desired state of the SPTPM subject, these goals should be systemic and determine the finiteness of many factors for analysis;

$V = \{V_1, V_2, \dots, V_m\}$  - set of formalized descriptions of the identified factors, when choosing a formalization method, one should take into account the possibility of reflecting the desired, acceptable, required level of manifestation of this factor in the SPTPM and/or its influence on the possibility of achieving the target state of the SPTPM subject;

$C(V)$  - function describing the principle of interaction of environmental factors to achieve the target state of the SPTPM subject;

$B = \{B_1, B_2, \dots, B_l\}$  - set of restrictions on the factors of SPTPM development (for example, legal, technological, financial, economic, etc.);

$X_d = \{X_{d_1}, X_{d_2}, \dots, X_{d_j}\}$  - set of assessments of the significance of the analyzed factors (their influence on the achievement of the target state of the SPTPM subject);

$X_c = \{X_{c_1}, X_{c_2}, \dots, X_{c_i}\}$  - set of assessments of the significance of combinations of SPTPM factors in terms of their influence on the achievement of the target state of the SPTPM subject;

K - criterion for choosing a set of preferred factors and their combinations;

F(f)- a function that determines the calculation of group expert assessments;

f- individual expert assessments;

$X_{rd} = \{X_{rd_1}, X_{rd_2}, \dots, X_{rd_o}\}$  - set of factors recommended as a basis for developing options for the actions of the SPTPM subject;

$X_{rc} = \{X_{rc_1}, X_{rc_2}, \dots, X_{rc_p}\}$  - set of combinations of environmental factors recommended as a basis for developing options for the actions of the SPTPM subject.

Then, taking into account (2), we will formulate the main tasks posed to the experts at the stage of analysis:

1. For the identified set of factors of the external and internal environment  $S = \{S_1, S_2, \dots, S_n\}$ , detailing the problem situation  $S_o$ , based on information about the goals of the SPTPM subject  $A = \{A_1, A_2, \dots, A_k\}$  and restrictions  $B = \{B_1, B_2, \dots, B_l\}$ , evaluate the desired (planned, required)  $V = \{V_1, V_2, \dots, V_m\}$  and actual  $X_d = \{X_{d_1}, X_{d_2}, \dots, X_{d_j}\}$  values of the analyzed factors in terms of their influence on achieving the target state of the SPTPM subject.

2. Establish their interrelationships and assess the importance of taking into account combinations of environmental factors in terms of their influence on the achievement of the target state of the SPTPM subject  $X_c = \{X_{c_1}, X_{c_2}, \dots, X_{c_i}\}$  based on the function  $C(V)$ .

3. On the basis of the selected criterion  $K$ , make a choice of environmental factors  $X_{r_d} = \{X_{r_{d_1}}, X_{r_{d_2}}, \dots, X_{r_{d_o}}\}$  and their combinations  $X_{r_d} = \{X_{r_{c_1}}, X_{r_{c_2}}, \dots, X_{r_{c_p}}\}$ , recommended as a basis for developing options for the actions of the SPTPM subject.

### **3.2. Typical model of the decision-making problem at the selection stage**

At the stage of selection, the decision-maker needs to evaluate and select the best options for the actions of the SPTPM subject in terms of their influence on the achievement of the target state of the SPTPM subject. At the same time, a distinctive feature of the task at this stage is the assessment of the impact that the rest of the SPTPM subjects and other stakeholders (acting forces) can have on the development plans of this SPTPM subject, as well as the impact that the projects implemented by this subject can have on achieving the goals of these stakeholders. The model of the decision-making problem at the stage of selection has the form (3).

$$\langle S_o, T, Q | S, A, B, C(S), P, V_s, V_A, V_p, K, F(f), L, P_r \rangle, \quad (3)$$

where  $S_o$  is the problem situation, the target state of the SPTPM subject, which must be achieved when implementing projects (options) for the development of the SPTPM subject;

$S = \{S_1, S_2, \dots, S_e\}$  - set of elements of the SPTPM environment (SPTPM and other subjects) influencing and interested in the implementation of development projects for the SPTPM subject (acting forces);

$A = \{A_1, A_2, \dots, A_k\}$  - multitude of goals set by the decision maker as the desired state of the SPTPM subject, as well as the goals of the acting forces;

$C(S)$  - function that characterizes the relationship and influence of individual elements on the achievement of the target state of the SPTPM subject,  $S_o$ ;

$P = \{P_1, P_2, \dots, P_l\}$  - set of alternative development projects for the SPTPM subject;

$V_s = \{V_{s_1}, V_{s_2}, \dots, V_{s_e}\}$  - set of assessments of the influence exerted by the acting forces of the SPTPM on solving the problem situation;

$V_A = \{V_{A_1}, V_{A_2}, \dots, V_{A_k}\}$  - set of assessments of the importance of the goals of the acting forces in the implementation of development projects of the SPTPM subject;

$V_p = \{V_{p_1}, V_{p_2}, \dots, V_{p_m}\}$  - set of assessments of the significance of alternative projects (options) for the development of the SPTPM subject;

$K$  - criterion for the selection of projects;

$P_r = \{P_{r_1}, P_{r_2}, \dots, P_{r_d}\}$  - set of recommended projects for the development of the SPTPM subject.

