

## Assessment of University Intellectual Potential

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### Abstract

*High competition in the educational environment requires the search for factors and the development of methods to improve the quality of education. The article deals with the issues related to the logic of development and the structure of the intellectual potential of the organization based on the principles of a systematic approach. The definition of the "intellectual potential of the university" concept has been proposed. Based on the structure of intellectual potential, a set of indicators has been proposed to assess the level of intellectual potential of the university. The weighting coefficients of the significance of the indicators have been calculated using the paired comparison method. The level of intellectual potential of the university has been considered as one of the main objective prerequisites for ensuring the competitiveness of the university and the quality of the educational services provided. It has been found that the main factors determining the level of intellectual potential of the university are highly qualified teaching staff, their scientific research, and their work.*

**Key-words:** System Approach, Indicators of Intellectual Potential, Weighting Coefficients of Indicators.

### 1. Introduction

The processes of economic globalization and real international economic competition in the modern world have a significant impact on the educational services market, exacerbating competition and putting forward new requirements for universities [3, 6, 9, 16]. This leads to the need to increase

attention to specific indicators that characterize the activities of universities. It is considered appropriate to include university intellectual potential in such indicators.

Broadly, the abstract concept of "potential" (potential – power, opportunity) reflects the ability of an object to move from possibility to reality. The literature contains several dozen descriptions of the "intellectual potential" concept, which are used depending on the goals of the study, have a rational basis, and the right to exist [2, 8, 13, 19, 20, 21]. An analysis of the definitions of the "intellectual potential" concept shows that the differences in the definitions are primarily associated with the approaches of the authors, from whose positions this category is considered, namely: resource, effective, target, reserve, systemic approach.

Despite the recognition by all researchers of the importance of intellectual potential as a key factor in economic development, currently, there is practically no methodology for assessing intellectual potential at the micro-level and identifying the influence of the main indicators on it. The objectivity of the assessment of intellectual potential can be ensured only with the correct choice of indicators of intellectual potential. The most important problem is also the co-measurement of different indicators among themselves.

## **2. Methods**

From our point of view, it is possible to reveal the concept of "intellectual potential" as fully as possible if we proceed from the principles of a systematic approach. It is known that the system approach originated in biology and engineering. As it developed, the ideas of the systems approach were extended to other areas of knowledge, including to solve the problems of the economy. A system approach is an adequate approach when studying not any objects, but only objects that can be represented as a system. Any system can be considered as a set of interrelated elements in the system approach, using the cybernetic interpretation of the system: input, output (goal), communication with the external environment, and feedback.

A systematic approach to the analysis of the intellectual potential of an organization is to create such a set of indicators and their interrelations that would give an objective and reliable assessment of its state and direction of development, which cannot be obtained by considering these indicators separately, without linking to each other. Thus, the system of indicators should create a synergistic effect due to the manifestation of the emergence property.

The systematic approach implies that the assessment of intellectual potential should, first of all, be guided by the strategic goals of its management. The following criteria can be distinguished based on a systematic approach to assessing the intellectual potential of an organization:

1. compliance with the requirements of universality and comparability of results,
2. creating a synergistic effect from building a system of evaluation indicators,
3. maximum reflection of the specifics of the evaluation object by highlighting the final evaluation indicators based on the components of intellectual potential,
4. compliance with a reasonable assessment sequence.

This approach to evaluation allows assessing the impact of factors on the intellectual potential and identifying the most important reasons that affect the state of the system. The use of a systematic approach may lead to the need to apply heuristic approaches along with formal procedures, i.e., search for solutions using informal rules based on knowledge, experience, and intelligence.

When calculating the weighting coefficients of indicators, it seems appropriate to use the method of paired comparisons. The initial data can serve as completed expert survey questionnaires in the form of a pairwise comparison matrix (PCM).

Table 1 – Expert survey questionnaire

	$k_1$	$k_2$	...	...	$k_{i-1}$	$k_i$
$k_1$	<b>1</b>					
$k_2$		<b>1</b>				
...			<b>1</b>			
...				<b>1</b>		
$k_{i-1}$					<b>1</b>	
$k_i$						<b>1</b>

The elements of the PCM (Table 1) are numerical values according to the T. Saaty rating scale, which reflect the expert's preferences (Table 2). The  $k_i$  indicators are compared with each other in pairs relative to each other in terms of the significance of the contribution to the intellectual potential. Each comparison of indicators is encoded by a number 1/9, 1/8, 1/7.....7, 8, 9. For example, if the expert attaches absolute importance to the indicator  $k_1$  over the indicator  $k_2$ , then the number 9 is entered in row 1, column 2, and the inverse number, i.e. 1/9, is entered in row 2, column 1.

