Multidimensional Statistical Analysis Methods in the Study of University Activities

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Abstract. The task of increasing the university's rating in international rating systems is urgent. An approach to solving the problem is proposed to ensure the required values of the basic indicators of the university's activity in the international institutional ranking QS using models developed on the basis of SWOT analysis methods, as well as correlation-regression and factor analysis. SWOT - analysis methods allowed to identify a set of factors that affect the main indicators of the university. Based on the methods of correlation-regression analysis, estimates of the relationship between base indicators and rating are obtained. A comparative analysis of the results obtained for the universities of the reference group is carried out. Based on the methods of factor analysis, a set of latent factors has been identified that have a significant impact on the basic indicators. It is shown that measures to achieve the specified indicators must be carried out considering the identified correlations between latent factors and basic indicators, as well as the results of interpretation of the developed factor model. The novelty of the developed proposals lies in the assessment of the significance of latent factors influencing the basic indicators of the university's activity, based on the use of correlation-regression methods and methods of factor analysis. The developed factorial model made it possible to structure and group the obtained data, as well as to reduce the dimension of the problem being solved. The results obtained made it possible to substantiate the conditions for achieving the required indicators of the university ranking in the international institutional ranking QS.

Keywords: Correlation - Regression Analysis, Factor Analysis, Basic Indicators, Institutional Rating.

1. Introduction

The Ministry of Education and Science has launched Project 5-100, which is a state program to support the largest Russian universities [1]. The goal of the project is to increase the prestige of Russian higher education and to bring at least five universities out of the project participants to the top 100 universities in three authoritative world

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rankings: Quacquarelli Symonds (QS), Times Higher Education (THE) and Academic Ranking of World Universities.

Currently, the QS institutional ranking includes 25 Russian universities [2,3]. In the first place among Russian universities is the Moscow State University, who entered the top 100 of the institutional rating at 74th position, in second place - Novosibirsk National Research State University (228th position), participating in the "Project 5-100", in third place - St. Petersburg State University (225th position). The Higher School of Economics (HSE), as of 2020, takes the 298th position, the National Research Technological University "MISiS" - 428th position, the Plekhanov Russian University of Economics - 755th position.

Over the past 5 years, Russian universities have shown noticeable dynamics in entering the top 500 of the QS institutional rating, having increased their representation by one and a half times, mainly due to the participants of the "Project 5-100". This indicator is one of the main benchmarks of the federal project "Young Professionals".

In view of the above, the leadership of the Plekhanov Russian University of Economics, the task was formulated to move in the world ranking of universities QS by 2025. to the position currently occupied by MISIS. For this purpose, an analysis of the conditions for achieving a given position was carried out and, based on the developed models, proposals were justified to ensure the fulfillment of the task.

The purpose of the research is to develop scientifically grounded proposals for increasing the target performance indicators of the university, considering the impact on them of latent factors in the international institutional ranking QS to the required values. The degree of achievement of the set values of the baseline readings and, as a consequence, the rating of the university depends on changes in latent factors.

To achieve this goal, the methods of SWOT - analysis, as well as methods of correlation - regression and factor analysis were used, which made it possible to identify the degree of influence of latent factors on the basic indicators and the main indicator (rating) functional.

The task was solved in 4 stages. At the first stage, the analysis of the correlation of the basic indicators that ensure the promotion of Plekhanov Russian University of Economics in the institutional ranking QS World University Ranking: academic reputation, reputation with the employer, the ratio of the number of students to the number of academic staff, citations per teacher, international teachers, international students. The listed indicators are used in the university ranking system and are presented in the QS - analytics information and analytical system [4]. Based on the methods of correlation and regression analysis in the environment of the analytical platform Deductor 5.3, the pairwise correlation coefficients of the functional values and basic indicators for the Plekhanov Russian University of Economics and MISIS University. Based on the obtained values, the analysis of the correlation of indicators providing the promotion of Plekhanov Russian University of Economics in the QS World University Ranking. The calculation results made it possible to assess the closeness of the relationship between the base indicators and the rating functionality.

