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Розглядаються питання підтримки прийняття рішень при розробці плану розвитку вузу. Це важливо, тому що сучасні тенденції розвитку організації вищої освіти постійно змінюються і ускладнюються. Управління організацією в сучасних умовах стає адаптивним, випереджувальним, стратегічним, що вимагає перегляду інструментів управління. Основою стратегічного планування виступає індикативне планування, яке в свою чергу є формою, вирішальною проблему недосконалої інформації через показники, що описують об'єкт, процес або явище. Ефективне управління діяльністю вищого навчального закладу в рамках планування включає форми і методи формування системи показників, що відображають картину стану організації.

Процес розробки плану розвитку університету стикається з проблемою вибору і ранжирування показників розвитку вищого навчального закладу, охоплює як матеріальні, так і нематеріальні сторони і є багатокритеріальної завданням прийняття рішень. Для вирішення цього завдання необхідно вибрати метод для підтримки прийняття рішень для формування системи індикативних показників. Оцінювання індикативних показників здійснюється через побудову когнітивної карти, апріорного ранжирування і методу аналізу ієрархій із залученням експертів зі сфери управління вищою освітою. Отримані результати порівнюються з урахуванням переваг і недоліків обраних методів. Прийняте рішення щодо вибору методу формування показників полягає в спільному використанні методу аналізу ієрархій та побудові когнітивної карти. При гібридному застосуванні методів враховується взаємний вплив показників і відповідність показників напрямками розвитку університету. Апріорне ранжування для формування показників застосовувати недоцільно, так як відсутні дані про спільне вплив один на одного декількох досліджуваних показників.

Результати дослідження спрямовані на спрощення процесу прийняття рішень в плануванні: облік вузьких місць при розробці плану розвитку, підвищення якості роботи і навчання, ефективне використання матеріальних і нематеріальних ресурсів

Ключові слова: оцінка, система, показник, управління, стратегія, розвиток, ієрархія, когнітивна карта, рішення

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DEVELOPMENT OF A DECISION-MAKING METHOD TO FORM THE INDICATORS FOR A UNIVERSITY DEVELOPMENT PLAN

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1. Introduction

The problems related to ensuring the quality of higher education and sustainable development of regional higher educational establishments of the Republic of Kazakhstan are becoming more relevant. The lack of marketing research into local labor markets, reliable forecasts of the state of external environment for a regional university is accompanied by non-coordinated numerous units of universities in the formation of tasks and activities. Ambiguous assessment of

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the current situation due to subjectivity, inaccuracy or information distortion lead to the idea of having to use modern methods and tools in the process of planning the activities of a university. That is why the problem of the formation of planning indicators [1], which would reflect the picture of the state of a university and enhance the quality of the management of the regional education system, is important and relevant today.

The market of educational services implies the use of the strategic approaches in the system of management of higher education institutions. To date, all higher educational establishments of Kazakhstan introduced strategic management through the designed strategic plans and programs of social development [2]. For the most part, they include medium-term strategic indicative plans designed for a period of three to five years, containing specific objectives and describing their indicators, as well as the planned activities to achieve the indicative indicators. Strategic planning covers the period, at the end of which it is possible to update the trends of development, for example, under the influence of changes of the requirements of external environment, behavior of competitors, the situation in a region or in a country in general. The changing needs of the society, technological progress and market conditions, academic freedom of universities are all important and relevant factor to refine, improve and update the plans of universities development [3, 4]. Monitoring and control of attaining strategic objectives directly depend on the degree of achievement of planned indicators.

2. Literature review and problem statement

Modern studies propose a variety of approaches to form a system of performance indicators of enterprises.

Most of the procedures were developed for financial institutions and are based on financial analysis. Paper [5] estimated the procedures of development of the procedure based on the analysis of financial-economic activity of organizations [6, 7], the method of A. Pismarov [8], the system of balanced indicators "MAG Consulting" [9], etc. A plenty of merits of this procedure were identified: availability of financial and non-financial indicators in the system, relation of indicators operational efficiency to a strategy, integrated characteristic of an activity by 4 prospects and so on. The following shortcomings were pointed out: incomplete study of causal relationships, lack of indicators' balance in the system, lack of the relation to the strategy, etc. Bearing in mind the identified shortcomings, as well as general aiming of the methods at the construction of indicators related to a greater extent to the economic (financial) efficiency – these procedures are not suitable for the formation of indicators of development of the socio-economic system of a university. The effectiveness of a university can be measured not only by the financial component, it is also necessary to determine indicators of the educational, scientific and international activities.

One of the first papers related to the study of the structure of the indicators for a university [10], focuses on a comparative analysis of the balanced system of indicators of four institutions of higher education. It is proposed to use the results as a basis for the development of the overall structure of the balanced system of indicators in higher educational establishments. However, the methods and techniques used to develop a system of indicators were not covered.

In study [11], the traditional approach to the formation of the indicators of development was supplemented only with theoretical study of the advantages of the management model by stakeholders.

Article [12] examines the existence of missions and strategic development plans in Ukrainian universities. It was found that the most common mistakes when developing a strategy include the lack of quantitative indicators, the use of very small indicators that are operational and local in nature. This work deals with the problems of indicators of a development plan, but the information has a general exploratory character.