Table 2 – Description of the T. Saaty verbal-numerical scale [10]

Level of significance	Definition	Comment
1	Equal importance	Two indicators contribute equally
3	Weak significance	Experience and judgment give an easy preference to one indicator over another
5	Strong significance	Experience and judgment give a strong preference for one indicator over another
7	Obvious significance	The superiority of one indicator over another is very strong.
9	Absolute significance	The preferences of one indicator to another are highly convincing
2, 4 ,6, 8	Intermediate values	Situations when a compromise solution is needed

The consistency of a positive inversely symmetric matrix can be estimated by calculating the conformity relation (CR) using the formula:

$$CR = \frac{ИС}{СИ} \cdot 100\%,$$

where  $ИС = \frac{\lambda_{max} - n}{n - 1}$  is the consistency index;

$\lambda_{max}$  - the maximum eigenvalue of the matrix;

$n = i$  - the number of compared indicators;

$СИ = 1,24$  (the average consistency index of a 6x6 inversely symmetric matrix generated randomly on a scale from 1 to 9).

To get a reliable solution, the CR value is recommended to be less than or equal to 10%. If the CR goes beyond these limits, then the PCM of such experts should be excluded from consideration. For each transitive PCM ( $OC \leq 10\%$ ), an eigenvector is calculated that corresponds to  $\lambda_{max}$ .

### 3. Results

#### The logic of intellectual potential development

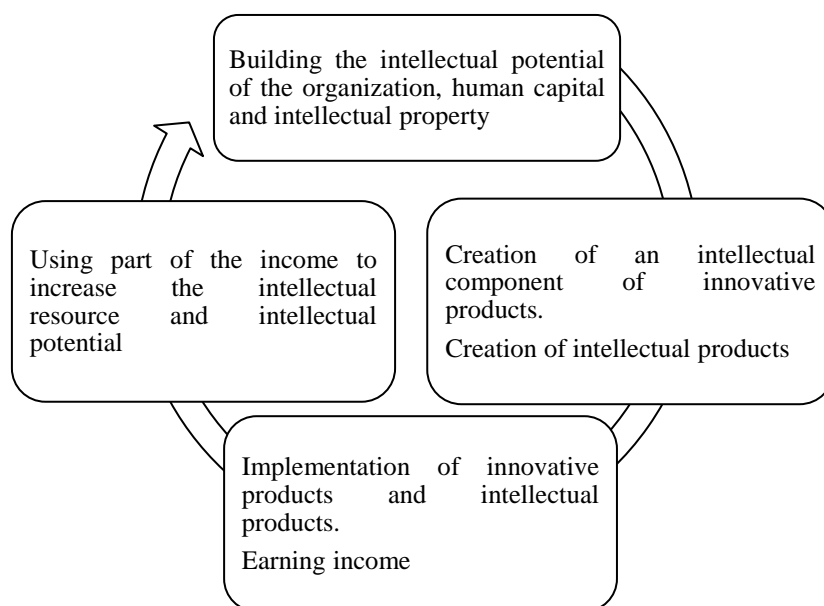
The economic aspect of the interpretation of the "intellectual potential" concept focuses on production and the result of human activity. Intellectual resources, as a factor of production, are the foundation of the innovative development of the organization, generating innovations, expanding the production function, and diversifying the products of the enterprise, ensuring its competitiveness. The intellectual potential is such a relationship of a human resource with the organizational and market potential of an organization, which ensures its competitiveness and the creation of added value.

Therefore, the following scheme of development of the intellectual potential of the organization takes place (Figure 1):

- creation of the intellectual potential of the organization, including personnel and intellectual property;
- creating an intellectual component of innovative products;
- implementation of innovative products and income generation;
- using part of the income to increase the intellectual resource and to increase the intellectual potential of the organization.