At the second stage, to identify the factors affecting the basic indicators of the university's activity, to identify the most significant factors, their SWOT analysis was carried out [5-8].

As you know, the SWOT analysis technique involves a deep analysis of the object of research, provides the most objective assessment of it in terms of the strengths (positive) and weak (negative) sides of the external and internal environment, as well as opportunities and threats. The results of the SWOT analysis made it possible to subsequently build the problem field of the situation, on the basis of which the goals and objectives of cognitive modeling were formulated, and the structure of the cognitive map was determined, with the help of which the problem of predicting the performance indicators of the university was solved.

When constructing the problem field of the situation for structuring knowledge, the object-structural approach was used [9], according to which the analysis and presentation of knowledge is carried out in strategic, organizational, conceptual, functional, spatial, temporal, causal and economic aspects (strata).

The purpose of a SWOT analysis is to maximize the strengths of professional activities, minimize weaknesses, and use favorable opportunities to improve activities. SWOT analysis includes an analysis of the situation inside the university, as well as an analysis of external and internal factors and the situation in the educational services market.

SWOT analysis made it possible to identify and structure the strengths and weaknesses, potential opportunities and threats, as well as many factors, which must be taken into account when developing a university development strategy and achieving the required values of key indicators.

The SWOT analysis technology includes the following stages:

1. Formation of a list of strengths and weaknesses;
2. Formation of a list of risks (dangers) and opportunities;
3. Revealing connections between various elements of the lists;
4. Positioning of different strategy options.

For the SWOT analysis, materials related to the activities of the university were used, as well as materials from the site of the International Institutional Ranking QS World University Rankings [4].

The use of the SWOT analysis methodology provided a deep diagnosis of the university's activities based on the totality of its assessments in the following areas:

- S (strength) - strengths;
- W (weakness) - weaknesses;
- O (opportunity) - favorable opportunities;
- T (threat) - threats.

The results of the analysis made it possible to structure the knowledge of experts using the problem field of knowledge, to build and identify, based on the method of expert assessments, a set of factors and the degree of their influence on the performance indicators of the university.

Registration of the SWOT analysis results was carried out in a tabular form, where the main elements were recorded according to the categories presented (Table 1).

If necessary, combinations of different elements of the SWOT analysis allow you to form certain local strategies:

Table 1. Results of SWOT analysis.

The analyzed factors (characteristics)	**The degree of embodiment of the factor (characteristics) Strong factor + Weak factor -**	**The degree of importance of the factor (characteristics)**
1. Availability of well-known scientific schools and dissertation councils	Strong factor +	0,6
2. The presence of close collaboration with foreign universities and research organizations (the number of joint research projects	Strong factor +	0,3
3. Availability of basic departments at enterprises	Strong factor +	0,2
…..	….	…..
N. Factor (characteristic)	….	….

1. The combination of "opportunities - strengths" - development strategy.

2. The combination of "opportunities - weaknesses" - a strategy for internal transformation.

3. The combination of "threats - weaknesses" is seen as a limitation of strategic development.

4. The combination of "threats - strengths" is used as a strategy for potential benefits.

The result of the SWOT analysis was the identification and grouping of a set of latent factors that affect the performance of the university. Since the number of factors influencing the activities of the university is a significant value, it became necessary to highlight the most significant factors, taking into account the correlation relationships, including the factors of the second level that affect the factors of the first level.

At the third stage of the study, the most significant latent factors affecting the basic indicators of the university's activity were identified using the methods of factor analysis. Their grouping was carried out, as well as an assessment of their significance and the degree of influence on the basic indicators. The use of the mathematical apparatus of factor analysis made it possible to reduce the dimension of the problem being solved and to ensure the structuring of the data obtained. Interpretation of the results of factor analysis made it possible to identify latent factors that provide the main contribution to obtaining the result.

At the fourth stage of the study, a set of measures was substantiated to achieve planned indicators to increase the institutional ranking of the QS University.

