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MODELING OF LABOR POTENTIAL OF UKRAINE: FORMATION OF KNOWLEDGE BASE

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Abstract. *The adaptation of the Ukrainian economy to the requirements of the European Union requires increasing the effectiveness of the system of making public management decisions regarding the development and assessment of the labor potential of our country. Currently, a unified system of evaluation indicators of the labor potential of Ukraine has not yet been developed. The authors substantiated and systematized the groups of medico-demographic, socio-economic and educational factors that affect the health of the employed population, and suggested the use of the "preserving the health of the employed population" indicator for assessing the labor potential. Accordingly, a mathematical model for evaluating the health of the employed population at the macro level is proposed, which is based on the theory of fuzzy logic. The application of the proposed model will make it possible to increase the efficiency of the system of public management decision-making in the process of developing concepts, strategies, and practical measures for the implementation of policies for the preservation of the health of the employed population, as well as to make timely adjustments during implementation, which should positively reflect on the steady growth of the index human development (HDI).*

Keywords: labor potential, knowledge base, evaluation terms, factors, modeling, fuzzy logic

MODELOWANIE POTENCJAŁU SIŁY ROBOCZEJ UKRAINY: BUDOWANIE BAZY WIEDZY

Streszczenie*. Dostosowanie gospodarki ukraińskiej do wymogów Unii Europejskiej wymaga zwiększenia efektywności systemu podejmowania decyzji z zakresu zarządzania publicznego dotyczących rozwoju i oceny potencjału pracy kraju. Obecnie nie został jeszcze opracowany jednolity system wskaźników oceny potencjału pracy Ukrainy. Autorzy uzasadnili i usystematyzowali grupy medyczno-demograficznych, społeczno-ekonomicznych i edukacyjnych czynników, które wpływają na zdrowie populacji zatrudnionych, i zaproponowali wykorzystanie wskaźnika "zachowanie zdrowia populacji zatrudnionych" do oceny potencjału pracy. W związku z tym zaproponowano model matematyczny oceny stanu zdrowia populacji zatrudnionych na poziomie makro, który opiera się na teorii logiki rozmytej. Zastosowanie proponowanego modelu umożliwi zwiększenie efektywności systemu podejmowania decyzji w zarządzaniu publicznym w procesie opracowywania koncepcji, strategii i praktycznych środków realizacji polityki zachowania zdrowia populacji zatrudnionych, a także dokonywania terminowych korekt w trakcie realizacji, co powinno pozytywnie wpłynąć na stały wzrost wskaźnika rozwoju społecznego (HDI).*

Słowa kluczowe: potencjał pracy, baza wiedzy, warunki oceny, czynniki, modelowanie, logika rozmyta

Introduction

Despite the significant amount of research, a single system of evaluation indicators of labor potential of Ukraine has not yet been developed. labor potential should be understood as a set of quantitative and qualitative characteristics of the productive forces of the country, which are formed and developed in the social environment. Domestic scientists [1, 2, 10–17, 20, 21, 23, 24, 26] and many others consider the qualitative and quantitative characteristics of the economically active population to be labor potential.

Considering the structure of labor potential, domestic scientists identify the following main components, namely, professional, moral, demographic, educational, creative, social, intellectual, qualification, organizational, psychophysiological, natural-biological, organizational, communicative, personal, competence and others. Thus, in [1, 2, 10–17, 20, 21, 23, 24, 26] the structure of labor potential consists of the following interconnected subsystems: socio-economic, demographic and socio-psychological. In addition, the structure of labor potential has been thoroughly studied in scientific work [1, 2, 10–17, 20, 21, 23, 24, 26].

Comparative analysis and generalization of the existing methodological approaches to the assessment of labor potential of Ukraine convinces that both theoretically and methodologically it is necessary to conduct a deep meaningful assessment. Thus, the main components of labor potential were studied in [1, 12, 14, 23], and methodological aspects of labor potential assessment using qualitative and quantitative characteristics, in particular, applying the methods of mathematical modeling, attention were paid attention in [3–7].