The intellectual potential is the result of human intellectual activity and allows making the transition from possibility to reality. The level of the intellectual potential of the organization determines the probability that employees will receive an intellectual product, reflects the opportunities that can be used to achieve certain goals. Therewith, these features may or may not be implemented. Thus, the presence of the intellectual potential of the organization is a prerequisite for increasing intellectual capital – a means of creating new value, while it does not guarantee this increase by 100%. The intellectual potential for its development has an unlimited resource and can be improved. The costs of forming the intellectual potential created based on the intellectual resource available to the enterprise can give a much greater return than the costs of forming fixed assets [14].

Figure 1 – The scheme of development of the intellectual potential of the organization



## **Definition and structure of university intellectual potential**

The success of any organization depends on the professionalism and motivation of its employees who are responsible for specific results. The main task of universities is to provide balanced labor resources to the economies and social spheres of the regions of their country following the needs of employers and to provide an opportunity for each graduate to become in demand. The activities of universities have specific features. Firstly, it is based on an intangible base, which includes the knowledge and experience of the teaching staff, whose intellectual resource allows them to provide educational services and produce their innovative products (educational and methodological literature, scientific developments, patents). Secondly, the intellectual resources of subjects and objects of scientific and educational activity interact at the university. Thirdly, the assessment of intellectual potential in monetary terms is not required, because Russian universities are not objects of purchase and sale. A qualitative assessment of the university's activities is significant for potential consumers of university products (educational services, research, and development work, graduates), which is mainly determined by its intellectual potential.

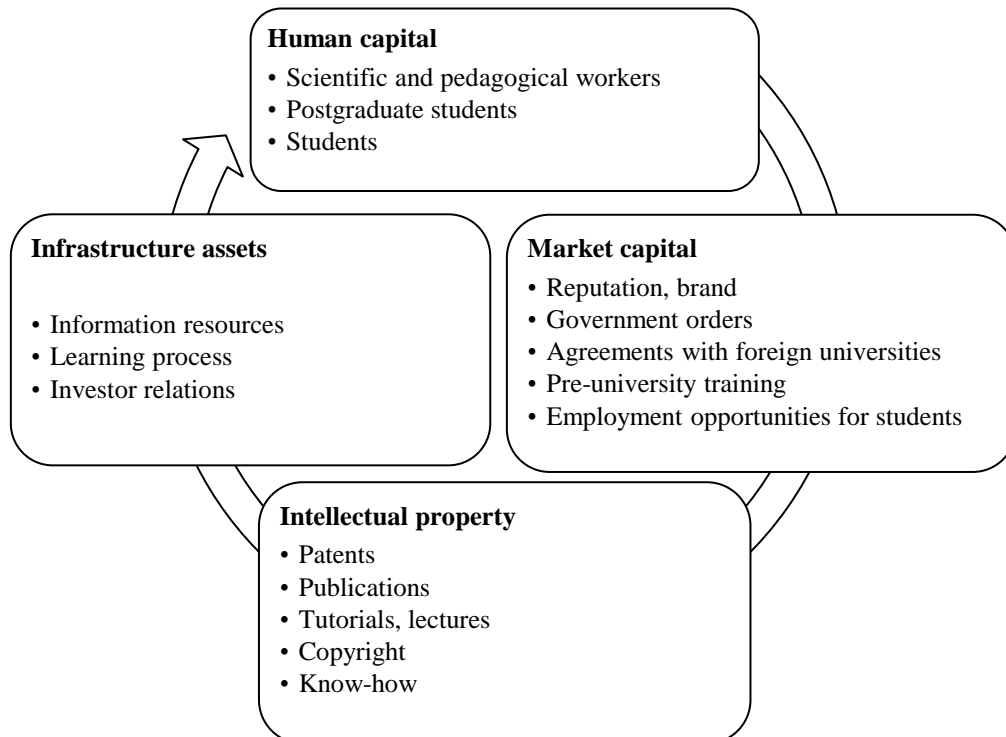
The system analysis is based on a descriptive approach to the system, which consists of the fact that the structure of the system is reasonably identified and understood. Based on the analysis of approaches to the concept of "intellectual potential of an organization" and consideration of its structure from the standpoint of a systematic approach to the process of integration of incoming elements, the following definition of the concept of "intellectual potential of a university" is a set of abilities and capabilities of all scientific and pedagogical workers and students, which, based on the resources available to them, can provide economic entities with qualified personnel, disseminate and accumulate knowledge, skills, and competencies, as well as reproduce, create and implement scientific and technical innovations, embodying new knowledge in them. The structure of university intellectual potential can be defined as a set of four components interacting with each other: human capital, market capital, intellectual property, infrastructure assets. The proposed division into parts is also since each of these parts is managed differently. It should be noted that the approach of dividing the intellectual potential into components presented in Figure 2 is not the only one [1, 8, 12]. However, to form a relevant assessment based on the principles of a systematic approach, it is necessary to avoid both excessive simplification and excessive detailing of this concept. Therefore, the allocation of these four components is the optimal solution.