The economic-mathematical model, the objective function of which is an integrated indicator that takes into account the degree of attainment of strategic objectives by structural subdivisions of a university, was studied in [13]. The solution to the model was found numerically using the developed software and is an action plan in the field of human capital of development of structural subdivisions of a university.

The development of two quantitative innovation indicators and the indicators related to them are explored in paper [14]. This study draws new indicators and indicators for comparing innovations between universities, industry and the state. Article [15] deals with the creation of benchmarking indicators for employees' job satisfaction using a large sample of various industrial and professional sectors. The study provides comparative data for researchers and practitioners in the diagnosis and strategic planning initiatives, as well as in improvement of the development plans.

At the University of Cienfuegos, the methodology of the development of strategic control indicators for harmonization of management and a strategy was applied [16]. Results [13–16] were applicable for the stages, following the formation of indicators of the development plan – for diagnosis, control, and improvement of the development plans.

The development of a result-oriented information-analytical system of control of management of the scientific and educational activities of the university is presented in [17]. The concept is based on the methodology of indicative planning in the university scientific and educational activities and is represented in the form of formalized procedures. Special attention is paid to the system of indicators, their formalization and algorithms for designing the analytics of functioning of the educational system. The model includes indicators that are consistent with the university's orientation plans. In this work, indicators are considered only as input parameters of the information system "Indicative planning".

Analysis of publications shows that a large number of methods and mechanisms directed to implementation and formation of different stages of strategic planning in higher educational establishments were developed. Starting with analysis of external and internal environment, they cover selection, design, implementation of strategies and scenarios, evaluation and control over planning. There remain the gaps in the choice of the methods for formation of development indicators for the university. In addition, analysis and performance assessment for any university are individual and should take into consideration the institution specifics.

3. The aim and objectives of the study

The aim of this study is to choose the method for decision making support in the development of a university

development plan, in particular, in formation of the system of indicative indicators.

To achieve the aim, the following tasks were set:

– to substantiate the main decision-making criteria in the formation of the indicators of the university development plan;

– to offer the method for making a decision on the formation of indicative indicators of the university development plan.

4. Methodological principles of the formation of indicative indicators of the university development plan

In terms of the set goals, one can distinguish the following types of indicative plans: marketing, structural and strategic; relatively to the development horizon: strategic long-term, strategic medium-term, the current short-term plans.

Most universities of Kazakhstan develop medium-term strategic development plans, on average for 5 years, which include certain missions, goals and objectives of a university [17]. According to the same study, the main methods used for the development of a strategic plan are 88.6 % of SWOT-analysis and 27.3 % of PEST analysis. The following stages of strategic planning, as well as methods and models recommended for the development and implementation of each of the stages, are distinguished (Table 1).

Table 1

Systems of methods for designing strategic plans

Implemented stage	System of recommended methods
analysis of internal, external University environment	SWOT, PEST, competitive, comparative analyses, analysis of resources
determining the mission and the aims of the university	brain storm, target tree
choice of strategies and scenarios	method by the Boston Consulting Group, McKinsey method, method of product life cycle, portfolio analysis
development of the basic strategy	I. Ansoff model, G. Steiner model, quality deployment of plans
strategy implementation	method of network planning, work sharing method
formation of the system of indicators	system of balanced indicators, financial analysis
assessment and control of strategy implementation	strategic audit, diagnostic self-assessment

The basis for the development of indicative plans includes indicators that allow describing the processes and phenomena, generate and substantiate the tasks for a specified period. Generation of indicators for a higher education institution through the proposed methods is difficult, because the specifics of the organization are not considered. For effective management of the activity of a higher educational institution in the framework of planning, it is necessary to consider the forms and the methods for the formation of a system of indicators that would reflect the full picture of the state of a university, the effectiveness of which lies not in the economic, but rather in the educational and scientific research activities.

An indicator is a quantitative-qualitative representation of a process, an object or a phenomenon. The quantitative side reflects quantitative certainty, whereas the qualitative side shows the essence and belonging of an object to the time and place in a plan. When developing the target indicators, a system of indicators that are interrelated and supplement each other, rather than a separate indicator are determined. Basically, it is required that the system of indicators should reveal the essence of an object, a process and a phenomena, reflect the features of an object, meet the development goals and objectives, focus on the effective use of resources, have methodological unity and the possibility of comparison with the indicators of accounting and statistics.

Principles of formation of the indicators of the university development plan:

1. Comprehensiveness. A higher education institution is considered as a system, the indicators should reflect the situation in all spheres of activity, at the same time should be interrelated describing various aspects.

2. Completeness. Reflection of the widest possible spectrum of phenomena and processes taking place both in internal and external university environment.

3. Simplicity. Limitation of the number of indicators to the most important for operative monitoring and control of execution, at the same time, the informative value of the plan should not be lost.

4. Comparability across time and space, unambiguity. Indicators should be comparable in the time horizon, tracked in dynamics, comparable with the indicators of programs and plans of higher levels.

5. Decision-making method for the formation of indicators of the university development plan

Formation of indicators of the university development plan is based on a set of indicators proposed by the structural divisions of a university (Table 2).

