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COMPARATIVE ANALYSIS OF THE ACADEMIC PERFORMANCE IN THE AGRICULTURAL UNIVERSITIES FROM ROMANIA AND REPUBLIC OF MOLDOVA USING THE NONPARAMETRIC METHOD OF DATA ENVELOPMENT ANALYSIS

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Abstract

The aim of the paper is to evaluate adequately the academic performance efficiency of the teaching and research staff employed in the agricultural higher education institutions and organizations in the field of agricultural science and innovation. At the same time it is developed the nonparametric method of Data Envelopment Analysis for rating assignment DEA_UASM. As a result of analyzing the academic performance rating by option variable returns to scale, it is possible to determine the resources for improving staff activity by evaluating the distance function for each causal factor.

***Key words*:** *academic performance, data envelopment analysis, higher education, research rating*

INTRODUCTION

Conducting a general, complex and specific analysis of the Human Resource Management within the organizations, including the agricultural ones, we could state that Human Resource Management deals with finding the most effective ways to improve and use staff skills, competencies and knowledge: starting with recruiting and hiring qualified people for vacant positions and continuing with directing and encouraging staff development and training as they face issues and challenges that may occur along the way of achieving the established goals. The goals of the Human Resource Management can be grouped as follows: organizational, personal and economic goals. Academic performance in the field of staff management represents the achievement of organization's goals, methodological-didactical results, stability, flexibility and adaptability to the changing environment with minimal staffing costs. The indicators that characterize the academic performance are the following: efficiency of the activity results, material efficiency of the academic process and non-material efficiency of the academic process. Social efficiency can be defined as the level of satisfying the interests and needs of the staff, namely: remuneration for work, its content, the possibility of personal self-realization, improving staff's communication and job satisfaction through team building strategies. The indicators that characterize social efficiency focus on the employment objectives and objectives related to relationships with other employees. Economic efficiency refers to the organizations operating under conditions of market economy and competition, but staff management also extends to non-commercial organizations, and respectively to central and local administrative-public organizations and state institutions that do not have as targets the maximization of profits and significant gains in competitive struggle. Employee productivity means achieving the goals of any organization with minimum resources. Staff management represents the activity of providing the organization with employees of a certain qualification and quality, their

motivation and use in achieving the goals related to the economic and social efficiency [1].

The resources of agricultural higher education institutions and organizations in the field of agricultural science and innovation include the material, financial, human and informational potential they have at a given moment:

-*Material resources* that represent the physical components of the capital of an agricultural higher education institution and organizations in the field of agricultural science and innovation, which also include study facilities, libraries, accommodation and other spaces, etc.;

-*Financial resources* that include the potential of the higher agricultural education institution and organizations in the field of agricultural science and innovation in the form of money from the state budget as well as from special means;

-*Human resources* representing the teaching, scientific and auxiliary staff, the most active and creative resources at the level of an agricultural higher education institution and organizations in the field of agricultural science and innovation;

-*Information resources* that constitute a real tool for managers to take advantage of opportunities that appear in the academic environment or to avoid situations that could endanger the scientific, teaching, research and innovation activity.

Generally, sustainable development of agriculture and rural areas in the Republic of Moldova is conditioned by a number of factors, among which, the human resources with a high level of qualification and professional training occupy, in our opinion, a priority position. Considering the present level of development and capitalization of agricultural enterprises in the rural areas of the Republic of Moldova, and the competition on a free market that forces them to confront directly with the Western partners much better positioned, both in terms of existing facilities and of the necessary human and financial resources, they are forced to act operatively to reduce these gaps. The staff employed in agricultural higher education institutions and organizations in the field of agricultural science and innovation represents the main resource of any agricultural institution, the quality and efficiency of which depend to a great extent on the results of their activity and competitiveness. Human resources are the engines that set in motion the material, financial and informational elements, develop new inventions and make innovations, develop and promote science, create new products and services, homologated varieties, and concomitantly, train young specialists who become graduates with a wide range of agricultural specialties and specializations required on the labour and educational market.