Thus, a new approach to solving the problem of providing conditions for achieving the required values of the university performance indicators in the international institutional ranking QS using models developed based on statistical analysis methods is proposed. The novelty of the approach is determined by obtaining estimates of the strength of the relationship between the basic indicators and their relationship with the rating functional based on the methods of correlation-regression analysis, solving the problem of identifying latent factors based on the application of SWOT-analysis methods and the method of the main components of the developed factor model, reducing the dimension of the problem being solved, since a large number of interrelated (dependent, correlated) variables significantly complicates the analysis and interpretation of the results obtained, and a reasonable assessment of the degree of influence of latent factors on the basic indicators, which made it possible to formulate a list of necessary measures to solve the problem of increasing the university's rating.

Section 2 contains a literature review on the research topic, section 3 presents the results of assessing the correlation of university performance indicators, section 4 based on the factor analysis method provides identification of latent factors and an assessment of their significance, section 5 substantiates measures to achieve the planned performance indicators of the university.

2. Literature Review

The issues of SWOT - analysis and its application for the study of socio-economic systems are considered in works [5-8]. A fairly large number of works by domestic and foreign scientists are devoted to the problem of applying the methods of correlation-regression and factor analysis [10-28]. In works [10-16] theoretical issues of statistical analysis are considered, in works [17-23] the features of the application of methods of correlation-regression and factor analysis in the socio-economic sphere are considered, in works [24-28] the features of building applied statistical models are considered.

The analysis of the sources showed that in the presented formulation, the problem of substantiating the conditions for achieving the required values of the university performance indicators in the international institutional ranking QS using models developed on the basis of methods of correlation-regression and factor analysis was not solved.

3. Methodology. Application of correlation and regression analysis of university performance indicators

The following initial data on the university for the period 2013 - 2020 were taken as a basis for calculations: rating functionality, basic indicators - academic reputation; reputation with the employer; the ratio of the number of students to the number of teaching staff; citations per teacher; international teachers; international students.

Based on the methods of correlation and regression analysis in the environment of the analytical platform Deductor 5.3, the pairwise correlation coefficients of the functional values and basic indicators for the Plekhanov Russian University of Economics, and for "MISiS" (Table 2) using the Pearson test (allows you to assess the significance of differences between the actual and theoretical number of characteristics of the sample).

Coefficients of pairwise correlation between the basic indicators were calculated in a similar way. In accordance with the Chaddock scale (Table 3), an assessment of the tightness of the connections of the correlation comparisons was carried out [10].

Table 2. Matrix of rating functional correlation with basic indicators using Pearson criteria.

Basic indicators	**Rating functional, Plekhanov Russian University of Economics**	**Rating functional, MISIS**
AR	0,152	0,854
ER	0,726	0,607
RS/T	0,939	0,511
CT	0,141	0,883
IT	0,182	0,494
IS	0,604	0,667

Table 3. Chaddock scale.

Pairwise correlation coefficient	**Bond strength**
up to 0,3	Practically absent
0,3-0,5	Weak
0,5-0,7	Noticeable
0,7-0,9	Strong

The calculations made it possible to draw the following conclusions.

The presence of a strong connection between the rating functional and the basic indicators was revealed: “The ratio of the number of students to the number of teaching staff” (r = 0.939), “Reputation with employers” (r = 0.726) and “International students” (r = 0.604). The strength of the link between the rating functionality and other indicators is practically absent.

For the rating functional "MISiS" the greatest closeness of connection was revealed for the basic indicators "Academic reputation" (0.854) and "Citations per teacher" (0.883), the smallest - for the indicator "International teachers".

A more reliable criterion for assessing the tightness of relationships is a statistical assessment of the coefficients of pair correlation by comparing its absolute value with the table value rcrit, which is selected from a special table [11]. If the inequality $|r_{calc} \geq r_{crit}|$ is satisfied, then with a given degree of probability (usually 95%) it can be argued that there is a significant linear relationship between the numerical populations under consideration. That is, the hypothesis about the significance of the linear relationship is not rejected. In the case of the opposite relation, i.e., for $|r_{calc} < r_{crit}|$, a conclusion is made about the absence of a significant connection.