The most significant part of the human capital of the university is made up of academic staff. In order for the human capital of the university to work, it is necessary to form a working team that will

be focused on performing specific tasks and have the knowledge, have research laboratories, knowledge and databases, centers for bringing research and development to the know-how of wide application. The management of human resources by creating conditions and incentives for their development can only be indirect. The client base provides orders for the execution of works and the provision of educational services, it allows realizing the capabilities of the working team. This component reflects the university's relations with the consumers of its services and the results of its developments.

The "intellectual potential" includes various phenomena – a set of employee values, the image of the organization, brands, customer relations, etc. (figure 2). All elements of the potential interact with each other, while the growth of any component contributes to the development of others. The unifying condition is the idea of the intellectual potential cycle. An important task of the management is to ensure the transformation of human capital into structural capital, which already belongs to the university by right of ownership, and determines the level of human capital at the next stage of development. Thus, intellectual potential is a self-developing system.

Figure 2 – Elements of the structure of university intellectual potential



## Assessment of university intellectual potential

As it is known, it is possible to control only the object that is being measured, so the search for a way to assess university intellectual potential has real practical significance.

Based on the criteria formed on the basis of the principles of a systematic approach, and the experience of the studies of various authors [4, 5, 11, 15, 17, 18], an approach is proposed in which the object of assessment is the level of development, the degree of use and the effectiveness of the intellectual potential of an educational organization. To assess the intellectual potential, it is advisable to proceed from its structure, i.e. it is necessary to consider each structural element of the potential [7]. It is assumed that the level of intellectual potential is mainly determined by six quantitative indicators ( $i = 6$ ) given in Table 3.

Table 3 – Indicators of intellectual potential

A structural element of university intellectual potential	Name of the intellectual potential indicator	The purpose of evaluating the intellectual potential indicator
Human capital	Indicator of the personnel potential of scientific and pedagogical workers	Assessment of the educational level, qualifications, and prospects of the staff, that is, an assessment of the intellectual resource of scientific and pedagogical workers.
	Student potential indicator	Assessment of the "contribution" of students and graduate students to university intellectual potential, that is, the assessment of the intellectual resource of students of all levels (bachelor's, master's, postgraduate studies).
Intellectual property	Indicator of scientific and technical potential	Evaluation of the results of intellectual activity created at the university during the reporting period, that is, an assessment of the impact of the intellectual potential that the university has, including within the framework of the world scientific and educational space.
Infrastructure assets	Information potential indicator	Assessment of the information potential through the provision of the university with computer technology and the publication activity of the university.
Market capital	Indicator of innovative potential	It includes transformed scientific knowledge into new products (services) and characterizes the readiness of the university (the presence of the necessary departments, the degree of participation of the academic staff) for innovative developments, that is, the assessment of creative activity and the effectiveness of innovative activities.
	Customer potential indicator	It characterizes the demand for educational services by school graduates, the products of the university's activities by employers and customers, that is, an assessment of the image and product produced by the university in the educational services market, the research and development market, and the labor market.



We propose the following ratio to assess the level of intellectual potential of the university (UIP):

$$UIP = w_1 \cdot I_1 + w_2 \cdot I_2 + w_3 \cdot I_3 + w_4 \cdot I_4 + w_5 \cdot I_5 + w_6 \cdot I_6$$

The designations of indicators and their weighting coefficients of significance used in the ratio are shown in Table 4.

Table 4 – Designations of indicators and weight coefficients

Indicator name	Indicator designation	Indicator weight designation
HR potential of the academic staff	$I_1$	$w_1$
Student potential	$I_2$	$w_2$
Scientific and technical potential	$I_3$	$w_3$
Information potential	$I_4$	$w_4$
Innovative potential	$I_5$	$w_5$
Customer potential	$I_6$	$w_6$

### Weighting factors of the significance of indicators

The method of paired comparisons was used to determine the weighting coefficients of the significance of the indicators. Six professors of the Technological University (Moscow region, Korolev) took part in the expert assessment.