This essential component of an economy that depend on the agricultural higher education institutions and organizations in the field of agricultural science and innovation contributes significantly to the economic development and growth of a country in general and of the rural areas in particular by training and providing the necessary number of qualified specialists in various fields. It is therefore necessary to make a more comprehensive assessment of the academic performance of staff employed in higher agricultural education institutions and organizations in the field of agricultural science and innovation in order to identify whether all costs provided for research, teaching-learning and innovation activities are being used efficiently and effectively. All the more, it is necessary to identify those optimal performance standards through which agricultural higher education institutions and organizations in the field of agricultural science and innovation could make the most efficient use of the ratio of all existing resources under any form of inputs and outputs.

MATERIALS AND METHODS

Our survey included a sample of 228 students enrolled at four faculties of the University of Agricultural Sciences and Veterinary Medicine of Bucharest (USAMV) in 2017. As for the State Agrarian University of Moldova (UASM), the survey was similar to the one

carried out in Bucharest and included a sample of 324 respondents i.e. 3rd, 4th and 6th year students. In recent years, several studies have been conducted to determine performance efficiency of the academic staff employed in higher education institutions using Data Envelopment Analysis (DEA). If we emphasize the importance of implementing DEA, then we can observe that in most cases the studies are conducted on two segments, the first being at the academic performance level of the higher education institution (the strategic level), and the second segment being at the level of departments/faculties or laboratories (operational level) within these institutions. At the same time, the method of Data Envelopment Analysis has been widely applied to various industries such as healthcare, transport, and many other industries and organizations [3]. The scientific and unique novelty of our research consists in the fact that we conducted a DEA involving all three hierarchical levels of a modern organization: strategic, operational and individual level. The efficiency of the object under evaluation can be defined as the ratio of the weighted sum of outputs over the weighted sum of inputs [4].

RESULTS AND DISCUSSIONS

According to the framework regulation on the standardization of the scientific-teaching activity in the higher education system, the full time status of staff means that the employee has a didactic/scientific/scientific-didactic position, who carries out his/her basic activity in the higher education institutions and who is registered nominally in the institution's framing scheme.

It is described the comparative analysis of the academic performance of different faculties and different years of study in the Fig. 1 and Fig. 2. The best academic performance is obtained by the faculty of Biotechnologies with the 8.24 rating. As to the results obtained by the students at the different years in the Faculty of Management, Economic Engineering in Agriculture and Rural Development in the 2017 we can state that the best is the four year of the study. The scientific innovation of the paper consists in justifying the method of assessing the academic performance by using the linear programming techniques of the data envelopment analysis in the comparison of results obtained by the University of Agricultural Sciences and Veterinary Medicine of Bucharest and the State Agrarian University of Moldova. A nonparametric rating approach has been developed to evaluate the performance management in the higher education and research.

The notion of teaching staff includes several scientific, didactic and teaching positions (recently also called functions), such as: university assistant, university lecturer, senior lecturer (it disappeared as a didactic-scientific position in November 2014 with the entry into force of the Education Code), associate professor and university professor.

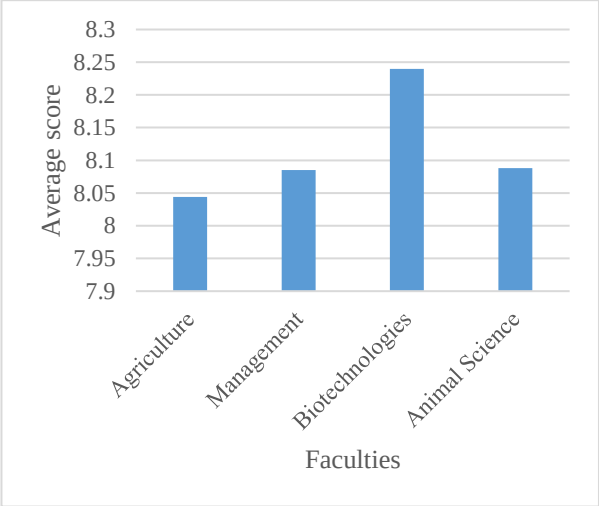

Fig. 1. The academic achievement of the students of the faculties of USAMV in the 2017 year.
Source: Own calculations based on data of the Survey.

Each successive teaching position corresponds to a higher professional level, the highest being the university professor. All these positions, except for the first one, are taken by competition every five years. Respectively, we consider it appropriate to carry out a detailed analysis of the scientific-didactic and didactic positions regarding the level of quality and professional development.

The comparative analysis of the students' academic performance in the two agricultural higher education institutions supposes to

identify the indicators able to better highlight the efficiency of the performed study.