Then, taking into account (3), we formulate the main tasks posed to the experts at the stage of selection:

1. For a given set of acting SPTPM forces  $S = \{S_1, S_2, \dots, S_e\}$ , interested in achieving the target state of the

SPTPM subject  $S_o$ , based on the information about their goals in the implementation of the subject's projects  $A = \{A_1, A_2, \dots, A_k\}$  and restrictions  $B = \{B_1, B_2, \dots, B_t\}$ , using the function  $C(S)$  assess the impact  $V_s = \{V_{s_1}, V_{s_2}, \dots, V_{s_e}\}$  they have on achieving the target state of the subject  $S_o$ .

2. For each of the acting SPTPM forces  $S = \{S_1, S_2, \dots, S_e\}$ , assess the significance of each of the goals  $V_A = \{V_{A_1}, V_{A_2}, \dots, V_{A_k}\}$  in achieving the target state of the SPTPM subject  $S_o$ .

3. For the existing set of projects of the SPTPM subject  $P = \{P_1, P_2, \dots, P_l\}$ , assess the contribution  $V_p = \{V_{p_1}, V_{p_2}, \dots, V_{p_m}\}$  that each of the projects makes to the implementation of the goals of the acting forces  $A = \{A_1, A_2, \dots, A_k\}$ .

4. On the basis of the criterion  $K$ , select a set of recommended development projects for the SPTPM subject  $P_r = \{P_{r_1}, P_{r_2}, \dots, P_{r_d}\}$ .

### **3.3. A typical model of the decision-making problem at the control stage**

At the stage of control the decision maker needs to assess the degree of achievement of the selected targets of the SPTPM subject. The results of the assessment are used for the next management cycle, and, if necessary, adjustments to the activities implemented by the subject of the SOCM to achieve the target state. The model of the decision-making problem at the control stage has the form (4).

$$\langle S_o, T, Q | S, B, V, X_s, P, C(S), V_s, K, F(f), L \rangle \quad (4)$$

where  $S_o$  is the target state of the SPTPM subject;

$S = \{S_1, S_2, \dots, S_n\}$  - set of target landmarks of the SPTPM subject, selected as indicators of the implementation of activities and projects, and clarifying the target state;

$V = \{V_1, V_2, \dots, V_n\}$  - set of formalized descriptions of targets that characterize the desired (acceptable, required) level of manifestation of this indicator for the SPTPM M subject;

$B = \{B_1, B_2, \dots, B_k\}$  - set of restrictions on the values of targets;

$X_s = \{X_{s_1}, X_{s_2}, \dots, X_{s_n}\}$  - set of assessments characterizing the achieved level of targets of the SPTPM subject in a given period of time;

$P = \{P_1, P_2, \dots, P_l\}$  - time periods in which the assessment of the achievement of the target state is carried out;

$C(S)$  - function that sets the level of influence of individual targets on the achievement of a given target state of the SPTPM subject  $S_o$ ;

$V_s = \{V_{s_1}, V_{s_2}, \dots, V_{s_l}\}$  - set of assessments of the achievement of the target state of the SPTPM subject during periods  $P$ ;

$K$  - criterion for the interpretation of assessments of the achievement of the target state of the SPTPM subject.

Then, taking into account (4), we formulate the main tasks posed to the experts at the stage of selection:

1. For the existing set of target landmarks of the SPTPM subject  $S = \{S_1, S_2, \dots, S_n\}$ , characterizing the achievement of the target state  $S_o$ , taking into account the restrictions

$B = \{B_1, B_2, \dots, B_k\}$ , assess the desired (planned, required) values of target landmarks  $V = \{V_1, V_2, \dots, V_n\}$ .

2. Based on the set of assessments of the achieved level of target points of the SPTPM subject  $X_S = \{X_{S_1}, X_{S_2}, \dots, X_{S_n}\}$ , and the function  $C(S)$ , to assess the achievement of the target state of the SPTPM subject during periods  $P$ , that is, to give estimates  $V_s = \{V_{s_1}, V_{s_2}, \dots, V_{s_l}\}$ .

#### 4. CONCLUSIONS

As a result of the application of the methods of system analysis (decomposition/composition), standard models of decision-making problems in the system of priority training of personnel in a monotown, based on the use of expert knowledge, have been developed. As a result, all the variety

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