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ISBN 978 - 86 - 6335 - 056 - 4

3rd International Conference on Quality of Life

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CONFERENCE MANUAL

November 28th-30th - 2018, Kopaonik
Faculty of Engineering, University of Kragujevac

ISBN: 978 - 86 - 6335 - 056 - 4

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Technical Editor:	***Dr Aleksandar Aleksić,*** assistant professor Faculty of Engineering, Kragujevac
Publisher:	**FACULTY OF ENGINEERING** 34000 KRAGUJEVAC Sestre Janjić 6 **CENTER FOR QUALITY** 34000 KRAGUJEVAC Sestre Janjić 6
For publishers:	***Dr Dobrica Milovanović,*** full professor ***Dr Miladin Stefanović,*** full professor
No. of copies:	200
Printing:	Faculty of Engineering, Kragujevac

Publication of Conference manual and organization of
3rd International Conference on Quality of Life is supported by:
Department of Education, Science and Technological Development of Republic of Serbia

Izdavanje Zbornika radova, organizovanje i održavanje
3rd International Conference on Quality of Life podržalo je:
Ministarstvo prosvete, nauke i tehnološkog razvoja Republike Srbije

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This Conference has a motto "From quality to happiness".

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Sincerely yours,
President of Programme Committee

Prof. dr Slavko Arsovski

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ANALYSIS OF THE KEY PERFORMANCE INDICATORS IN SERBIAN HIGHER EDUCATION INSTITUTUIONS AND PROPOSAL OF THEIR WEIGHTS

Abstract: *In this paper, the issue of addressing the weights of different key performance indicators (KPIs) within higher education institutions (HEIs) in Serbia has been treated. Since performance based management is not yet established, this research has a goal to set appropriate suggestions of directions how to define a finite model for determining the value of adopted system of performances. The analytical hierarchy process (AHP) is proposed as a suitable framework for the determination of KPIs weights. An illustrative example for the determination of KPIs weight related to scientific research activity.*

Keywords: *Performance, management higher education institutions*

1. INTRODUCTION

The number of EU countries have adopted performance based management system for HEIs which have been used for funding of HEIs based on performances [1]. Generally, HEIs in EU have different goals such as:

- to enhance performance values in core activities – continual quality improvement,
- to strengthen accountability and transparency (satisfy stakeholders' demands,
- to encourage HEIs' profiling and diversification,
- to enhance human capital [2],
- and to align national and regional institutional policies and activities.

Having insight into ongoing changes in Serbia, it may be suggested that there is a need for Serbian HEIs to interconnect with EU environment and to provide and use the best experience from EU in development of its model that will be compatible with EU in the terms of establish performance system. On the other side, HEIs in Serbia are adopting new study programs in compliance with the demands of accreditation standards which may be seen as institutional pattern of structure and functioning [3].

In practice, Republic of Serbia is facing the challenge of defining the model for performance evaluation, profiling and ranking of institution and study programs in Serbian higher education systems. This challenge is partially faced in the scope of activities of international project Project No 573820-EPP-1-2016-1-RS-EPPKA2-CBHE-SP – PESHES.

The motivation for this research comes from the fact that is necessary to provide optimization of the indicators for study programs, institutions and HE. In the same time, it is necessary to provide process of tuning of the indicators, definition of limits and scopes. As the proposed indicators are new and unknown to Serbian higher education systems, it is meaningful to define values and limit for specific indicators. In this paper, the approach for determining the weights of indicators is proposed. The proposed method is tested on one group of the proposed indicators within the project.

There are many methods that may be used for the determination of criteria weight of good classification. It may be said that some of them are good for solving some types of problems, but they cannot be used for others. For example, the traditional ABC method may not be appropriate to provide a good classification of items in practice [4]. If there is a goal to make the classification more realistic, the more criteria and imprecise data should be used so this problem is going to become a multi-criteria classification problem under uncertainties. However, for the purpose of this research where definition of KPIs and determination of their weight is focus, unprecise data is not

going to be studied. Due to suitability for the determination of criteria weights, the chosen framework for the research is AHP method [5]. It was assumed that weights of criteria are different and are defined by the matrix of pairs for comparison of relative relation of criteria importance.