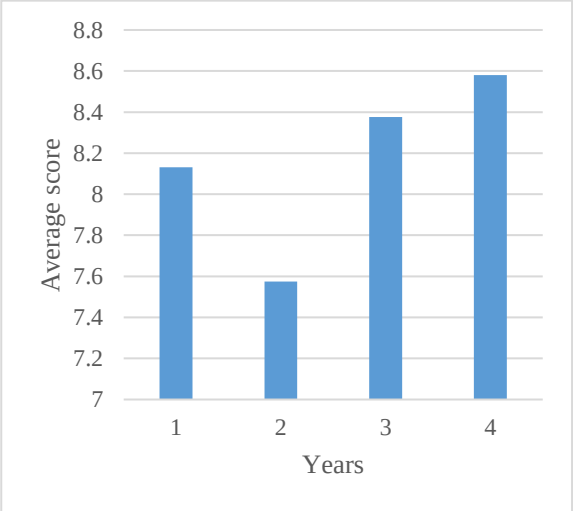

Fig. 2. The academic achievement of the students of the Faculty of Management, Economic Engineering in Agriculture and Rural Development USAMV.
Source: Own calculations based on data of the Survey.

First, we can mention the rating of performance assessed through data envelopment analysis techniques which, compared to the average score of academic success, can serve as an indicator of overall evaluation.

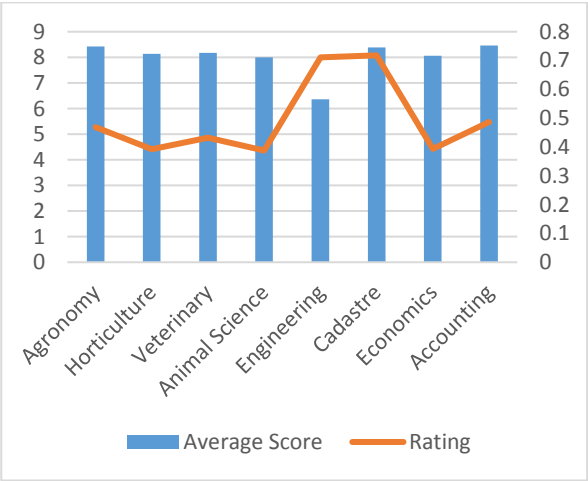

Fig. 3. Evaluating students' academic performance through the DEA rating compared to the average score for different faculties of UASVM.

Source: Own calculations based on data of the Survey.

The information presented above highlights higher academic performance for technical specialities compared to economic specialities. For example, despite the fact that the Faculty of Accounting has recorded a fairly high average score m = 8.46, it shows a relatively low r = 0.48 according to the rating accomplished per 24 types of activities included in the survey and subsequently processed using the principal component analysis method up to six eigenvalues with the superunit values of own vectors. Conversely, the Faculty that has the lowest average score m = 6.36 records a high rating of r=0.71 of academic performance evaluated per those 24 types of activities included in the survey [5].

Table 1. Academic performance of UASM students on foreign language learning skills.

	English	French	Spanish	Russian
Score 3rd	7.87	8.05	7.96	8.86
Rating 3rd	0.71	0.78	0.73	0.79
Score 4th	8.39	8.31	8.25	8.49
Rating 4th	0.48	0.47	0.44	0.52
Score 6th	8.17	7.96	8.14	7.92
Rating 6th	0.42	0.34	0.43	0.35

Source: Own calculations based on data of the Survey.

A significant indicator in assessing students' academic performance is the level of foreign language learning in the university. For example, English, being a traditionally accepted means of communication both in the academic environment and private life, represents a sensitive threshold of individual's ability to fit into foreign society. Students internships offered by the Erasmus+ and other programmes require a good level of English that could be checked by Toefl scores application programs. Of the total number of 324 surveyed students, only 77% study English. There are also students who study at the same time two or three languages and they represent 56% of the total sample. Students with the highest English language skills account for 14% of the total sample and have a DEA rating higher than the arithmetic mean. Also, the study of Russian language represents an exceptional performance in the educational process at the State Agrarian University of Moldova. The 3rd year students who record a definitely higher DEA rating and average score are those who study in Russian. Spanish and French are very important in the teaching process and the academic performance of students ranges between the values of good and very good.

Intermediate values of the average score and the DEA rating for French, Spanish, and Russian show that the study of these languages is not of primary importance in the teaching process.