The first step in creating such an assessment methodology should be the provision of clear understanding what elements, components, phenomena of labor potential development are subject to assessment, to create the notion regarding its real state in both functional and territorial terms. Numerous approaches are used in in the methodology and evaluation. But the most reliable, in our opinion, is the rating assessment. The essential component of the introduction of rating assessment in various areas is the calculation of the integrated indices as a basis for ranking. Integral assessment itself is becoming more common in measuring labor potential [3–7].

1. Formulation of the problem

Since the specific values of any index are usually not assessed in comparison with standards or other samples, such assessments do not actually measure the real situation, but its differentiation between regions and countries. As a result of calculations of integrated indices it is possible to estimate regional differences, but in itself such index is pointless. Without discarding the scientific and analytical value of such research, we will try to evaluate the tools of rating assessment [6, 7, 27].

Since only the information that allows the authorities and economic entities to make effective decisions is useful, ratings (as a tool for decision-making) should be part of certain information-analytical systems. In the absence of regulatory application of ratings, their only value lies in the reliability of the information they contain for potential investors, the government, including managers of budget funds. However, the situation changes if ratings determine the conditions under which budget funds can be allocated, benefits, investments, etc. are provided (in particular, credit ratings determine the conditions under which an investor can buy securities, obtain loans, etc.).

Assessing the adequacy of the level of development of labor potential should involve solving a number of theoretical and methodological issues:

- analysis of labor potential, carried out on the basis of opinion polls, which characterize the state of its development;
- assessment of compliance of actual indicators with current standards;
- comparison with sample indicies, which can be considered standards recommended by experts of international organizations (ILO, WHO, IBRD, UN projects, etc.) and adopted in the most developed socially oriented economies of the world. Conformity assessment of developed

countries can be done by comparing economic indicies such as employment growth, reducing unemployment, improving public health [8, 9, 25].

Therefore, it is necessary to build a new concept of labor potential assessment. We propose to make such an assessment based on the use of mathematical modeling methods, namely the theory of fuzzy sets. When assessing the rating of labor potential, a number of parameters are not available for accurate quantitative measurement, so a subjective component is introduced, which is expressed by fuzzy estimates such as "high", "low", "medium", etc. What appears in science is defined as a linguistic description and is set by the so-called membership functions of a fuzzy set factor.

2. Theoretical research

In order to create an expert modeling system for multifactor analysis of labor potential assessment (R), we used a mathematical apparatus based on the theory of fuzzy logic, which was studied by well-known scientists [3, 22].

The generalized algorithm for estimating R Ukraine is the follows:

- construction of a logical conclusion tree, which will determine the sequence of further calculations;
- fuzzification of the Input variables. A term set is defined to evaluate each variable and the membership functions of each term are built on a discrete universal set. Using these functions and forming knowledge bases, we obtain analytical models of membership functions of terms and setting fuzzy knowledge bases for the corresponding relations, as well as the values of all input variables;
- calculation of values of membership functions of terms – estimates for all variables, and, according to the constructed logical equations, values of membership functions for all nonterminal vertices;
- calculation of the values of membership functions for the terms of a complex indicator of labor potential assessment and by defuzzification of the fuzzy set of determining the rank of labor potential.

Linguistic statements should correspond to the obtained fuzzy logical equations at the appropriate hierarchical level: system (R) and the proposed factors that bound the membership functions of input and output variables, due to the use in their construction operations "max" and "min". That is, the logical operations "I" (∧) and "OR" (∨). Over the membership functions are replaced by the operations "max" and "min" [18, 19]:

$$\mu_{(a)} \wedge \mu_{(b)} = \min [\mu_{(a)}, \mu_{(b)}];$$
$$\mu_{(a)} \vee \mu_{(b)} = \max [\mu_{(a)}, \mu_{(b)}].$$

The considered algorithm uses the idea of identification of a linguistic term by the maximum of the membership function and generalizes this idea to the whole matrix of knowledge. Using membership functions and corresponding formulas, we find analytical models of membership functions of estimates of the input variables for all the terms. Since there are cases when the maximum membership functions are the same for two adjacent terms and this complicates the ranking of projects, for greater clarity it is proposed to consider the interval of changes of the input parameter R as continuous and rank projects on a given scale [D^1: D_2]. To obtain a clear number that corresponds to the rank of the project, in this interval you need to use the operation of the defuzzification, i.e. the operation of converting fuzzy information into clear or quantitative.