The matrices of paired comparisons of the significance of indicators obtained from experts are presented in Figure 3.

Figure 3 – Data for analysis obtained by the survey method

Expert No. 1							Expert No. 4						
	$I_1$	$I_2$	$I_3$	$I_4$	$I_5$	$I_6$		$I_1$	$I_2$	$I_3$	$I_4$	$I_5$	$I_6$
$I_1$	<b>1</b>	4	2	8	6	8	$I_1$	<b>1</b>	5	1/5	1/3	7	5
$I_2$	1/4	<b>1</b>	1/3	1/3	4	3	$I_2$	1/5	<b>1</b>	1/6	1/3	4	2
$I_3$	1/2	3	<b>1</b>	1	3	2	$I_3$	5	6	<b>1</b>	5	9	9
$I_4$	1/8	3	1	<b>1</b>	3	4	$I_4$	3	3	1/5	<b>1</b>	5	4
$I_5$	1/6	1/4	1/3	1/3	<b>1</b>	1	$I_5$	1/7	1/4	1/9	1/5	<b>1</b>	1
$I_6$	1/8	1/3	1/2	1/4	1	<b>1</b>	$I_6$	1/5	1/2	1/9	1/4	1	<b>1</b>

Expert No. 2

	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	I <sub>5</sub>	I <sub>6</sub>
I <sub>1</sub>	1	2	2	8	6	8
I <sub>2</sub>	1/2	1	3	3	5	3
I <sub>3</sub>	1/2	1/3	1	3	3	2
I <sub>4</sub>	1/8	1/3	1/3	1	3	7
I <sub>5</sub>	1/6	1/5	1/3	1/3	1	8
I <sub>6</sub>	1/8	1/3	1/2	1/7	1/8	1

Expert No. 5

	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	I <sub>5</sub>	I <sub>6</sub>
I <sub>1</sub>	1	5	3	2	7	5
I <sub>2</sub>	1/5	1	1/6	1/3	4	2
I <sub>3</sub>	1/3	6	1	3	8	8
I <sub>4</sub>	1/2	3	1/3	1	5	4
I <sub>5</sub>	1/7	1/4	1/8	1/5	1	1
I <sub>6</sub>	1/5	1/2	1/8	1/4	1	1

Expert No. 3

	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	I <sub>5</sub>	I <sub>6</sub>
I <sub>1</sub>	1	7	5	3	9	7
I <sub>2</sub>	1/7	1	1/4	1/5	5	2
I <sub>3</sub>	1/2	4	1	1/5	6	5
I <sub>4</sub>	1/3	5	2	1	8	5
I <sub>5</sub>	1/9	1/2	1/6	1/8	1	1/4
I <sub>6</sub>	1/7	1/5	1/5	1/5	4	1

Expert No. 6

	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	I <sub>5</sub>	I <sub>6</sub>
I <sub>1</sub>	1	5	1/5	3	5	6
I <sub>2</sub>	1/5	1	1/7	1/2	5	3
I <sub>3</sub>	5	7	1	6	9	9
I <sub>4</sub>	1/3	2	1/6	1	5	4
I <sub>5</sub>	1/5	1/5	1/9	1/5	1	1/2
I <sub>6</sub>	1/6	1/3	1/9	1/4	2	1

The result of checking the experts' PCM for transitivity is shown in Table 5 ( $n = 6$ ).

Table 5 – The result of checking the consistency of the expert's PCM

Expert	The maximum eigenvalue of the matrix	Consistency indicators		PCM verification criteria
	$\lambda_{max}$	IP	OS, %	
1	6.53	0.11	9	in progress
2	7.21	0.24	19	not in progress
3	6.47	0.09	7	in progress
4	6.55	0.11	9	in progress
5	6.36	0.07	6	in progress
6	6.50	0.10	8	in progress

The obtained values of the eigenvectors are shown in Table 6.