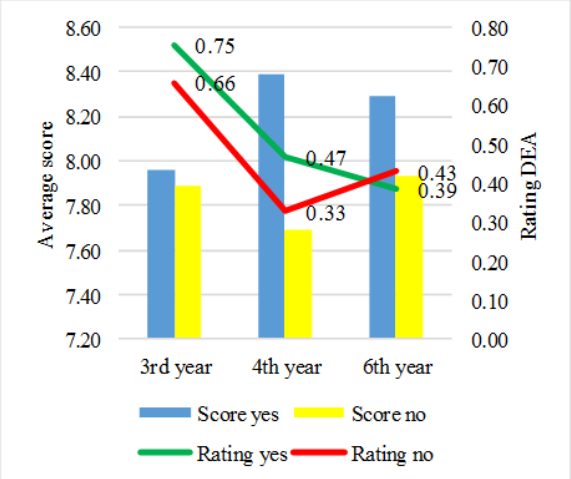

Fig. 4. Distribution of academic performance of UASM students regarding the scholarship.
Source: Own calculations based on data of the Survey.

According to Fig. 4, the students who benefit of scholarship have a definitely higher average score in all years of study. This is obviously due to the fact that the scholarship is calculated based on the average grade during the evaluation session. In the total of the surveyed sample, 71% of the enrolled students receive scholarships, which is an obvious advantage for the university. The professional orientation of high-school students during admission to universities has an additional argument for choosing UASM for studies due to the high rate of students receiving scholarships compared to other higher institutions in the country.

For example, the average score for the 4th year students receiving the scholarship is 8.39, which exceeds by 9.1% the average score of the students who do not receive scholarships.

The DEA rating of the 3rd and 4th year students also repeats the upper academic performance trend for scholarship students, representing respectively 13% for the 3rd year and 42% for the 4th year student.

Table 2. Rotated component matrix of eigenvalues vectors of the factors included in the model

No.	Faculty	Component					
		1	2	3	4	5	6
1	Faculty	0.685	-0.239	-0.337	-0.142	-0.14	-0.023
2	Academic year	0.633	-0.195	-0.516	-0.243	-0.141	-0.046
3	Age	0.519	-0.407	-0.385	0.013	-0.247	-0.096
4	If_no 1	0.424	0.209	0.262	-0.164	0.134	-0.181
5	If_no 2	0.392	0.067	0.224	-0.188	0.012	0.013
6	Yes_residence	0.359	-0.117	0.117	0.354	0.15	0.008
7	Yes_others	0.346	-0.154	0.281	0.342	0.114	0.022
8	If_no 3	0.335	0.022	0.202	-0.162	-0.085	0.036
9	No_business	0.324	0.05	-0.029	-0.179	-0.116	-0.256
10	Yes_scholarship	0.25	0.248	-0.143	0.195	0.162	0.193
11	If_yes 1	0.194	0.083	-0.02	0.08	0.186	0.088
12	Publications	-0.158	0.049	-0.009	0.133	0.065	-0.118
13	Foreign Language	-0.124	0.061	-0.054	-0.024	0.014	0.01
14	Life_priority 1	0.116	0.503	-0.094	-0.119	-0.267	0.212
15	Life_priority 2	0.076	0.452	-0.077	0.179	-0.123	-0.059
16	Life_priority 3	0.284	0.426	0.071	-0.062	-0.132	0.269
17	Life_priority 4	0.22	0.377	0.036	-0.23	-0.22	0.116
18	If_yes 2	0.056	0.373	-0.247	-0.013	0.261	0.133
19	Life_priority 5	0.039	0.368	-0.111	0.243	-0.195	-0.247
20	If_yes 3	0.14	0.357	-0.29	0.196	0.158	0.321
21	Studies	-0.315	0.342	0.228	0.185	-0.151	-0.245
22	If_no 4	0.256	0.31	0.176	-0.218	-0.121	-0.101
23	If_no 5	0.209	0.282	0.175	-0.169	0.224	-0.195
24	No_others	-0.069	-0.206	-0.069	0.073	-0.045	0.092

Source: Own calculations based on data of the Survey

The advantage of evaluating students' academic performance through the DEA rating compared to the average score of current success is obvious as it includes complex information obtained based on the

survey performed per 24 types of activity and three levels of performance assessment [2].

