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## Integrated assessment and ranking of universities by fuzzy inference

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### Abstract

For the evaluation and the subsequent ranking of universities for the quality of educational services provided by them it is proposed two approaches: statistical based on weighted estimates of key indicators of universities, and verbal based on the application of fuzzy inference engine. By applying these methods to the evaluation of five randomly selected universities (hypothetical alternatives), it is obtained their aggregate estimations (ratings) and corresponding two ways of ranking.

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### 1. Introduction

The quality of educational services (ES) provided by the university in a particular country (region) is a complex indicator that reflects a sufficiently large number of parameters that characterize the degree of conformity of educational programs, logistical support of the educational process (EP), research and educational base, cadre personnel, etc. Therefore, in the course of building a system for assessing the quality of a university, the task of forming the set of educational indicators and quality rating is first-priority. Moreover, according to Zadeh (1973) EP is undoubtedly a system of a humanistic type as a complex, open and dynamically developing structure, i.e. a system in which an essential role belongs to the judgments and heuristic knowledge of the decision-maker. As opposed to mechanistic systems that allow a numerical description of its behavior, humanistic systems are weakly structured

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and much more complex. The principal feature is that observations of educational indicators as inputs and output are performed at the level of “soft measurements”. As a rule, these indicators are grouped according to Ackmatov (2017) as: a) key indicators of the conditions for the implementation of the EP (the target strategy and the concept of the university, personnel, educational resources); b) indicators of the process itself (university management, the content of educational programs, social infrastructure); c) outcome indicators (the quality of training bachelors, masters, level of employment, effectiveness of research activities). Moreover, in practice, most indicators are weakly structured values, i.e. such of which there are known its belonging to a certain type. In other words, the weakly structured quality indicators may be statements such as “HIGH”, “PREFERRED”, etc., i.e. by Zadeh (1974) as terms of linguistic variables, formalization of which is successfully provided by fuzzy sets. Actually, just this paradigm became the basis for writing this article, within which the construction of an adequate system for the integrated assessment of ES of the university appears to be a very complex, weakly structured and, consequently, difficult to formalize procedure in the usual sense.

## 2. General statement of problem

It is necessary to choose a sufficient set of indicators characterizing the activity of the university in the three projections, namely: 1) the potential; 2) activity and ES quality; 3) international recognition. Then, taking into account the key quality indicators, it is necessary to form a set of criteria for evaluating the activities of the university and on its basis to develop basic models (traditional and fuzzy) for a comprehensive assessment of ES of five arbitrarily chosen (hypothetical) universities with their subsequent ranking.

## 3. Criteria for assessment the quality of educational services

According to the recommendations arising of ISO (International Organization for Standardization), the quality of EP is understood as the ability of its core properties to meet the requirements of all process participants and other stakeholders. At the same time, the main constituent factors are: 1) quality of the objectives of the educational business process; 2) quality of means and conditions for achieving the goals of the EP; 3) quality of the EP result. By Sobolev and Stepanov (2004) the quality of the EP goals is determined by the expectations and requirements of the subjects of education and other stakeholders. Consumers of ES formulate the goals of education as a motivated social order expressed by educational standards. Conversely, the university formulates the strategic goals of its activities, draws up development programs in individual directions, etc. Employers, parents, and students determine their goals of education, making their demands on the knowledge and skills of graduates. At the same time, the requirements of EP subjects, and the quality criteria of the EP often do not coincide. Below it is presented the list of criteria for assessment the ES quality, which are the most universal and comprehensive in the post-Soviet field:  $C_{01}$ —the number of teachers;  $C_{02}$ —the number of Doctors of Science (DS) and Professors;  $C_{03}$ —the number of PhD and Ass. Professors;  $C_{04}$ —the number of DS and Professors under 50 years of age;  $C_{05}$ —the number of PhD and Ass. Professors under 30 years of age;  $C_{06}$ —the number of full-fledged members of Academy of Science (AS);  $C_{07}$ —the number of Corresponding Members of AS;  $C_{08}$ —the number of Laureates of State Prize;  $C_{09}$ —the number of employees holding Honorary Titles, including “Honored Teacher”, “Honored Worker of Art”, “Honored Doctor”, etc.;  $C_{10}$ —the area of training and laboratory facilities;  $C_{11}$ —the number of computers used;  $C_{12}$ —the library fund, including the number of teaching aids in the electronic library;  $C_{13}$ —the number of local students living in hostels;  $C_{14}$ —the number of students from other regions of given country;  $C_{15}$ —the number of foreign students staying in hostels;  $C_{16}$ —the number of foreign studying students;  $C_{17}$ —the number of sports grounds, including indoor sports halls;  $C_{18}$ —the number of undergraduate students studying for all forms of study;  $C_{19}$ —the number of Master's students studying in all forms of study;  $C_{20}$ —the number of full-time doctoral students;  $C_{21}$ —the number of doctoral students in correspondence courses;  $C_{22}$ —the number of dissertations defending over the last 5 years for the degree of DS;  $C_{23}$ —the number of dissertations defending over the last 5 years for the degree of PhD;  $C_{24}$ —the fund received from paid education of students from given country;  $C_{25}$ —the fund received from paid education of foreign students;  $C_{26}$ —prestige of the university among applicants;  $C_{27}$ —the amount of fund received from extended ES (including  $C_{24}$  and  $C_{25}$ );  $C_{28}$ —the number of graduates provided with work in the last 3 years;  $C_{29}$ —the number of graduates in the last 3 years;  $C_{30}$ —the amount of funds received from research activities for the last 2 years;  $C_{31}$ —the number of scientific works and scientific articles published at home by full-time employees for the last 2 years;  $C_{32}$ —the number of scientific works and scientific articles published abroad by full-time employees for the last 2 years (with the exception of periodicals

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