The calculation of the fuzzy logical set D^* is given in [18]. According to the principle of the center of gravity, defuzzification of the fuzzy set gives a quantitative estimate of D^* – the rank of the complex estimate R for given input factors (1).

$$D^* = (R^*) = \sum \left[D_2 + (i-1)\frac{D^1 - D_2}{m-1} \right] \mu^{u_i}(D) \Bigg/ \sum_{i=1}^{m} \mu^{u_i}(D) \quad (1)$$

where m is the number of terms of the variable D;
D^1, D_2 − lower and upper limits of the range of variable D;
$\mu^{ui}(D)$ is a function of belonging of variable D to fuzzy term u_i.

3. Experimental research

The source of knowledge base, which models the relationship between integrated and individual indicies of labor potential rating (R), are the opinions of experts, specializing in this field. The peculiarity of expressions such as "if – then, otherwise", which are formulated in natural language, is that their adequacy, unlike the quantitative models, does not change with slight fluctuations in input estimates in one direction or another. The set of such statements is a set of points in the space "individual criteria – an integral criterion". The integral criterion is evaluated by fixed linguistic estimates of individual criteria R.

Expert evaluation is formalized in the form of answers to the questions of the expert questionnaire and provides the following options for the final expert opinion (we give the example of evaluation R): d1 (or the value falls in the interval [15, 16, 21]) − labor potential is quite low; d2 (value of the interval [16, 20]) − the level of labor potential can be assessed as average; d3 (the value lies in the interval [20, 24]) − labor potential is used effectively and there are prospects for its further growth. We will consider in more detail the specific parameters of the proposed model and give the composition of factors that should be determined when estimating R, that depends, in our opinion, on the following factors:

$$R = f_r = (X, Y, Z) \quad (2)$$

where: X − medical and demographic factors; Y – socio-economic factors of influence; Z − educational factors.

Medico-demographic factors can be presented as follows:

$$X = f_x(x_1, x_2, x_3, x_4, x_5, x_6) \quad (3)$$

where: x_1 − the share of persons in epy working age, %;
x_2 − the level of occupational injuries per 100 thousand employees;
x_3 − the level of occupational injuries with a fatal outcome per 100 thousand workers, %;
x_4 − the level of occupational disease per 100 thousand employees;
x_5 − the share of employees who work in conditions that do not meet sanitary and hygienic standards, in the average number of registered personnel (ANRP), %;
x_6 − the proportion of employees who were absent from work due to illness in ANRP, %.

Socio-economic factors of impact can be written as:

$$Y = f_y(y_1, y_2, y_3, y_4, y_5, y_6, y_7, y_8) \quad (4)$$

where:
y_1 is the level of employment (population aged 16–59 years, %);
y_2 − the level of registered unemployment, %;
y_3 − turnover ratio in connection with the release, %;
y_4 − workload per vacancy, %;
y_5 − average duration of unemployment, months;
y_6 − the share of funds of the Social Insurance Fund in case of unemployment, which are directed to the active employment policy, %;
y_7 − level of forced under employment, %;
y_8 − loss of working time, %.

Educational factors of influence are written in the form:

$$Z = f_z(z_1, z_2) \quad (5)$$

where z_1 is the share of persons who have improved their skills (in % to ANRP); z_2 − share of employees with higher education in% to ANRP.

Estimates of the values of linguistic variables given in relations (2–5) are performed using a system of qualitative terms, the number of which for each individual variable may be different, for example, for variable x_1 – „*Specific weight of people of working age*" (with universal set from 15–75% − the terms for evaluation are: „Low" (L), „Below average" (BA), „Medium" (M).

The tree of the logical conclusion of the hierarchical connections of the factors that allow to assess R is shown in Fig. 1, where the root of the tree is R, and the leaves, respectively, are the factors influencing this rating: medical-demographic, socio-economic and educational factors.