Table 2

A set of assessed indicators

Code	Indicator
1	2
C_1	Share of university graduates, taught by the state order, employed according to speciality within the first year after graduation
C_2	Number of foreign students, including those who were taught on a fee-paying basis
C_3	Academic and teaching staff (ATS) having Master's degree
C_4	Academic and teaching staff (ATS) having a scientific degree
C_5	Share of ATS involved in production
C_6	Share of ATS and employers who have upgraded their qualification
C_7	Number of ATS members invited from abroad
C_8	Number of university ATS members

Continuation of Table 2

1	2
C_9	Students' body
C_{10}	The body of Master students and doctoral students
C_{11}	Admission to Bachelor's programs
C_{12}	Admission to Master's programs
C_{13}	Admission to Doctor of sciences program
C_{14}	Number of educational programs in English
C_{15}	Number of ATS teaching in English
C_{16}	Body of multi-lingual groups
C_{17}	Number of educational programs in the framework of the social project - «Serpin-2050»
C_{18}	Increase in the amount of educational- methodological literature in the state language
C_{19}	Share of a university site, implemented in accordance with the requirements for accessibility for users with disabilities
C_{20}	Creation and improvement of the infrastructure of a university for barrier-free access to education and accommodation of the students with special educational needs
C_{21}	Annual upgrading computers and telecommunication means
C_{22}	Share of educational programs developed based of the area frameworks and professional standards
C_{23}	Share of educational programs of baccalaureate containing the discipline aimed at formation of entrepreneurs' skills
C_{24}	Increase in the number of social partners
C_{25}	Amount of educational-methodological literature designed by ATS members and implemented in academic process
C_{26}	Number of students who have taken part in the program of external academic mobility
C_{27}	Number of joint educational programs and the programs of two-diploma education
C_{28}	Number of events to attract foreign students, trips to the countries of Central Asia
C_{29}	Number of agreements signed with foreign educational organizations
C_{30}	Number of students studying in English
C_{31}	Share of educational programs, accredited in national and international agencies
C_{32}	Belonging to top-10 national ratings of the best multi-profile higher educational institutions of Kazakhstan
C_{33}	Share of scientific research funding in the total university budget
C_{34}	Share of ATS and scientific researchers having publications in the international reviewed scientific journals
C_{35}	Number of commercialized projects
C_{36}	Number of implemented start-ups
C_{37}	Number of obtained national patents
C_{38}	Number of ATS members taking part in implementation of the fundamental and applied research
C_{39}	Share of students taking part in implementation of fundamental and applied research
C_{40}	Number of teachers taking part in the competition for the title of «The best teacher of a higher educational institution»
C_{41}	Number of students taking part in subject Olympiads, scientific competitions
C_{42}	Number of scientific studies performed within international cooperation
C_{43}	Number of publications of scientific articles in the international reviewed scientific journals
C_{44}	Number of patents and other protective documents, obtained by the university scientists
C_{45}	Number of Master degree students and doctoral students taking part in implementation of fundamental and applied research
C_{46}	Number of publications of scientific articles of Master degree and doctoral students in the international reviewed scientific journals
C_{47}	Share of university students involved in socially useful activity
C_{48}	Involvement of students in events on information support
C_{49}	Share of students who have taken part in round tables, meetings on prevention of religious extremism
C_{50}	Number of students of a higher educational institution taking part in students' self-governing bodies
C_{51}	Number of participants in state and private partnership in the work of SK «Sunkar»
C_{52}	Share of students taking part in sports sections
C_{53}	Increase in the number of sports and sport health sections
C_{54}	Functioning of the organs of corporative management (Supervisory Board)
C_{55}	Implementation of Road map on translation of the experience of Nazarbayev University
C_{56}	Attraction of foreign specialists to the university top management
C_{57}	Transition to the new organizational-legal form
C_{58}	Number of publications in regional and republican printing editions about the university activity
C_{59}	Existence of valid certificate of compliance of QMS with the ISO 9001 standard
C_{60}	Organization of overhaul and premises re-planning using the contractors with application of new decorating materials and modern design
C_{61}	Decrease in power consumption (with increasing total)

Stage 1. Evaluation of indicators as for the existence of interrelations between the indicators. The cognitive map of mutual influence of indicators (Table 1) through the representation of the variety of description of a complex system is constructed.

$$D=<C, E>, \quad (1)$$

where D is the directed graph, $C=\{c_1, c_2,..., c_n\}$ correspond to the set of graph vertices (indicators), E corresponds to the set of arcs that reflects the relation between the vertices of the modeled system.

The problem is to find the total influence of concepts on the graph beginning with c_i to c_j, i. e. in determining the total causal effect $c_j(c_i \rightarrow c_{k1} \rightarrow ... \rightarrow c_{km} \rightarrow c_j)$. The causal path can be found by the following formalization [19]:

$$c_i c_j : \left(i, k_1^r, k_2^r, \ldots k_m^r, j\right) = P_r, \quad r = \overline{1,m}, \quad (2)$$

The degree of concepts' influence is evaluated by experts through the totality of linguistic variables "strong", "moderate", "weak", etc., with the compared numerical values from the interval [0.1]. The influence direction is assigned by the "+" sign provided that an increase/decrease of concept c_i leads to an increase/decrease in concept c_j; provided that an increase/decrease in concept c_i leads to a decrease/increase in concept of c_j.

Formation of indicative indicators of the development plan through a cognitive model makes it possible to visualize a phase of analysis and study results [20]. Indicative indicators (Table 1), represented as vertices of a cognitive map – a digraph, give the following assessment of mutual influence Fig. 1.