The goal of this paper is to propose KPIs of related to scientific research activity of HEIs and proposal how to determine the weights of KPIs in Serbian higher education institutions related to emerging performance-based management system for HEIs. It is worth to mention that the proposed performance-based management system for HEIs is supposed to be supported by appropriate information system for collecting and managing input data.

This paper is organized in the following way: in Section 2 the problem statement is given, in Section 3 the analytical hierarchy framework is analysed, Section 4 the determining of the KPIs'weights related to scientific research activity is proposed, and the conclusion is set in the Section 4.

2. THE LITERATURE REVIEW

For the purpose of determining how successful are some study programs and HEIs, it is necessary to propose some system for determining for success assessment. This kind of system may be used for benchmarking of study programs and HEIs, too. In that sense, performance can be treated as values necessary to determine the success of a HEIs activities. The rate of success may be assessed through the performance of organization so very important tasks are identification and assessment of performances. Each performance has its quantitative or qualitative representation or indicator by which the performance value is determined so these indicators may be explained as KPIs [6]. The goal of performance assessment is to identify which element of HEis' activities is not meeting the set demands. That information basically represents input data for strategy forming and decision-making process, so the appropriate corrective measures may be proposed for the set goals could be achieved. This way of thinking may be very useful since study programs, and HEIs simultaneously may be assessed. Different tools may be used for determining of criteria weights.

2.1 Basic assumptions of AHP as base for determining KPIs weight

It may be said that AHP (Saaty, 1990) is one of the most used methods of multicriteria decision making methods. Basically, it belongs to the group of techniques related to multiatribute decision analysis and the methods of ranking. The basic assumptions of the method may be articulated as hierarchy, priority settings and the check of consistency (Agarski, 2015). Setting the hierarchy is related to definition of hierarchy levels of decision making. The goal of analysis is set at the top of hierarchy and criteria and subcriteria are set below ($c_1,\ldots,c_n$). The treated alternatives are set at the bottom ($a_1,\ldots,a_n$). The idea of introducing hierarchy is to decompose complex problem into smaller pieces so it can be treated in easier way (figure 1).

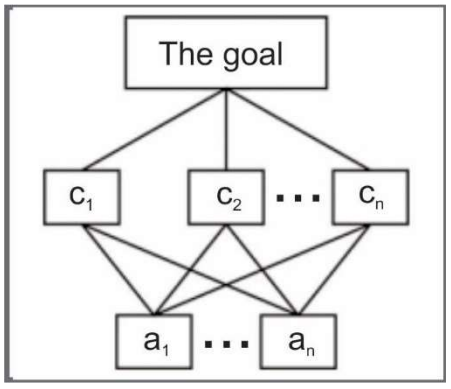

Figure 1 – An example of hierarchy in AHP method

Figure 1 shows the general hierarchical order of AHP analysis. The basic purpose of the method is to determine the weight coefficients of all elements of the hierarchy, that is, the goal, the criteria, the subcriteria and the alternatives.

The prioritization is set by performing a comparative analysis of each pair of elements at each hierarchical level. In this case, the decision maker for each pair of comparisons expresses an estimate on the Saaty's scale of measures [1-9]. Numerical values on Saaty's scale of measure are explained in Table 1.