To compile fuzzy logical equations, knowledge bases are set (table 1−4) in the form of expert statements about the connections of fuzzy terms of input and output linguistic variables in the ratios (2−5).

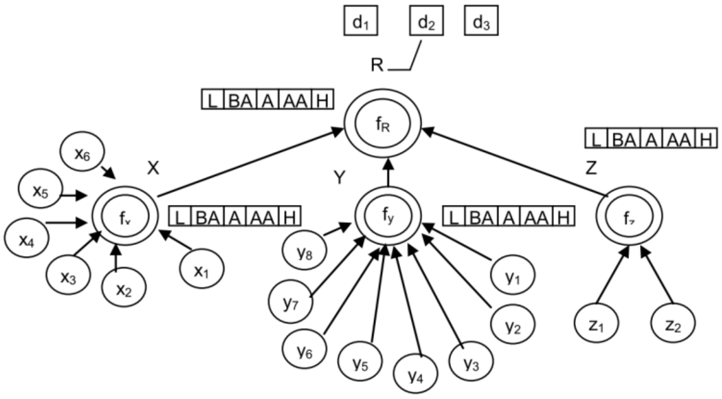

Fig. 1. Tree of logical conclusion of hierarchical connections of the factors, where L, BA, A, AA, H − terms for assessment (respectively: L – "low level", BA – "below average level", A – "average level", AA – "above average level", H – "high level")

Table 1. Knowledge bases and systems of fuzzy logical equations for the dependence 2

IF			THEN
Medico-demographic factors of influence (X)	Socio-economic factors of influence (Y)	Educational factors of influence (Z)	Rating of labor potential of Ukraine (R)
Low (L)	Low (L)	Low (L)	Low (L)
Low (L)	Low (L)	Lower average (LA)	
Low (L)	Lower average (LA)	Lower average (LA)	
Lower average (LA)	Lower average (LA)	Lower average (LA)	Lower average (LA)
Lower average (LA)	Lower average (LA)	Lower average (LA)	
Lower average (LA)	Lower average (LA)	Average (A)	
Lower average (LA)	Average (A)	Average (A)	Average (A)
Average (A)	Average (A)	Average (A)	
Average (A)	Above average (AA)	Above average (AA)	
Average (A)	Above average (AA)	Above average (AA)	Above average (AA)
Average (A)	Above average (AA)	Above average (AA)	
Above average (AA)	Above average (AA)	Above average (AA)	
Above average (AA)	Above average (AA)	Above average (AA)	High (H)
Above average (AA)	High (H)	High (H)	
High (H)	High (H)	High (H)	

Source: author's calculations.

System of fuzzy logical equations based on knowledge base (table 1):

$\mu_L(R) = \mu_{Lx} \wedge \mu_{Ly} \wedge \mu_{Lz} \vee \mu_{Lx} \wedge \mu_{Ly} \wedge \mu_{Baz} \vee \mu_{Lx} \wedge \mu_{Bay} \wedge \mu_{Baz};$

$\mu_{BA}(R) = \mu_{BAx} \wedge \mu_{Bay} \wedge \mu_{Baz} \vee \mu_{BAx} \wedge \mu_{Bay} \wedge \mu_{Baz} \vee \mu_{BAx} \wedge \mu_{Bay} \wedge \mu_{Az};$

$\mu_A(R) = \mu_{BAx} \wedge \mu_{Ay} \wedge \mu_{Az} \vee \mu_{Ax} \wedge \mu_{Ay} \wedge \mu_{Az} \vee \mu_{Ax} \wedge \mu_{AAy} \wedge \mu_{AAz};$

$\mu_{AA}(R) = \mu_{Ax} \wedge \mu_{AAy} \wedge \mu_{AAz} \vee \mu_{Ax} \wedge \mu_{AAy} \wedge \mu_{AAz} \vee \mu_{AAx} \wedge \mu_{AAy} \wedge \mu_{AAz};$

$\mu_H(R) = \mu_{AAx} \wedge \mu_{AAy} \wedge \mu_{AAz} \vee \mu_{AAx} \wedge \mu_{Hy} \wedge \mu_{Hz} \vee \mu_{Hx} \wedge \mu_{Hy} \wedge \mu_{Hz}.$