According to this model, concepts C_8, C_9, C_{10}, C_{29} have the largest number of relations. The number of detected relations ranges from 4 to 11:

$C_8 \rightarrow C_3 \rightarrow C_4 \rightarrow C_5 \rightarrow C_6 \rightarrow C_{15} \rightarrow$
$\rightarrow C_{25} \rightarrow C_{36} \rightarrow C_{38} \rightarrow C_{43} \rightarrow C_{44}$,
$C_9 \rightarrow C_1 \rightarrow C_2 \rightarrow C_{16} \rightarrow C_{19} \rightarrow C_{26} \rightarrow$
$\rightarrow C_{36} \rightarrow C_{39} \rightarrow C_{41} \rightarrow C_{49} \rightarrow C_{50} \rightarrow C_{52}$,

$C_{10} \rightarrow C_{27} \rightarrow C_{36} \rightarrow C_{39} \rightarrow C_{45}$,

$C_{29} \rightarrow C_{26} \rightarrow C_{27} \rightarrow C_{30}$,

which indicates an important role of these concepts in the formation of the rest of the indicators.

Stage 2. Evaluation of the indicators as for meeting strategic objectives. The method of hierarchy analysis (MHA) is the method of decision-making, which allows representation of a complicated multi-purpose problem as the elements, such as objectives, criteria and alternatives in order to make decisions [21]. This method can be used to develop multiple hierarchical structures having an impact on difficult decision making. After constructing a hierarchy of factors, the significance of factors is determined by pairwise comparison. The weight of various factors influencing the objective of a decision-making system can be calculated in accordance with the comments by the method of analytical hierarchy [23].

When deciding on the structure of the system of indicative indicators, we will consider the hierarchy, for example, in the form:

– objective – estimation G of the priority of the classical strategies of M. Porter [24] on the university development;

– criteria of level 1 – group of strategic direction of development. P_1 ensures high-quality training of competitive staff. P_2 is the modernization of the content of educational programs of higher and post-graduate education in the context of the world tendencies. P_3 is the development of research and innovations, enhancement of their effectiveness. P_4 is the involvement of the youth in strengthening spiritual and moral values within modernization of social awareness and culture of healthy way of life. P_5 is improving the management and monitoring of development of the educational activity of the university;

– criteria of level 2 – individual indicators. C_1 is the share of graduates who studied by the state order, who found the employment within a year after graduation from the university. ... C_4 is the number of ATS members with a scientific degree. ... C_{22} is the share of the educational programs of baccalaureate, containing disciplines on the formation of entrepreneur skills. ... C_{61} is the decrease in power consumption (Table 1);

– alternatives – strategies: S_1 – generation of cost-effective educational services; S_2 is the differentiation of educational services; S_3 is the orientation to a wide market; S_4 – orientation to a narrow market niche.

The 9-point scale of relationships is applied for the qualitative assessment of alternatives by rather inert criteria [23, 24].

Matrix of estimates

$$B = \left(b_{ik}\right), \quad (3)$$

$$\left(i, k = \overline{1;I}\right) \quad (4)$$

is formed in accordance with the degrees of preference of criterion a_i to a_k element, b_i is equal to: 1 if the criteria are equally important; 3 at moderate preference of a_i to a_k; 5 at essential prevalence; 7 is significant prevalence; 9 is the case of absolute dominance of a_i over a_k; degrees of significance of 2, 4, 6, 8 are interpreted as intermediate judgments. In this case, it is natural that b_i=1; requirement of the local consistency is achieved by the "automatic condition".

$$b_{ki} = \frac{1}{b_{ik}}. \quad (5)$$

Full consistency can be ensured by the "automatic" calculation of preference:

$$b_{ik} = b_{is} \cdot b_{sk}. \quad (6)$$

But, in this case, the estimate loses "purity" and an opportunity to check the point of view on sincerity, confidence is missed. The preference matrix reflects human judgments, so it is difficult to expect full accuracy in the presence of a rather broad spectrum of preferences shades. But if degree of controversy is inadmissible – estimates' consistency index b_{ik} exceeds the permissible level CR>0.1, it is proposed to revise estimates, because the logic of an expert opinion is violated.

The matrix of paired comparisons of all alternatives (3) is reverse-symmetric with the elements of the main diagonal equal to 1. Normalized vector of priorities (weights) and consistency coefficient are determined using the method of eigenvalue of the matrix of paired comparisons.