In accordance with the table “Critical values of the correlation τcrit for the significance level α = 0.05, the probability of an admissible error in the forecast 0.95, and the degree of freedom $f = n\text{-}k = 4$ (for a given number of measurements $n = 6$, the number of calculated constants $k = 2$, in the formula for calculating r involves two constants $-x$ and $-y$), the tabular value $r_{crit} = 0.811$ is found.

The calculation results (hypothesis testing) are presented in table. 4 practically confirmed the grades obtained on the Chaddock scale, except for the indicator "International students".

Table 4. Strength of connection between functionality and indicators.

$R = r^2$	r_{calc}	r_{crit}	**Bond strength**
AR	0,140	0,811	Insignificant
IT	0,194	0,811	Insignificant
IS	0,636	0,811	Insignificant
RS/T	0,952	0,811	Significant
ER	0,854	0,811	Significant
CT	0,174	0,811	Insignificant

The calculation of the coefficients of determination ($R = r^2$), which is a measure of the variability of the result y (the value of the rating functional) as a percentage of the change in the factor (base indicator) x showed that for the base indicator "Number of students in relation to the teacher" $r^2 = 0.9063 = 90.3\%$ means that 90.3% of the functional variation is determined by the basic indicator “Number of students in relation to the teacher”.

At the next stage of the study, the identification and interpretation of latent factors affecting the baseline indicators was carried out using the methods of factor analysis, which is a class of multivariate statistical analysis procedures aimed at identifying latent variables (factors) responsible for the presence of correlations between the observed variables [12-14].

4. Results. Identification of Latent Factors and Assessment of their Significance

Factors are groups of certain variables that correlate with each other more than with the variables included in another factor. Thus, the meaningful meaning of the factors can be identified by examining the correlation matrix of the initial data.

To assess the influence of latent factors on basic indicators, one of the most common methods of factor analysis, the principal component method, was used, which makes it possible to reduce a large number of interrelated variables, since a large number of variables significantly complicates the analysis and interpretation of the results [14].

The mathematical model of factor analysis is a set of linear equations in which each observed variable xi is expressed as a linear combination of common factors F_1, F_2, …, F_n and a unique factor U_i [14]:

$$x_i = \sum_{k=o}^{n} a_{ik} F_k + U_i \quad (2)$$

where x_i is a variable, i = 1, m, (m is the number of variables); n is the number of factors; $n<m$, a_{ik} - factor load; F_k - common factor, k = 1, n; U_i is a private factor.

The factor analysis procedure includes the following stages [15-18].

Stage 1. Construction of the correlation matrix of the system of variables by calculating the Pearson's linear correlation coefficients.

Stage 2. Extracting factors and calculating factor loads a_{ik}, which are the main subject of interpretation. At this stage, methods of component analysis (principal component analysis), principal factors and maximum likelihood are used. When solving the problem, the method of principal components was used, which made it possible to select groups of closely correlated variables in a multidimensional space and replace them with principal components without loss of information content.

The mathematical model of the principal component method is represented by formula (3).

$$y_j = \sum_{i=1}^{k} \alpha_{ij} z_i \,, \quad (3)$$

where: y_j is the main component; α_{ij} is the coefficient reflecting the contribution of the variable z_i to the principal component y_i; z_i - standardized initial variable $z_i = (x_i - \bar{x}_i)/s_i$, s_i - variance, i = 1, k.

The calculation of the principal components is reduced to the calculation of eigenvectors and eigenvalues ($\lambda_1, \lambda_2, \ldots, \lambda_k$) of the correlation matrix of the initial data. The α_{ij} values are factor loadings. They represent the correlation coefficients between the original variables and the principal components. Factors include those variables for which $|\alpha_{ij}| > 0{,}7$.

To reduce the dimension of the space $Y = (y_1, y_2, \ldots, y_k)$ by cutting off non-informative variables, the Kaiser criterion is used, which is associated with eigenvalues: the number of principal components includes variables that correspond to the eigenvalues $\lambda_i > 1$, since their informative value is higher.

Stage 3. Rotation of the factorial solution, which is used if the selected factors cannot be interpreted clearly enough.