Table 2. Knowledge bases and systems of fuzzy logical equations for the dependence 3

IF						THEN
Specific weight of working age persons, %, (x1)	The level of occupational injuries per 100 thousand employees, % (x2)	The level of occupational injuries with fatal consequences per 100 thousand employees, (x3)	The level of occupational disease per 100 thousand employees, % (x4)	The share of employees working in conditions that do not meet sanitary and hygienic standards in the average number of employees, %, (x5)	Proportion of employees who were absent from work due to illness in ANRP %, (x6)	Medical and demographic factors of influence, (X)
Low (L)	Above average (AA)	High (H)	High (H)	High (H)	High (H)	Low (L)
Low (L)	Above average (AA)	High (H)	High (H)	High (H)	High (H)	
Lower average (LA)	Above average (AA)	High (H)	High (H)	High (H)	High (H)	
Lower average (LA)	Above average (AA)	High (H)	High (H)	High (H)	High (H)	Lower average (LA)
Lower average (LA)	Above average (AA)	High (H)	High (H)	High (H)	High (H)	
Average (A)	Above average (AA	High (H)	High (H)	High (H)	High (H)	
Average(A)	Average (A)	High (H)	High (H)	High (H)	High (H)	Average (A)
Average (A)	Average (A)	Average (A)	Average (A)	High (H)	High (H)	
Above average (AA)	Average (A)	Average (A)	Average (A)	Average(A)	Average (A)	
Above average (AA)	Lower average (LA)	Average (A)	Low (L)	Average (A)	Low (L)	Above average (AA)
Above average (AA)	Lower average (LA)	Low (L)	Low (L)	Average (A)	Low (L)	
High (H)	Lower average (LA)	Low (L)	Low (L)	Low (L)	Low (L)	
High (H)	Low (L)	Low (L)	Low (L)	Low (L)	Low (L)	High(H)
High (H)	Low (L)	Low (L)	Low (L)	Low (L)	Low (L)	
High (H)	Low (L)	Low (L)	Low (L)	Low (L)	Low (L)	

Source: author's calculations.

System of fuzzy logical equations based on knowledge base (table 2):

$\mu_L(X) = \mu_{L(x1)} \wedge \mu_{AA(x2)} \wedge \mu_{H(x3)} \wedge \mu_{H(x4)} \wedge \mu_{H(x5)} \wedge \mu_{H(x6)} \vee \mu_{L(x1)} \wedge \mu_{AA(x2)} \wedge \mu_{H(x3)} \wedge \mu_{H(x4)} \wedge \mu_{H(x5)} \wedge \mu_{H(x6)} \vee$
$\mu_{BA(x1)} \wedge \mu_{AA(x2)} \wedge \mu_{H\,(x3)} \wedge \mu_{H(x4)} \wedge \mu_{H(x5)} \wedge \mu_{H(x6)};$
$\mu_{BA}(X) = \mu_{BA(x1)} \wedge \mu_{AA(x2)} \wedge \mu_{H(x3)} \wedge \mu_{H(x4)} \wedge \mu_{H(x5)} \wedge \mu_{H(x6)} \vee \mu_{BA(x1)} \wedge \mu_{AA(x2)} \wedge \mu_{H(x3)} \wedge \mu_{H(x4)} \wedge \mu_{H(x5)} \wedge \mu_{H(x6)} \vee$
$\mu_{A(x1)} \wedge \mu_{AA(x2)} \wedge \mu_{H(x3)} \wedge \mu_{H(x4)} \wedge \mu_{H(x5)} \wedge \mu_{H(x6)};$
$\mu_A(X) = \mu_{A(x1)} \wedge \mu_{A(x2)} \wedge \mu_{H(x3)} \wedge \mu_{H(x4)} \wedge \mu_{H(x5)} \wedge \mu_{H(x6)} \vee \mu_{A(x1)} \wedge \mu_{A(x2)} \wedge \mu_{A(x3)} \wedge \mu_{A(x4)} \wedge \mu_{H(x5)} \wedge \mu_{H(x6)} \vee$
$\mu_{AA(x1)} \wedge \mu_{A(x2)} \wedge \mu_{A(x3)} \wedge \mu_{A(x4)} \wedge \mu_{A(x5)} \wedge \mu_{A(x6)};$
$\mu_{AA}(X) = \mu_{AA(x1)} \wedge \mu_{BA(x2)} \wedge \mu_{A(x3)} \wedge \mu_{L(x4)} \wedge \mu_{A(x5)} \wedge \mu_{L(x6)} \vee \mu_{AA(x1)} \wedge \mu_{BA(x2)} \wedge \mu_{L(x3)} \wedge \mu_{L(x4)} \wedge \mu_{A(x5)} \wedge \mu_{L(x6)} \vee$
$\mu_{H(x1)} \wedge \mu_{BA(x2)} \wedge \mu_{L(x3)} \wedge \mu_{L(x4)} \wedge \mu_{L(x5)} \wedge \mu_{L(x6)};$
$\mu_H(X) = \mu_{H(x1)} \wedge \mu_{L(x2)} \wedge \mu_{L(x3)} \wedge \mu_{L(x4)} \wedge \mu_{L(x5)} \wedge \mu_{L(x6)} \vee \mu_{H(x1)} \wedge \mu_{L(x2)} \wedge \mu_{L(x3)} \wedge \mu_{L(x4)} \wedge \mu_{L(x5)} \wedge \mu_{L(x6)} \vee$
$\mu_{H(x1)} \wedge \mu_{L(x2)} \wedge \mu_{L(x3)} \wedge \mu_{L(x4)} \wedge \mu_{L(x5)} \wedge \mu_{L(x6)}.$