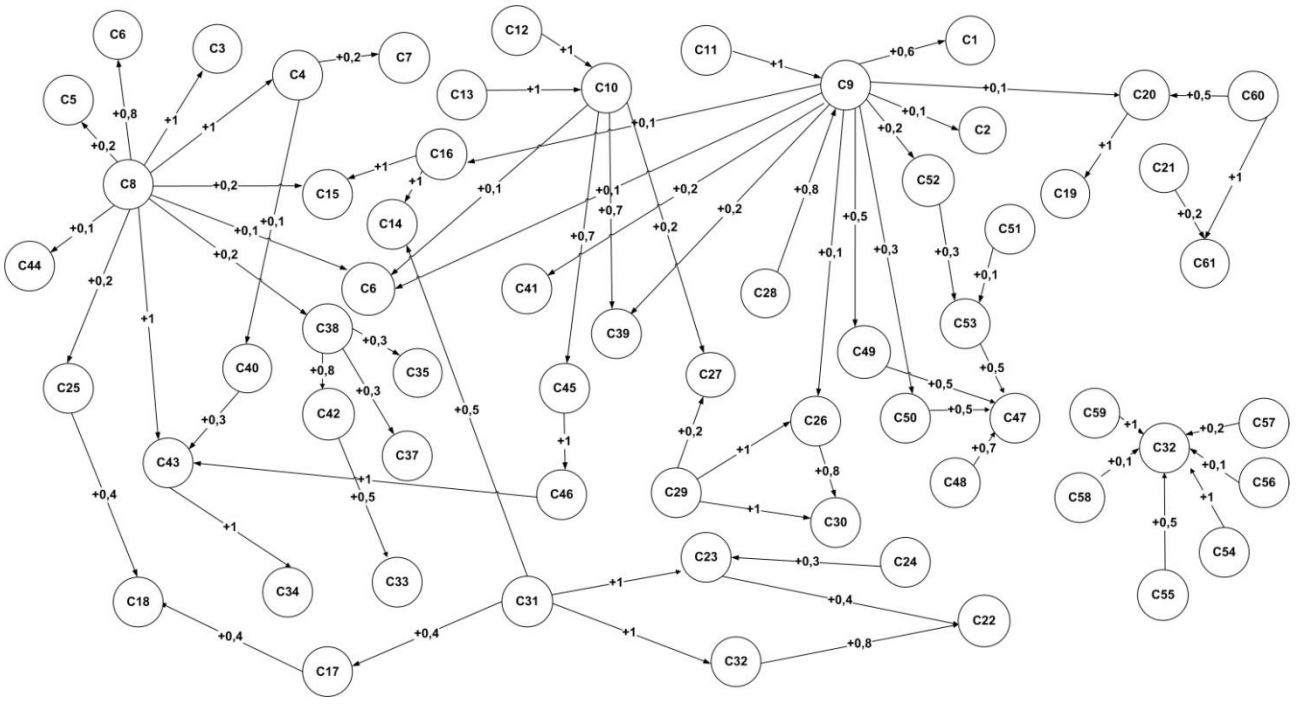

Fig. 1. Cognitive model of indicators for a development plan

The calculation scheme of method:

Solve the equation

$$\det(B-\lambda\cdot E)=0, \tag{7}$$

where E is the identity matrix.

We will determine the maximum eigenvalue λ_{max} as follows:

$$\lambda_{max}=\max_{i=\overline{1;I}}\lambda_i, \tag{8}$$

where

$$\forall i \quad \lambda_i \,|\, \det(B-\lambda_i\cdot E)=0. \tag{9}$$

We calculate eigenvector g as the solution to the system:

$$\begin{cases}(B-\lambda_{max}\cdot E)\cdot g=0,\\ \sum\limits_{i=1}^{I} g_i=1.\end{cases} \tag{10}$$

The found vector g will be the vector of relative weights.

To solve the given problem, it is necessary to solve the I-degree equation (I – the number of alternatives) and a system of I linear equations. To avoid lengthy arithmetic operations, especially at large dimensionality, the methods for finding the approximate values of eigenvalues and eigenvectors are used, that is, the matrix operations are reduced to numerous iterative procedures [22].

The first scheme of determining the approximate value of g:

$$g_i=\frac{\sum\limits_{k=\overline{1;I}} w_{ik}}{I}, \tag{11}$$

$$w_{ik}=\frac{b_{ik}}{\sum\limits_{i=\overline{1;I}} b_{ik}}, \tag{12}$$

the elements of the weight vectors actually represent the eigenvector that corresponds to a maximum eigenvalue λ_{max} of comparison matrix (3).

The second scheme of determining the approximated value g is most accurate with respect to the non-consistent matrix of judgments (3):

$$g_i=\frac{\sqrt[I]{\prod\limits_{k=\overline{1;I}} b_{ik}}}{\sum\limits_{m=\overline{1;I}}\sqrt[I]{\prod\limits_{k=\overline{1;I}} b_{mk}}}, \quad i=\overline{1;I}. \tag{13}$$

Approximate value λ_{max} is derived from equation

$$B\cdot\overline{g}=\lambda_{max}\cdot\overline{g}, \tag{14}$$

$$\lambda_{max}=\sum_{i=\overline{1;I}}\left(\sum_{k=\overline{1;I}} b_{ik}g_k\right). \tag{15}$$

The index of consistency CR of matrix B is calculated as the ratio of consistency coefficient CI of this matrix to stochastic consistency coefficient RI:

$$CR=CI/RI, \tag{16}$$

where

$$CI=\frac{\lambda\max-I}{I-1}, \tag{17}$$

$$RI=\frac{1{,}98\cdot(I-2)}{I}. \tag{18}$$

If the value of the index does not exceed value 0.1 (10 %), mismatch of matrix B is considered permissible.

For the studied hierarchy, we will assess alternatives S_1, S_2, S_3 and S_4 in relation to C_4. We will obtain priority vector g=(0.54; 0.31; 0.09; 0.06); λ_{max}=4.31; CR=0.10. In

this case, local consistency of opinions is not observed; nevertheless, consistency index is within the norm, the review of the expert estimate is not required. Thus, achievement of indicator C_4 – the number of ATS members with a scientific degree, – is most influenced, according to the expert, by S_1 – most cost-effective production of educational services (Table 3).