For the analysis and interpretation of the results obtained, the varimax method and the quartimax method are used [19-23]. Varimax is the method most often used in practice, the purpose of which is to minimize the number of variables that have high loads on the given factor (which helps to simplify the description of the factor by grouping around it only those variables that are more associated with it than with the rest), cannot be used, since in the problem being solved the variables (basic indicators) cannot be reduced, since they are all significant. Considering the above, to interpret the results of factor analysis, we used quartimax, a method that ensures the reduction (minimization) of the number of factors necessary to explain the variation of a variable.

The mathematical apparatus of factor analysis made it possible to solve the following two problems [24-28]:

1) reducing the dimension of the number of variables used due to their explanation by a smaller number of factors;

2) grouping and structuring of the received data.

Thus, the result of the application of the principal component method is the calculation of the eigenvalues of the factors, the volume of the explained variance in% (the contribution of each factor to the obtained result), the total percentage of variance (the total contribution of factors to the final result (Table 5) and the construction of the matrix of factor loads (Table 6), which is the correlation coefficients between the original variables (baseline indicators) and the main components (factors).

Table 5. Factor analysis results.

Principal components	**Eigenvalues**	**Contribution to the result**	**Total contribution**
Value 1	3,715	61,9133%	61,9133%
Value 2	1,364	22,7306%	84,6439%
Value 3	0,585	09,7306%	94,3924%
Value 4	0,276	04,5992%	98,9916%
Value 5	0,060	01,0067%	99,9983%
Value 6	0.000	00.0017%	100,0000

The factor loadings matrix illustrates the strength of the relationship between a variable and a factor. The higher the factor load in absolute terms, the higher the bond strength.

The eigenvalue of the factor λ_i reflects its contribution to the variance of variables, explained by the influence of general factors. In accordance with the Kaiser criterion, it is believed that those factors for which this indicator is significantly less than 1.0 do not make a significant contribution to the result explanation.

Table 6. Factor loading matrix.

Variables	**Final factors (Quartimax method)**			
	Factor 1	**Factor2**	**Factor3**	**Factor4**
AR	0,2466		0,684	
ER	0,2938	0,8769	0,1026	0,3664
RS/T	0,1357	0,9455	0,1416	0.2490
CT	0,9754		0.1113	0,1470
IT	0,9906			0,1090
IS	0,7938	0,5435	0,2365	

The second calculated indicator in Table 5 is the percentage of explained variance of variables (column - total contribution). It is generally accepted that with a well-grounded factorial solution, so many factors are chosen so that they together explain at least 70-75% of the variance. In some cases, this figure can reach 85-90%.

In the problem being solved, the first 4 factors turned out to be significant (see Table 7), providing a contribution to obtaining the result equal to 99%. The contribution of the first factor is equal to 61.91%; the second factor - 22.73%; the third factor is 9.75%, and the fourth factor is 4.60%.

The factorization of the matrix (the procedure for extracting factors) for various levels of significance is carried out. It is generally accepted that with a well-grounded factorial solution, so many factors are chosen so that they together explain at least 70-75% of the variance. In some cases, this figure can reach 85-90%. The factor loadings matrix illustrates the strength of the relationship between a variable and a factor. The higher the factor load in absolute terms, the higher the bond strength.

Thus, the interpretation of the results of the performed factor analysis made it possible to extract the significant factors of the first level (affecting the basic indicators), the second level (affecting the factors of the first level) and calculate the factor load.

The results of the interpretation of factor analysis and the identification of significant factors of the first and second levels (with an indication of the expert assessment of the factor's weight) made it possible to form a list of factors of the first and second levels that affect the basic indicators:

Level 1 factors (affect the underlying factors): F1, The presence of well-known scientific schools and dissertation councils (0.6); F2, Close collaboration with foreign universities and research organizations (number of joint research projects (0.3); F3, Availability of basic departments at enterprises (0.2); F4, Number of publications in the Scopus database, WoS (0.6); F5, Availability of demanded directions and training profiles (0.3); F6, The qualification level of the teaching staff (the number of the teaching staff of the highest qualification) (0.2); F7, Number of teaching staff (0.6); F8, The level of training (competencies) of students (0.5); F9, Number of teaching staff with language training; (0.4); F10, places in a hostel (0.2); F11, Demand for graduates from employers ((0.3); F12, Areas for educational activities (0.3); F13, The level of payment for the teaching staff (0.4); F14, Stimulating factors (0.2); F20, Foreign Entry Company (0.3).