Table 3. Knowledge bases and systems of fuzzy logical equations for the dependence 4

IF								THEN
Employment rate (% of the population aged 16−59),%, (y1)	Registered unemployment rate, %, (y2)	Turnover ratio, %, (y3)	Load per vacancy (vacancy), % (y4)	Average duration of unemployment, months, (y5)	Share of the Fund's funds in case of unemployment for active employment policy, %, (y6)	Level of forced underemployment, %, (y7)	Loss of working time, %, (y8)	Socio-economic factors
Low (L)	High (H)	High (H)	High (H)	Above average (AA)	Low (L)	High (H)	High (H)	Low (L)
Low (L)	High (H)	Above average (AA)	High (H)	Above average (AA)	Low (L)	High (H)	High (H)	
Low (L)	Above average (AA)	Above average (AA)	High (H)	Above average (AA)	Low (L)	High (H)	High (H)	
Low (L)	Above average (AA)	Above average (AA)	Above average (AA)	Above average (AA)	Low (L)	High (H)	High (H)	Lower average (LA)
Lower average (LA)	Above average (AA)	Above average (AA)	Above average (AA)	Above average (AA)	Average (A)	High (H)	Average (A)	
Lower average (LA)	Above average (AA)	Average(A)	Above average (AA)	Above average (AA)	Average (A)	High (H)	Average (A)	
Lower average (LA)	Average (A)	Average (A)	Average (A)	Above average (AA)	Average (A)	High (H)	Average (A)	Average (A)
Average (A)	Average(A)	Average (A)	Average (A)	Average(A)	Average (A)	Average (A)	Average (A)	
Average (A)	Lower average (LA)	Lower average (LA)	Average (A)	Average (A)	Average (A)	Average (A)	Average (A)	
Average (A)	Lower average (LA)	Lower average (LA)	Average(A)	Average (A)	Average (A)	Average (A)	Average (A)	Above average (AA)
Average (A)	Lower average (LA)	Lower average (LA)	Lower average (LA)	Lower average (LA)	Average (A)	Low (L)	Low (L)	
Above average (AA)	Lower average (LA)	Lower average (LA)	Lower average (LA)	Lower average (LA)	High (H)	Low (L)	Low (L)	
Above average (AA)	Lower average (LA)	Lower average (LA)	Lower average (LA)	Low (L)	High (H)	Low (L)	Low (L)	High (H)
Above average (AA)	Low (L)	Low (L)	Low (L)	Low (L)	High (H)	Low (L)	Low (L)	
High (H)	Low (L)	Low (L)	Low (L)	Low (L)	High (H)	Low (L)	Low (L)	

Source: author's calculations.