Table 1 – Saaty's scale (Saaty, 1990)

The significance	The definition
1	The two elements are **equally important** in relation to the set goal
3	One element in relation to the other is **slightly more important**
5	One element in relation to the other has a **far greater importance**
7	One element in relation to the other is **much more important**
9	One element in relation to the other has **an absolute and extreme importance**
2, 4, 6, 8	The values in between are representing a compromise between defined values

Based on the presented comparison of each element considered with each other element, the pairwise matrix is obtained. The pairwise matrix A can be presented as follows:

$$A = \begin{bmatrix} 1 & P(a_1, a_2) & \cdots & P(a_1, a_n) \\ P(a_2, a_1) & 1 & \cdots & P(a_2, a_n) \\ \vdots & \vdots & \ddots & \vdots \\ P(a_n, a_1) & P(a_n, a_2) & \cdots & 1 \end{bmatrix}$$

Checking consistency is a very useful technique developed in this method. It is used to determine whether the decisions of decision makers are consistent. Consistency checks are performed using the eigenvector method. The eigenvector of matrix A is determined:

$$A \cdot w = \lambda\_max \cdot w$$

w is the determined weights' vector.
λ_max is the maximum value of eigen vector of matrix A. The value of λ_max is greater or equal to K (Eigen value of matrix A) whose elements are positive and reciprocal. If the matrix is consistent, then

$$\lambda\_max = K.$$

The CR (Consistency Ratio) is determined as:

$$CR = (\lambda\_max - K)/(K-1)$$

The CI (Consistency Index) is determined as ratio of CI and RI (Random Index):

$$CI = CR/RI$$

The values of RI are presented in the Table 2 where RI depends on matrix dimension (denoted in upper row of the table 2).

Table 2 – Random index (Saaty, 1990)

1	2	3	4	5	6	7
0.0	0.0	0.58	0.9	1.12	1.24	1.32
8	**9**	**10**	**11**	**12**	**13**	**14**
1.41	1.45	1.49	1.51	1.48	1.56	1.57

The consistency index CI should be less than 0.1, which in fact means that the inconsistency of the decision makers' assessment should not be higher than 10% [5].

However, the practice supports the fact that in complex decision-making issues, when considering many criteria, sub-criteria and alternatives, it often happens that the CI consistency index is greater than 0.1, and that the resulting solution is nevertheless chosen as optimal. This problem closely attached to the attitude of the decision makers.

The advantage of AHP is that ay be extended in various ways. The extension may be delivered by applying fuzzy numbers type I [7], fuzzy numbers type II [8], intuitive fuzzy numbers [9], etc.

4. DETERMINNG THE WEIGHTS OF KPIS RELATED TO SCIENTIFIC RESEARCH ACTIVITY

In the scope of activities of international project Project No 573820-EPP-1-2016-1-RS-EPPKA2-CBHE-SP – PESHES, different performances have been analysed. In compliance with that, it is suggested that the considered performance is composed of four KPIs named:

1) Scientific capacity of the institution,
2) Publishing of journals,
3) Organizing conferences, and
4) Publishing activity.

1) Scientific capacity of the institution
This KPI represent the number of scientific research activity results produced by full-time employees of the HEI (S_{HEI}) divided by the number of full-time employees of the HEI with scientific and research degrees (E_{HEI}) and multiplied with Hirsch index (h).

$$\textbf{Scientific capacity of the institution} = \frac{S_{HEI}}{E_{HEI}} \times h$$

The number of scientific research results

includes scientific research papers, monographs, technical solutions and patents (M10, M20, M40, M50, M80 i M90), determined by categorization of The Ministry of Science shall, in accordance with the applicable Rulebook on the procedure, method of evaluation and quantitative presentation of scientific research results of researchers, for the relevant field of science. The relevant field of science include: 1) natural-mathematical and medical; 2) technical-technological and biotechnical, 3) social and 4) humanistic; h - The Hirsch index for the institution (for the HEI from the natural-mathematical, technical-technological and medical educational and scientific fields, while for the institutions of the socio-humanist field h = 1).

2) **Publishing of journals** represents the KPI that include the sum of scientific coefficients addressing the position of the journal that is published by the HEI.

Publishing of journals= $\sum_{j=1}^{n} M_j$

n – the number of journals that are published by the HEI

M – the coefficient denotes the value which is equal to scientific result identified by Rulebook on the procedure, method of evaluation and quantitative presentation of scientific research results of researchers by groups (21a, M22, M23, M24 and M51). These are applicable to the identified fields of science: 1) natural-mathematical and medical; 2) technical-technological and biotechnical, 3) social and 4) humanistic.