Table 3

Assessment of alternatives for criterion C_4

C_4	S_1	S_2	S_3	S_4
S_1	1	3	5	7
S_2	1/2	1	6	4
S_3	1/5	1/6	1	2
S_4	1/7	1/4	1/2	1

Estimation of the same alternatives S_1, S_2, S_3 and S_4 in relation to C_{22} proves the opinion that strategy S_2 (differentiation of educational services) will best be proved by an opportunity to form entrepreneur skills via implementation of baccalaureate educational programs. Actually, we have complete local consistency, priority vector g= =(0.26; 0.58; 0.09; 0.07); λ_{max}=4.13; CR=0.04. Consistency index is within the norm, the review of the expert estimates is not required (Table 4).

Table 4

Assessment of alternatives for criterion C_4

C_{22}	S_1	S_2	S_3	S_4
S_1	1	1/3	5	3
S_2	3	1	6	7
S_3	1/5	1/6	1	2
S_4	1/3	1/7	1/2	1

The estimate of the strategic directions of the university development in relation to the main focus has local consistency, priority vector g=(0.52; 0.07; 0.32; 0.04; 0.05); λ_{max}=5.07; CR=0.01. Thus, ensuring high-quality training of competitive staff, as well as the development of research and innovation, enhancement of their effectiveness, are top priorities in the development strategy of a higher education institution (Table 5).

Table 5

Assessment of alternatives for criterion C_4

G	P_1	P_2	P_3	P_4	P_5
P_1	1	9	3	9	7
P_2	1/9	1	1/9	1	5
P_3	1/3	9	1	9	3
P_4	1/9	1	1/9	1	1/3
P_5	1/7	1/5	1/3	3	1

For strategic direction P_1 – ensuring high-quality training of competitive staff, the priorities of the 21st criterion of level 2 are calculated (λ_{max}=24.03, CR=0.102≈0.10).

At a large number of the estimated parameters, it is difficult to apply a 9-point scale.

It is easy to facilitate the task for experts, for example, by ensuring full consistency, having performed the comparison of one alternative with the rest and having applied calculation formulas (4) and (5). For example, for the studied hierarchy, assessment of alternatives S_1–S_4 in relation to C_4 after comparison gives results: g=(0.60; 0.20; 0.12; 0.08); λ_{max}=4; CR=0 (Table 6).

Table 6

Assessment of alternatives for criterion C_4

C_4	S_1	S_2	S_3	S_4
S_1	1	3	5	**7**
S_2	1/3	1	5/3	7/3
S_3	1/5	3/5	1	7/5
S_4	1/7	3/7	5/7	1

Expert assessment of alternatives (criteria) may be carried out using another method – pairwise comparison with gradations in a three-point scale. In this case characterized by a large number of estimated indicators (61) of the plan that are compared pairwise when using a 9-point scale, this process may take a considerable amount of time. Efficiency, sufficient calculation simplicity, and clarity of requirements for the original information are the advantages of a 3-point scale of assessment of examination. To perform assessment, each j-th expert, comparing criteria a_i pairwise, forms the preference matrix (3), where formal points correspond to representations "$\prec$" – less important", "$\succ$" – more important", "$\approx$" – "equivalent", "indistinguishable"

$$b_{ik}^{j}=\begin{cases}0, & a_i \prec a_k,\\ \dfrac{1}{2}, & a_i \approx a_k,\\ 1, & a_i \succ a_k,\end{cases} \tag{19}$$

The matrix of non-normalized estimates

$$W=\left(w_{ik}\right)=\left(1/J\cdot\sum_{j=\overline{1;J}} b_{ik}^{j}\right), \tag{20}$$

$$w_{ik}+w_{ki}=1. \tag{21}$$

Zero approximation of weights is assigned for reasons of "initial equivalence":

$$g^{(0)}=\left(g_1^{(0)},...,g_i^{(0)},...,g_I^{(0)}\right). \tag{22}$$

Iterative calculation of coefficients of relative importance in the s-th iteration continues until it reaches the assigned accuracy, or the assigned number of iterations occurs:

$$g_i^{(s+1)}=\frac{\sum\limits_{k=\overline{1;I}} w_{ik}\cdot g_k^{(s)}}{\sum\limits_{m=\overline{1;I}}\sum\limits_{k=\overline{1;I}} w_{mk}\cdot g_k^{(s)}},\quad i=\overline{1;I} \tag{23}$$

$$g_i^{(s+1)}=\frac{\sum\limits_{k=\overline{1;I}} w_{ik}\cdot g_k^{(s)}}{\sum\limits_{m=\overline{1;I}}\sum\limits_{k=\overline{1;I}} w_{mk}\cdot g_k^{(s)}},\quad i=\overline{1;I}. \tag{24}$$

Assessment according to a three-point scale allows conducting expert examination without worrying about the violation of transitivity of judgments, using both single and group opinions without preliminary preparation of an expert group.

Evaluation of ten most significant indicators of the group of strategic direction P_1 by the four experts using a three-point scale is the following (Table 7).