System of fuzzy logical equations based on knowledge base (table 3):

$\mu_L(\text{У}) = \mu_{L(y1)} \wedge \mu_{H(y2)} \wedge \mu_{H(y3)} \wedge \mu_{H(y4)} \wedge \mu_{AA(y5)} \wedge \mu_{L(y6)} \wedge \mu_{L(y7)} \wedge \mu_{H(y8)} \vee$
$\mu_{L\,(y1)} \wedge \mu_{H(y2)} \wedge \mu_{AA(y3)} \wedge \mu_{H(y4)} \wedge \mu_{AA(y5)} \wedge \mu_{L(y6)} \wedge \mu_{H(y7)} \wedge \mu_{H(y8)} \vee \mu_{L(y1)} \wedge \mu_{AA(y2)} \wedge \mu_{AA(y3)} \wedge \mu_{H(y4)} \wedge \mu_{AA(y5)} \wedge \mu_{L(y6)} \wedge \mu_{H(y7)} \wedge \mu_{H(y8)};$
$\mu_{BA}(\text{У}) = \mu_{L(y1)} \wedge \mu_{AA(y2)} \wedge \mu_{AA(y3)} \wedge \mu_{AA(y4)} \wedge \mu_{AA(y5)} \wedge \mu_{L(y6)} \wedge \mu_{H(y7)} \wedge \mu_{H(y8)} \vee$
$\mu_{BA(y1)} \wedge \mu_{AA(y2)} \wedge \mu_{AA(y3)} \wedge \mu_{AA(y4)} \wedge \mu_{AA(y5)} \wedge \mu_{A(y6)} \wedge \mu_{H(y7)} \wedge \mu_{A(y8)} \vee \mu_{BA(y1)} \wedge \mu_{AA(y2)} \wedge \mu_{A(y3)} \wedge \mu_{AA(y4)} \wedge \mu_{AA(y5)} \wedge \mu_{A(y6)} \wedge \mu_{H(y7)} \wedge \mu_{A(y8)};$
$\mu_A(\text{У}) = \mu_{BA(y1)} \wedge \mu_{A(y2)} \wedge \mu_{A(y3)} \wedge \mu_{A(y4)} \wedge \mu_{AA(y5)} \wedge \mu_{A(y6)} \wedge \mu_{H(y7)} \wedge \mu_{A(y)} \vee$
$\mu_{A(y1)} \wedge \mu_{A(y2)} \wedge \mu_{A(y3)} \wedge \mu_{A(y4)} \wedge \mu_{A(y5)} \wedge \mu_{A(y6)} \wedge \mu_{A(y7)} \wedge \mu_{A(y8)} \vee \mu_{A(y1)} \wedge \mu_{BA(y2)} \wedge \mu_{BA(y3)} \wedge \mu_{A(y4)} \wedge \mu_{A(y5)} \wedge \mu_{A(y6)} \wedge \mu_{A(y7)} \wedge \mu_{A(y8)};$
$\mu_{AA}(\text{У}) = \mu_{A(y1)} \wedge \mu_{BA(y2)} \wedge \mu_{BA(y3)} \wedge \mu_{A(y4)} \wedge \mu_{A(y5)} \wedge \mu_{A(y6)} \wedge \mu_{A(y7)} \wedge \mu_{A(y8)} \vee$
$\mu_{A(y1)} \wedge \mu_{BA(y2)} \wedge \mu_{BA(y3)} \wedge \mu_{BA(y4)} \wedge \mu_{BA(y5)} \wedge \mu_{A(y6)} \wedge \mu_{L(y7)} \wedge \mu_{L(y8)} \vee \mu_{AA(y1)} \wedge \mu_{BA(y)} \wedge \mu_{BA(y3)} \wedge \mu_{BA(y4)} \wedge \mu_{BA(y5)} \wedge \mu_{H(y6)} \wedge \mu_{L(y7)} \wedge \mu_{L(y8)};$
$\mu_H(\text{У}) = \mu_{AA(y1)} \wedge \mu_{BA(y2)} \wedge \mu_{BA(y3)} \wedge \mu_{BA(y4)} \wedge \mu_{L(y5)} \wedge \mu_{H(y6)} \wedge \mu_{L(y7)} \wedge \mu_{L(y8)} \vee$
$\mu_{AA(y1)} \wedge \mu_{L(y2)} \wedge \mu_{L(y3)} \wedge \mu_{L(y4)} \wedge \mu_{L(y5)} \wedge \mu_{H(y6)} \wedge \mu_{L(y7)} \wedge \mu_{L(y8)} \vee \mu_{H(y1)} \wedge \mu_{L(y2)} \wedge \mu_{L(y3)} \wedge \mu_{L(y4)} \wedge \mu_{L(y5)} \wedge \mu_{H(y6)} \wedge \mu_{L(y7)} \wedge \mu_{L(y8)}.$