The method of principal component analysis performs the grouping of the variables included in the survey and the performance levels through the own vector technology of the coordinate system. According to the probability theory we have the equality of the overall dispersion to the sum of the partial dispersion of the factors included in the model, the cumulative sum must be 100%. Own vectors that have a overunit value of the components are included in the simplified model of variables with the partial values of each factor.

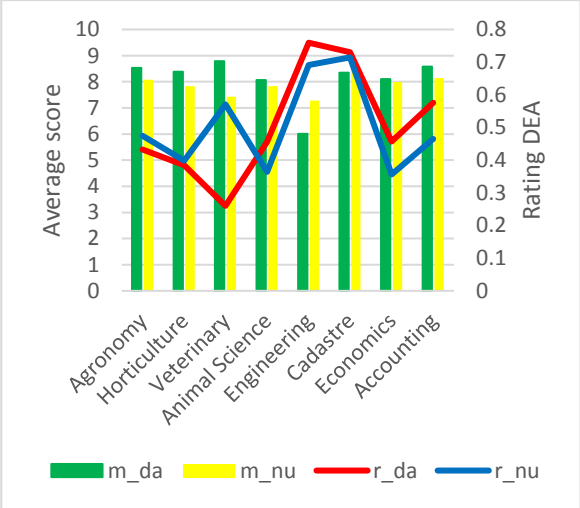

Fig. 5. Evaluating the students' academic performance through the DEA rating compared to the average score for different faculties of UASM depending on their participation in the scientific conferences.
Source: Own calculations based on data of the Survey.

The criterion of inclusion of the given factor in the Rotated component matrix is the maximum module value of own vector decomposition in components. The study undertaken in this paper involves 24 factors that were grouped into six own vectors with the overunit value of the component matrix.

An important indicator of students' academic performance is their participation in the scientific conferences at the university for the 1st, 2nd and 3rd cycles of study. Traditionally, the scientific event takes place in spring: March or April of the academic year and involves a serious preparation of the scientific content of the submitted reports. The best research projects are awarded at the institutional level and those highlighted by excellence are published in the collection of scientific articles edited at the university printing house.

Figure 5 presents the results of students' academic performance depending on whether or not they participate in the scientific conferences per faculties. The figures recorded by the Faculty of Agricultural Engineering, where students' average score participating in the student scientific conference is 6.01 and the non-participation in the research activity shows a current success of 7.27 do not represent a specific trend for UASM.

The distribution of the average score rate for other faculties shows a positive trend for the students participating in the scientific activity and, conversely, it can be argued that the arithmetic mean of the academic performance of students who were not included with presentations in the student conference is 18% lower. The advantage of student evaluation through the DEA rating, which is an overall indicator of performance contributing with 24 different parameters of the academic activity is obvious for the faculties of agricultural engineering and cadastre.

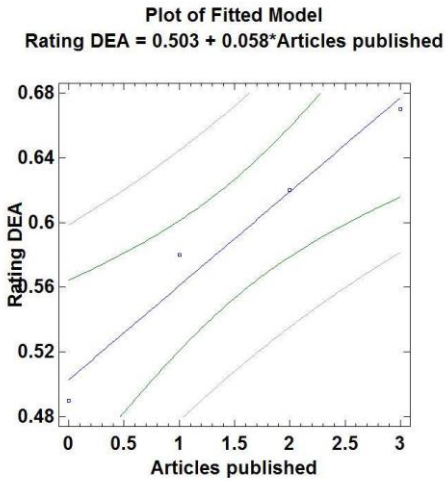

Fig.6. Linear regression of dependence of students' academic performance through DEA rating compared to the number of publications at the UASM student scientific conference.
Source: Own calculations based on data of the Survey.

For the Faculty of Agricultural Engineering the rating evaluated for the students participating in student scientific conferences is by 7% higher and it obviously reflects

accurately the academic performance relative to the average score of current success. Therefore, it is preferable to use the DEA rating concomitantly with the principal component analysis with the purpose of rating higher education institutions for different types of activities.