3) Organizing scientific events represents the KPI that include the sum of scientific events organized by the HEI.

Organizing scientific events =$\sum_{t=1}^{m} S_t$

m – the number of scientific conferences organized by the HEI during the year

S – the coefficient represents the value of the scientific event, in accordance with the relevant Rulebook on the procedure, the method of evaluation and the quantitative expression of the scientific research results of the researcher organized by the HEI. The coefficient is calculated as follows:

International scientific event: S = 0.5
National scientific event: S = 0.2

4) Publishing activity

Publishing activity represents the number of used ISBN for published items of HEI in the last five calendar years (P_{ISBN}) divided by the total number of HEI's full time employed teachers and associates (FTA).

Publishing activity $= \frac{P_{ISBN}}{FTA}$

ISBN is related to books related to education process.

4.1 An illustrative example

For the purpose of illustrative example, the working group members from University of Kragujevac have made assessment by consensus. The input data is presented in table 3.

Table 3 – The matrix of pair's comparison

Assessing criteria weight	KPI (i=1)	KPI (i=2)	KPI (i=3)	KPI (i=4)
KPI (i=1)	1	3	5	7
KPI (i=2)	0.333	1	2	3
KPI (i=3)	0.2	1	1	2
KPI (i=4)	0.143	0.333	0.5	1

The input data is normalized and presented in table 4.

Table 4 – the normalized data matrix

Assessing criteria weight	KPI (i=1)	KPI (i=2)	KPI (i=3)	KPI (i=4)
KPI (i=1)	0.5860	0.6537	0.6179	0.5074
KPI (i=2)	0.1951	0.2179	0.2471	0.2175
KPI (i=3)	0.1172	0.1090	0.1236	0.1450
KPI (i=4)	0.0838	0.0726	0.0618	0.0725

The obtained weights of KPIs are presented in table 5.

Table 5 – The KPI weights

Assessing criteria weight	KPI weights
KPI (i=1)	0.5860
KPI (i=2)	0.2179
KPI (i=3)	0.1236
KPI (i=4)	0.0725

The consistency of the matrix is tested, and it is acceptable.

λ_max=4.0281,

C.R. =0.009369,

C.I. =0.01041

After determining the weights, the value of the proposed performance can be obtained. For the purpose of illustrative example, input data is obtained from the Faculty of engineering, University of Kragujevac:

Scientific research activity= $0.5074x\frac{S_{HEI}}{E_{HEI}} \times h+$

$0.2179x\sum_{j=1}^{n} M_j+0.1236x\sum_{t=1}^{m} S_t+$

$0.0725x\frac{P_{ISBN}}{FTA}$

Scientific research activity=1.22

In compliance with the calculation, it may be said the KPI (i=1) - Scientific capacity of the institution, has the greatest weight under the performance of Scientific research activity. It is justifiably since existence of this KPI in real conditions makes the largest impact on research and teaching process in the HEI. The second place in rank is connected to the KPI of publishing journals activity. It is very important since this kind of HEI makes impact on others and participates in creating new directions in research agenda, regionally or even wider.

5. CONCLUSION

In this paper, the performance of scientific research activity of one HEI has been analysed. For the purpose of determining this performance, the four KPIs have been proposed. Those KPIs have been explained in terms of quantification. The second part of the paper is used for the proposal how to determine the weights of the proposed KPIs. For the purpose of determining KPIs weights, AHP has been used and tested.

The proposed KPIs and the proposal how to determine their weights may be used in other HEIs in Serbia as a part of performance management system for HEIs.

The constraint of the proposed methodology is that it takes account the opinion of decision makers team in terms of consensus. The future research should cover aspects of aggregating different opinions of decision makers into one.

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Acknowledgment: Research presented in this paper was supported by ERASMUS plus call, Project No 573820-EPP-1-2016-1-RS-EPPKA2-CBHE-SP – PESHES.