Table 4. Knowledge bases and systems of fuzzy logical equations for the dependence 5

IF		THEN
Proportion of % who improved their skills (in % to ANRP), (z1)	Share of employees with higher education (in % to ANRP), (z2)	Educational factors
Low (L)	Low (L)	Low (L)
Low (L)	Low (L)	
Low (L)	Low (L)	
Low (L)	Low (L)	Lower average (LA)
Average (A)	Low (L)	
Average (A)	Low (L)	
Average (A)	Average (A)	Average (A)
Average (A)	High (H)	
Average (A)	High (H)	
Average (A)	High (H)	Above average (AA)
High (H)	High (H)	
High (H)	High (H)	
High (H)	High (H)	High (H)
High (H)	High (H)	
High (H)	High (H)	

Source: author's calculations.

System of fuzzy logical equations based on knowledge base (table 4):

$\mu_L(Z) = \mu_{L(z1)} \wedge \mu_{L(z2)} \vee \mu_{L(z1)} \wedge \mu_{L(z2)} \vee \mu_{L(z1)} \wedge \mu_{L(z2)};$

$\mu_{BA}(Z) = \mu_{L(z1)} \wedge \mu_{L(z2)} \vee \mu_{A(z1)} \wedge \mu_{L(z2)} \vee \mu_{A(z1)} \wedge \mu_{L(z2)};$

$\mu_A(Z) = \mu_{A(z1)} \wedge \mu_{L(z2)} \vee \mu_{A(z1)} \wedge \mu_{A(z2)} \vee \mu_{A(z1)} \wedge \mu_{H(z2)};$

$\mu_{AA}(Z) = \mu_{A(z1)} \wedge \mu_{H(z2)} \vee \mu_{H(z1)} \wedge \mu_{H(z2)} \vee \mu_{H(z1)} \wedge \mu_{H(z2)};$

$\mu_H(Z) = \mu_{H(z1)} \wedge \mu_{H(z2)} \vee \mu_{H(z1)} \wedge \mu_{H(z2)} \vee \mu_{H(z1)} \wedge \mu_{H(z2)}.$

4. Conclusion

The analysis of scientific works on the definition of the structure and main components of the labor potential and the methodology of its assessment using the use of qualitative and quantitative characteristics and the application of mathematical modeling methods was carried out. Based on the results of research, the groups of demographic, socio-economic and educational factors that have the main influence on the health of the employed population have been substantiated and systematized. The need for the application of mathematical modeling is argued and a mathematical multifactorial model is built for the analysis and evaluation of indicators of health preservation of the employed population at the macro level using a mathematical apparatus based on the theory of fuzzy sets. This creates opportunities for increasing the effectiveness of the system of making public management decisions in the process of developing concepts, strategies, and practical measures to ensure opportunities for the employed population to live a long and healthy life, in particular working, to acquire, expand and update knowledge throughout life in the system of professional education and have access to decent working conditions and wages; and also to make timely adjustments during their implementation, which should be positively reflected in the steady growth of the human development index (HDI): increase in life expectancy, improvement in the quality of education, growth in real GDP per capita.

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