Table 7

Normalized table *G*

P_1	C4	C1	C2	C8	C3	C5	C11	C12	C6	C9
C4	0.5	1	1	1	1	1	1	1	1	1
C1	0	0.5	0.5	0.75	0.75	1	1	1	1	1
C2	0	0.5	0.5	0.75	0.5	0.5	0.5	0.5	0.5	0.5
C8	0	0.25	0.25	0.5	0.75	0.5	0.5	0.5	0.5	0.5
C3	0	0.25	0.5	0.25	0.5	0.5	0.5	0.5	0.5	0.5
C5	0	0	0.5	0.5	0.5	0.5	0.75	0.75	0.5	0.5
C11	0	0	0.5	0.5	0.5	0.25	0.5	0.5	0.5	0.5
C12	0	0	0.5	0.5	0.5	0.25	0.5	0.5	0.75	0.5
C6	0	0	0.5	0.5	0.5	0.5	0.5	0.25	0.5	0.75
C9	0	0	0.5	0.5	0.5	0.5	0.5	0.5	0.25	0.5

With an accuracy of 1/1,000, after the fifth iteration, we will get the priority vector g^*=(0.212; 0.148; 0.098; 0.84; 0.080; 0.085; 0.071; 0.075; 0.076; 0.071) (Table 8).

Indicator C_4 – the number of ATS members with a scientific degree – has the highest priority among the indicative indicators. The group of strategic direction P_1 has ten most significant indicators (Table 9).

The dynamics of values of indicative indicators for strategic direction P_1 – ensuring high-quality training of competitive specialists for estimates according to the 9- and 3-point scales are shown in Fig. 2.

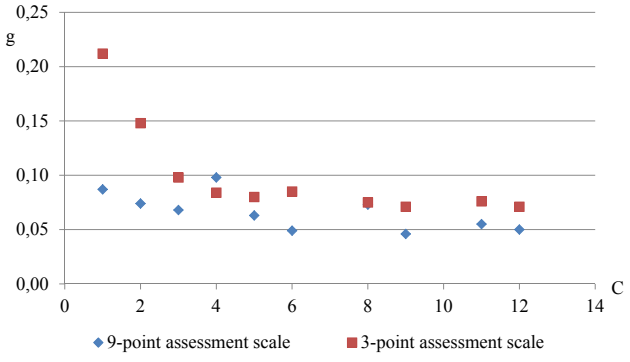

Fig. 2. Dynamics of values of indicative indicators for strategic value P_1

The data obtained show the correlation of the applied scales of expert estimates. Differences in assessing the impact of criterion C_6 on direction P_1 can be explained by the difference in the views of experts on the process of upgrading the qualification and incorrect name of indicator C_6 itself.

Stage 3. Evaluation and selection of indicators. At this stage, the indicators chosen at stages 1, 2 are assessed and criteria of the formation of the development plan indicators are developed.

Table 8

Iterative procedure

Iterations	*g*1	*g*2	*g*3	*g*4	*g*5	*g*6	*g*7	*g*8	*g*9	*g*10	Total
0	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	1
1	0.190	0.150	0.095	0.085	0.080	0.090	0.075	0.080	0.080	0.190	1
2	0.209	0.149	0.098	0.084	0.080	0.085	0.071	0.076	0.076	0.209	1
3	0.212	0.148	0.099	0.084	0.080	0.085	0.071	0.075	0.076	0.212	1
4	0.212	0.148	0.098	0.084	0.080	0.085	0.071	0.075	0.076	0.212	1
5	0.212	0.148	0.098	0.084	0.080	0.085	0.071	0.075	0.076	0.071	1

Table 9

Group of the most significant indicators of direction P_1

Code of criterion (C)	Criterion	Priority vector (*g*)	
		9-point assessment scale	3-point assessment scale
1	Share of graduates who studied by the state order and found a job according to speciality within 1 year after graduation	0.087	0.212
2	Number of foreign students, including those who studied on a fee-paying basis	0.074	0.148
3	Number of ATS with Master's degree	0.068	0.098
4	Number of ATS members with scientific degree	0.098	0.084
5	Share of ATS who work at production enterprises	0.063	0.080
6	Share of ATS and staff who upgraded qualification	0.049	0.085
8	Number of ATS members of university	0.073	0.075
9	Students' body	0.046	0.071
11	Admission to baccalaureate programs	0.055	0.076
12	Admission to Master degree programs	0.050	0.071

The evaluation results are considered through the construction of the table, which shows the estimation methods and a set of indicators that gained a maximum weight of each of the selected methods (Table 10).