Level 2 factors (affect the level 1 factors): F15, Expansion of the teacher social package (0.3); F16, Change in the structure of employment of the teaching staff (0.3); F17, The share of teaching staff planning to build an international scientific career (0.2); F18, Academic mobility of the teaching staff (0.3); F19, Convergence of educational programs with foreign universities (0.4); F21, Increase in the number of On-line courses MOOCs (0.3), F22, Implementation of individual educational trajectories (0.4); F23, Implementation of distance technologies (0.3); F24, The tightness of the relationship with the employer (0.4).

The interrelationships of factors are presented in the form of a graph (Fig. 1), based on which a cognitive model was subsequently developed.

When constructing a graph, the following designations are adopted:

AR - Academic reputation; ER - Reputation with employers; RS/T - The ratio of the number of students to the number of teaching staff; CT - Citations per teacher; IT - International teachers; IS - International students, F1-F24 factors of the first and second orders.

In accordance with the results of the identification of factors, the most significant factors influencing the baseline indicators are:

- factor 1, which affects the indicators of RR, CT, IT, IS and includes a set of private factors: the number of teaching staff, the level of their qualifications and the presence of close collaboration (the number of joint research projects) with foreign universities and research organizations, foreign applicant company.

- factor 2, which affects the RS/T indicator and includes a combination of private factors: the number of teaching staff, the level of payment for the teaching staff.

- factor 3, which affects the AR indicator and includes a set of private factors: The presence of well-known scientific schools and dissertation councils, The presence of

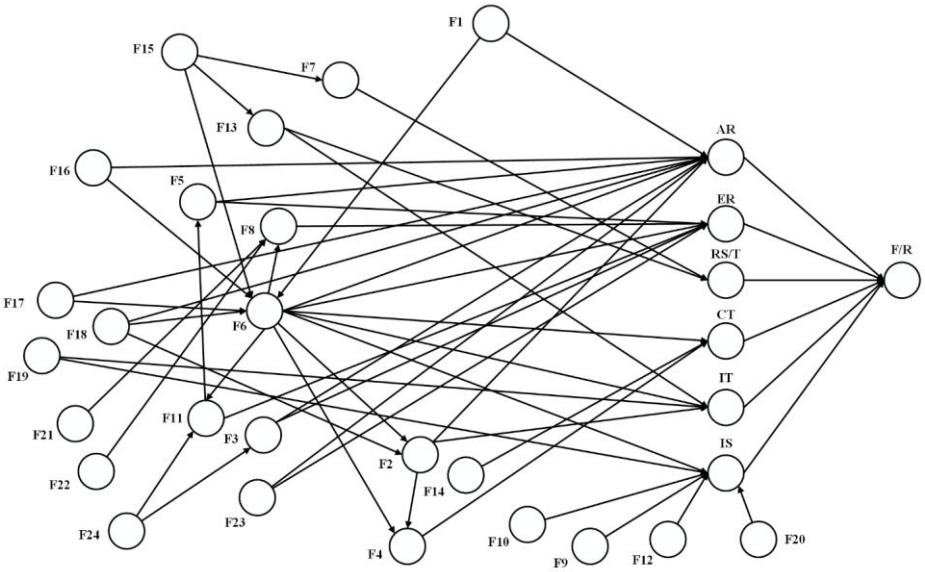

Fig. 1. Relationships Graph between factors of the first and second levels F1-F24, basic indicators (AR, ER, RS/T, CT, IT, IS) and the rating indicator F / R

close collaboration (the number of joint scientific projects) with foreign universities and scientific organizations, The number of teaching staff, The level of their qualifications, The introduction of distance technologies, The introduction individual educational trajectories.