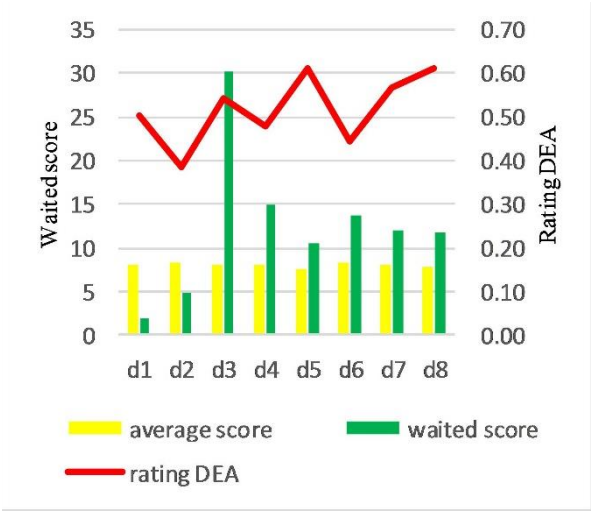

Fig. 7. Distribution of graduates by areas of employment.
Source: Own calculations based on data of the Survey.

The rational selection within the coordinate system of eigenvalue vectors gives the possibility to highlight the significant relationships between the factors included in the model. Figure 6 presents the functional relationship between the number of publications at the students' scientific conference and the academic performance. Thus, if we increase student participation in scientific conferences by 1%, the academic performance increases by 0.14%. This behavior shows a positive trend in the quality of studies depending on students' involvement in research activities. Selecting an interesting and attractive subject of research for students represents the primary responsibility of the teaching staff in the higher education institutions. The high determinant coefficient of functional relationship of 95% proves a close interdependence between students' academic performance and academic research in the university.

Evaluating the career plans of UASM students after graduation, we could identify their employment priorities, which closely correlate with the academic performance determined through the DEA rating. The survey highlights eight distinct areas demanded by the students from the Republic of Moldova:

d1 - education; d2 - research; d3 - public institutions (ministries, agencies, etc.); d4 - private agricultural companies; d5 - non-agricultural private companies; d6 - own business (agricultural); d7 - own business (non-agricultural); d8 - others.

Figure 7 shows the distribution of employment applicants within the indicated areas correlating the academic performance evaluated by the rating method, depending on the average score of the surveyed students. The most requested field of employment after the graduation is a public institution (budgetary employees) that refers to ministries, state agencies, public service organizations, etc. representing a share of 30% of the whole sample. The low demand of graduates regarding their inclusion in educational institutions of 1.86% reflects students' inadequate interest in this field. This denigrating attitude can be explained by very low and insufficient salaries of people employed in education and the low-level privileges granted by the society to this sector. The average score of current success for jobseekers in education after the graduation from UASM is 8.07 and it is a top priority occupying the 6th place among the above presented areas. A broader evaluation of this area through the DEA rating shows a sufficiently high attitude for jobseekers in the education sector r = 0.51 which corresponds to the arithmetic mean of academic performance for all areas. The area d3 has a high rating above the arithmetic mean and represents the value r=0.54 that correlates with the high demand for this field. Therefore, the average score of 8.14 corresponds to a higher demand in the evaluated sample. Regarding the area to set up an agricultural business, the average score of applicants for employment is 8.27 and it is ranked first in the order of preferences. This suggests that students who are evaluated during their studies hope to start their own business in agriculture. However, urban pressing reduces the share of applicants down to 13% of the surveyed students and the academic

performance rating is situated below the arithmetical mean of the sample and represents 0.44. Similarly, becoming employed in an agricultural company after graduating from university indicates a fairly high average score rate of 8.19, which together with a share of 14% of applicants represents a significant direction in the professional orientation of students. The DEA rating of d4 is of 0.47 and reflects a demand below the arithmetic mean based on the overall academic performance indicator.

CONCLUSIONS

Traditional employee performance appraisal as output/input ratio has a relative aspect and the evaluation techniques define the decision making units by numerical indicators that exploit economies of scale. As a criterion for the evaluation of the academic performance rating, it is suggested to use the distance output function, which involves a non-parametric approach of the decision making factors.

The primary data for the academic performance appraisal in the agricultural higher education institution and organizations in the field of agricultural science and innovation were collected in a standard format defined by the Ministry of Education of the Republic of Moldova. The sample of data is representative and reflects objectively all the methodical-didactic, scientific and research activities by including the whole institutional staff into the investigation procedure. The database developed for the storage of primary data allows statistical processing and nonparametric modeling for the evaluation of academic performance indicators in institutions.

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