Table 10

Comparative set of indicators for the university development plan

Technique/ method	Set of indicators
Cognitive map	C_8 (C_3, C_4, C_5, C_6, C_{15}, C_{25}, C_{36}, C_{38}, C_{43}, C_{44}) C_9 (C_1, C_2, C_{16}, C_{19}, C_{26}, C_{36}, C_{39}, C_{41}, C_{49}, C_{50}, C_{52}) C_{10} (C_{27}, C_{36}, C_{39}, C_{45}) C_{29} (C_{26}, C_{27}, C_{30})
Method of hierarchy analysis	C_4, C_1, C_8, C_3, C_5, C_2, C_{11}, C_6, C_{12}, C_{13}, C_9, C_{10}, C_7, C_{17}, C_{23}, C_{22}, C_{24}, C_{31}, C_{18}, C_{25}, C_{15}

The problem of evaluation and selection of indicators for the development plan depends on the qualitative analysis of indicators, which involves the selection of the most informative indicators in terms of realization of strategic goals and objectives. The selection criteria can be the existence of the greatest number of relations, for example, indicators C_8, C_9, C_{10}, C_{29} have the number of detectable relations from 4 to 11. Another criterion can be "weight of actions". The analysis of the hierarchies of indicative indicators revealed that 10 out of 61 indicators (Table 9) ensure more than 60 % of "weighing actions" in achieving the strategic university development. All the ten indicators ensure attainment of direction "Ensuring high-quality training of competitive specialists". Three indicators contribute only about 4 % of "weight" to the system. It is important to use these data to reduce dimensionality of the system of indicators and/or to identify "bottlenecks" of the organization's activities (Fig. 2).

It is necessary to pay attention to the accuracy of formulations and names of the assessed indicators. For example, it is not necessary to measure indicators "Availability of QMS certificate" or "Functioning of the Supervisory Board" in the plan, because their existence is regulated by the standard regulations of universities' activity. Important attention should be given to measurable indicators for successful planning of university development. It will be advisable in the formation of development to exclude all of criteria under numbers C_{47}–C_{61} (Table 1) as the least important, according to experts. Revision of the criteria with identical formulations of number C_{37}, C_{44} will allow optimization and facilitation of the plan implementation control.

Stage 4. Formation of the indicators of the university development plan. To form the indicators of the development plan, it is proposed to select a hybrid method of decision-making. To do this, we from a set, obtained at intersection of two subsets – indicators obtained by the method of construction of a cognitive map and the method of hierarchy analysis (Table 10). The optimal set has the following form:

C_1 – Share of the university graduates who studied by the state order and found a job according to speciality within one year after graduation;

C_2 – Number of foreign students, including those who studied on a fee-paying basis;

C_3 – Number of ATS members with Master's degree;

C_4 – Number of ATS members with a scientific degree;

C_5 – Share of ATS who work at production enterprises;

C_6 – Share of ATS and staff members who upgraded their qualification;

C_8 – Number of university ATS staff members;

C_9 – Students' body;

C_{10} – Body of Master degree students and doctoral students;

C_{15} – Number of ATS members teaching in English;

C_{25} – Amount of educational and methodological literature created by the ATS and implemented in the educational process.

The formed indicators give the most complete information about the state of the system as they take into account the mutual influence and the attainability of strategic directions of the university development.

This set can be expanded and supplemented by additional expert estimation or by including all indicators, selected during the first two stages. The quantitative composition of indicators depends on correct distinction between the types of plans (current or strategic).

Thus, the method of decision making to form the indicators of the plan of the higher educational institution development was proposed. The specific feature of the method is that it is proposed to assess the set of indicators under discussion by two methods and to form the indicators of the development plan based on the selected data. In this regard, the four-stage method of decision-making including the construction of a cognitive map and the method of hierarchy analysis was proposed.

6. Discussion of the decision-making method for the formation of the indicators of the university development plan

The problem of formation of indicators of the plan of the higher educational institution development, taking into account the interaction of indicators and strategic directions of development, was solved. The results obtained are explained by the leading role of a higher educational institution, focusing on educational activities. The directions of the strategic development "Ensuring high-quality training of competitive specialists", as well as "Development of research and innovations, enhancing their performance" are the highest priorities (Table 4) in the strategy of the higher educational institution development. This is proved by the number of relations between the indicators of these directions (Fig. 1).

The known procedures of formation of indicators, developed for financial enterprises, do not allow taking into account the social vector of development of a higher educational institution. That is why the undoubted advantage of the hybrid decision making method is strengthening the merits of the two methods – taking into account the interrelations of the indicators in a cognitive map and taking into account the directions of the development plan in the method of hierarchy analysis. This approach makes it possible to form a unique set of indicators that maximally correspond to the specificity of an institution of higher education and its development strategy.

It is necessary to note as a drawback the laboriousness of research performance, the risk of violations of transitivity of expert evaluations while increasing the dimensionality of the assessment scale. This study requires development, since the additional formation of the system of plan indica-

tors needs additional selection criteria that meet the stated requirements.

It is logical to aim the subsequent study to studying the interconnections and monitoring the given system of indicators in dynamics, making it possible to provide a decision maker with necessary information to generate certain recommendations of the management process.

7. Conclusions

1. The problem of formation of the indicators of the plan of the higher educational institution development is its inability to use the known method, based on financial analysis, for this purpose. The stages of the plan development and the methods and models of their support were considered. The basic principles of formation of indicators of the development plan, including comprehensiveness, completeness, simplicity, comparability, non-ambiguity, were presented.

2. We proposed the four-stage method for making a decision on the formation of indicative indicators of the plan, based on selection of indicators, as the intersection of a set of data, having a high estimate of experts in the method of hierarchy analysis and having some relations in the cognitive map. The generated set of indicators of the development plan included 11 indicators, aimed at achieving the development in the area "Ensuring high-quality training for competitive specialists" and "Modernization of the content of the educational programs in the context of world tendencies" The obtained indicators must be introduced explicitly at the stage of policy development as the basis for consideration of subsequent designing the university development plan.

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