- factor 4, which affects the ER indicator and includes a set of particular factors: the level of training (competencies) of students, the demand for graduates from the employer, the presence of basic departments at enterprises, the introduction of distance technologies, close interaction with the employer.

Thus, the results of the interpretation showed that the factors 1,2,3 have the greatest influence on the basic indicators. Those, the task of increasing the values of these indicators is directly related to the increase in the values of the factors of the first and second levels, characterizing:

- The number of teaching staff and the level of their qualifications; The presence of close collaboration (number of joint research projects) with foreign universities and scientific organizations; The level of training (competencies) of students, The demand for graduates from the employer; Availability of basic departments at enterprises; Availability of well-known scientific schools and dissertation councils; Introduction of remote technologies; Close interaction with the employer; Foreign entrant company; Implementation of individual educational trajectories.

Based on the graph of relationships (Fig. 1), a cognitive model of scenario forecasting has been developed, which makes it possible to select the most preferable scenario for the increment of latent factors to achieve the required value of the rating indicator under the conditions of the given restrictions.

5. Discussion. Measures to achieve the planned indicators of the university

The results obtained in paragraphs 3-4 made it possible to substantiate a set of measures to increase the values of particular indicators (factors) necessary to solve the problem of achieving university performance indicators by 2025, corresponding to the level of MISIS indicators in 2019.

Correlations between the functional and basic indicators are obtained. The presence of a strong connection of the functional with the indicators: "The ratio of the number of students to the number of teaching staff" (r = 0.952), "Reputation with employers" (r = 0.854) and "International students" (r = 0.636) The strength of the relationship of the functional with other basic indicators is insignificant.

The largest contribution (98.9%) to the final result (the value of the rating functional and the corresponding place in the QS rating) is made by the following particular indicators: The number of teaching staff and the level of their qualifications; Close collaboration (number of joint research projects) with foreign universities and research organizations; The level of training (competencies) of students, The demand for graduates from the employer, The presence of basic departments at enterprises, The presence of well-known scientific schools and dissertation councils, The introduction of distance technologies; Close interaction with the employer; Foreign entrant company; Implementation of individual educational trajectories.

Measures to increase the values of latent indicators should be carried out considering the obtained correlation dependences of the most significant factors affecting the basic indicators.

6. Conclusion

The use of SWOT analysis methods made it possible to solve the problem of identifying latent factors that affect the basic indicators of the university's activity. An approach based on the methods of correlation-regression and factor analysis has been

developed to solve the problem of providing conditions for achieving the required values of the performance indicators of the university in the international institutional ranking QS

The developed correlation-regression model made it possible to calculate the pairwise correlation coefficients of the values of the functional and basic indicators for the Plekhanov Russian University of Economics and MISIS University, the rating indicators of which are taken as a basis, as well as to carry out a comparative analysis of the results obtained for the universities of the reference group, to reveal the strength of the relationships between the basic indicators and their links with the rating functionality.

The procedures of multivariate statistical analysis using the method of principal components of the developed factor model made it possible to solve the problem of identifying and interpreting latent factors affecting the basic indicators, to identify the most significant factors, to ensure their grouping and structuring, as well as to reduce the dimension of the problem being solved, which made it possible to analyze its results.

The results obtained on the basis of the developed models made it possible to formulate a list of activities and substantiate the feasibility of their implementation in order to solve the problem of achieving the specified indicators of the university's activity.

The proposed approach is new. The obtained estimates of the correlation dependences between latent factors and basic indicators, the results of identifying latent factors formed the basis for constructing a cognitive model of scenario forecasting of measures to achieve the required values of the target indicators of the university's activity in the international institutional ranking QS.

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References

1. Decree of the President of the Russian Federation of May 7, 2012 "On measures to implement state policy in the field of education and science", URL: https://www.pravo.gov.ru
2. Information and analytical system QS - analytics Access mode, URL: https://analytics.qs.com/#/signin
3. The project to increase the competitiveness of leading Russian universities among the world's leading scientific and educational centers, URL: https://www.5top100.ru
4. Ratings of world universities, URL: https://www.education index.ru
5. Belyaev V.I. Marketing: fundamentals of theory and practice: textbook. 2nd ed., Stereotype. Moscow, KNORUS; 2007.
6. Bogomolova EV SWOT analysis: theory and practice of application. Economic analysis: theory and practice. 2004; 17(32):57-60.