Table 6 – Eigenvectors of transitive PCM experts

Expert	Eigenvector-column of the PCM
1	[0.88; 0.19; 0.31; 0.29; 0.09; 0.09] <sup>T</sup>
3	[0.84; 0.12; 0.29; 0.41; 0.04; 0.09] <sup>T</sup>
4	[0.28; 0.12; 0.88; 0.34; 0.05; 0.06] <sup>T</sup>
5	[0.73; 0.14; 0.58; 0.30; 0.06; 0.08] <sup>T</sup>
6	[0.37; 0.13; 0.89; 0.19; 0.05; 0.06] <sup>T</sup>

Assuming that all experts are equally competent for combining the values of eigenvectors, we use a geometric mean. Thus,

$$w_1 = (0,88 \cdot 0,84 \cdot 0,28 \cdot 0,73 \cdot 0,37)^{0,2} = 0,56;$$

$$w_2 = (0,19 \cdot 0,12 \cdot 0,12 \cdot 0,14 \cdot 0,13)^{0,2} = 0,14;$$

$$w_3 = (0,31 \cdot 0,29 \cdot 0,88 \cdot 0,58 \cdot 0,89)^{0,2} = 0,53;$$

$$w_4 = (0,29 \cdot 0,41 \cdot 0,34 \cdot 0,30 \cdot 0,19)^{0,2} = 0,30;$$

$$w_5 = (0,09 \cdot 0,04 \cdot 0,05 \cdot 0,06 \cdot 0,05)^{0,2} = 0,06;$$

$$w_6 = (0,09 \cdot 0,09 \cdot 0,06 \cdot 0,08 \cdot 0,06)^{0,2} = 0,07.$$

The normalized weights of the intellectual potential indicators calculated by the formula  $W_K^H = \frac{W_K}{\sum_{K=1}^6 W_K}$ ;  $K = 1, \dots, 6$ ;  $\sum W_K^H = 100\%$  are given in Table 7.

Table 7 – Weighting coefficients of the significance of indicators

Indicator	Indicator name	Weight $W_K^H$ , %
I <sub>1</sub>	HR potential of the academic staff	34
I <sub>2</sub>	Student potential	8
I <sub>3</sub>	Scientific and technical potential	32
I <sub>4</sub>	Information potential	18
I <sub>5</sub>	Innovative potential	3
I <sub>6</sub>	Customer potential	5

It is found that the indicator I<sub>1</sub> ( $w_1^H = 34\%$ ), which reflects the knowledge, experience, and competence of the academic staff, and the indicator I<sub>3</sub> ( $w_3^H = 32\%$ ), that reflects the effectiveness of the creative, intellectual work of the academic staff, has the greatest weighting factor of significance.

#### 4. Discussion

For the successful use of intellectual potential as an indicator of the competitiveness of the university, it is necessary to monitor it in dynamics, identify problems and take into account that effective management of intellectual potential involves the transformation of university services into an innovative product of commercial significance. An objective assessment of the constituent elements of university intellectual potential allows identifying its strengths and weaknesses, measuring the real capabilities of the university with the needs of the state and the market. It seems necessary to conduct regular monitoring of the effectiveness of the use of the intellectual potential of a particular university in dynamics, as well as by its defining indicators. It is advisable to assess university intellectual

potential annually. The accumulated information for several periods about the level of intellectual potential can be used for forecasting purposes, for example, using trend models. In addition, the results of the assessment will allow for a comparative analysis of the intellectual potential of a group of universities.

The proposed system of indicators takes into account scientific, educational, innovative, and cultural components, requires a relatively small amount of primary information and expert assessments, which allows for a more objective assessment, and guarantees a sufficient level of information about the state of university intellectual potential.

## **5. Conclusion**

The obtained values of the weighting coefficients of the indicators ("contribution" to university intellectual potential) confirm the hypothesis that the main factors determining the level of university intellectual potential are highly qualified teaching staff, their research, and work.

The purpose of using university intellectual potential is to support the economic and social development of the state by providing economic entities with qualified personnel; spreading and accumulating knowledge, skills, and competencies; conducting scientific research, research, and innovation; assisting the country's integration into the world educational space. An important factor in improving the scientific reputation of the university, its financial stability, and attracting students and new employees is the creation of an innovative ecosystem of the university, which should be focused on a specific result: technologies that have been brought to implementation and have given income.

It is necessary to develop a simulation analytical model for assessing intellectual potential, based on the proposed approach, which will allow predicting the level of intellectual potential of the university depending on changes in the parameters (indicators of intellectual potential) of the simulation model. Therewith, it is necessary to pay attention to finding a quantitative relationship between the value of the intellectual potential formed at the university and the results of the university's activities. In this regard, there is an objective need to study the problem of converting intellectual potential into competitive advantages of the university.

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