7. Bogomolova E.V. Conceptual approach to the application of the SWOT analysis method in trade organizations to assess the efficiency of the organization's functioning. Audit and financial analysis.
8. Ivanova E.A. Features of the application of SWOT analysis in the marketing activities of Russian enterprises. Scientific Bulletin of the Ural Academy of State Service. 2009; 1(6).
9. Gavrilova T.A., Khoroshevsky V.F. Knowledge base of intelligent systems. SPb.: Peter, 2000.
10. Baraz V.R. Correlation and regression analysis of the relationship between indicators of commercial activity using the Excel program: a training manual. Yekaterinburg: State Educational Institution of Higher Professional Education “USTU - UPI”; 2005.
11. Draper N. Applied regression analysis. M.: Williams I.D., 2019.
12. Sokolov G.A. Introduction to regression analysis and planning of regression experiments in the economy: Textbook. M.: Infra-M, 2016.
13. Ayvazyan S.A., Buchstaber V.M., Enyukov I.S., Meshalkin L.D. Applied statistics. Classification and reduction of dimension. M.: Finance and Statistics, 1989.
14. Rao S.R. Linear statistical methods and their applications. M.: Fizmatlit; 1968.
15. Fomina E.E. Factor analysis and categorical method of the main components: a comparative analysis and practical application for processing the results of the survey. Humanitarian Bulletin. 2017, no. 10. doi: 10.18698/2306-8477-2017-10-473
16. Jia-Fen Wu. Reproducing an Alternative Model of Intercultural Sensitivity for Undergraduates from Taiwan and Hainan. International Journal of Modern Education and Computer Science. 2016; 8(1):1-7. doi: 10.5815/ijmecs.2016.01.01
17. Olabiyisi S.O. Adetunji AB, An Evaluation of the Critical Factors Affecting the Efficiency of Some Sorting Technique. International Journal of Modern Education and Computer Science. 2013; 8(2):25-33. doi: 10.5815 /ijmecs.2013.02.04
18. Jayakishan Meher, Ram Chandra Barik, Madhab Ranjan Panigrahi, "Cascaded Factor Analysis and Wavelet Transform Method for Tumor Classification Using Gene Expression Data", International Journal of Modern Education and Computer Science. 2012; 9(2):73-79. doi: 10.5815/ijitcs.2012.09.10
19. Seagal E. Practical business statistics. Williams, Moscow; 2002.
20. Godin A.M. Statistics: textbook. M. Publishing and Trading Corporation Dashkov and Co.; 2002.
21. Bureeva N.N. Multivariate statistical analysis using the STATISTICA IFR. Nizhny Novgorod, Novosibirsk State University N.I. Lobachevsky; 2007.
22. Jolliffe I.T. Principal Component Analysis, Series: Springer Series in Statistics, 2nd ed., Springer, NY, 2002, XXIX.
23. Gorban AN, Kegl B., Wunsch D., Zinovyev AY (Eds.), Principal Manifolds for Data Visualization and Dimension Reduction, Series: Lecture Notes in Computational Science and Engineering 58, Springer, Berlin - Heidelberg - New York, 2008 XXIV.
24. Bolch B., Huan K.D. (1974). Multidimensional statistical methods for business and economics. M.: Statistics, 1979.
25. Nivorozhkina L.I. Multidimensional statistical methods in economics. Moscow: RIOR: INFRA-M, 2018.
26. Abraham B., Ledolter J. (1983). Statistical methods for forecasting. New York: Wiley.
27. Lawley D.N. Factor analysis as a statistical method. Moscow, Mir, 1997.
28. Tereshchenko O.V. et al. Multivariate statistical analysis of data in the social sciences: textbook. allowance. Minsk: BSU; 2012.