

Application of the InterCriteria Analysis to the universities rankings system in the Slovak Republic

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Abstract: In the paper, an application of the InterCriteria Analysis (ICA) approach to data about university rankings in the Slovak Republic for the years 2009–2015 is presented. The aim is to analyse the correlations between the criteria and find the dependencies between the faculties used in the ranking system. The ICA approach helps us to monitor the behaviour of the criteria/faculties in time.

Keywords: InterCriteria Analysis, University ratings, Intuitionistic fuzzy sets, Index matrix, Multicriteria decision making.

AMS Classification: 03E72.

1 Introduction

In this paper, an application of the ICA approach to the universities' rating in the Slovak Republic is presented. The study is following-up a series of research works for analysing the university rankings using the ICA method [11, 23, 30–32]. The purpose of the elaboration is to identify the most correlated criteria in the Ranking Systems for the universities. By applying the ICA approach over university rankings we can observe the behaviour of the criteria that have highest dependencies in time (several years). Similarly, we can obtain the opposite criteria or criteria that are frequently independent from each other. In the same way, we can find the faculties of universities in the Slovak Republic that have highest or lowest dependencies in time (several years).

There are three types of universities in the Slovak Republic. The first group represents public universities and high schools, which are 23. The second group represents private high schools and universities. There are 12 of them. The third group represents foreign high schools and universities, which are 5. Two institutions are mainly concerned with the evaluation of these schools: the Accreditation Commission and Academic Ranking and Rating Agency (ARRA) [37, 38].

The Accreditation Commission is created in 1990. The main tasks of the Commission are to monitor and independently evaluate the quality of education, research, development, artistic and other creative activity of the universities [39]. The second institution ARRA is an independent Slovak civil association established in 2004 with the objective of assessing the quality of Slovak higher education institutions. The mission of ARRA is to stimulate positive changes in Slovak higher education [40]. The aim of the ARRA ranking is to provide the general public and, in particular, applicants for a university study with an overview based on the use of legible and generally understandable criteria to help them decide to study at a specific school / faculty and also to initiate competition between higher education institutions and thus positive changes in Slovak higher education. The rating is based on publicly available and verifiable data, divided into two basic groups: education (number of students, teachers, and interest in study) and research (number of publications and citations, grants and doctoral studies). The report is published once a year [41].

The analysis is made with public data for faculties in different universities in the Slovak Republic [37]. The first university rankings from ARRA are published in 2005. The criteria of ARRA are separated into 5 main groups: education, attractiveness of education (prestige), science and research, PhD students and successful grants. In the years several criteria have been modified. The researched university faculties vary in the range of 24 to 21.

2 Presentation of InterCriteria Analysis method

The InterCriteria analysis approach was introduced by Atanassov, Mavrov and Atanassova in [5]. The method is based on the theory of intuitionistic fuzzy sets and index matrices. Intuitionistic fuzzy sets were first defined by Atanassov [6, 7] as an extension of the concept of fuzzy sets defined by L. Zadeh [36]. The theory of index matrices was introduced in [3].

The ICA method estimates the objects based on several criteria. The number of the criteria can be reduced by taking into account the correlations of each pair of criteria presented in the

form of intuitionistic fuzzy pairs of values [6]. The intuitionistic fuzzy pairs of values are the intuitionistic fuzzy evaluations in the interval $[0, 1]$. The relations can be established between any two groups of criteria.

In the current research, the ICA method is used to discover the relationships between the groups of criteria and university faculties in the Slovak Republic university ratings.

Let us have a number of C_p group of criteria, $p = 1, \dots, m$, and a number of O_q faculties of universities, $q = 1, \dots, n$. So we use the following sets: a set of group of criteria $C_p = \{C_1, \dots, C_m\}$ and a set of faculties $O_q = \{O_1, \dots, O_n\}$.

We will evaluate 21 faculties of universities in the Slovak Republic (objects) using 5 groups of criteria. We obtain an index matrix M that contains two sets of indices, one for rows and another for columns. For every p, q ($1 \leq p \leq m, 1 \leq q \leq n$), O_q in an evaluated object, C_p is an evaluation criterion, and a_{C_p, O_q} is the evaluation of the q -th object against the p -th criterion, defined as a real number or another object that is comparable to the rest of the elements of the index matrix M according to a relation R .

$$M = \begin{array}{c|ccccccc} & O_1 & \dots & O_k & \dots & O_l & \dots & O_n \\ \hline C_1 & a_{C_1, O_1} & \dots & a_{C_1, O_k} & \dots & a_{C_1, O_l} & \dots & a_{C_1, O_n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ C_i & a_{C_i, O_1} & \dots & a_{C_i, O_k} & \dots & a_{C_i, O_l} & \dots & a_{C_i, O_n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ C_j & a_{C_j, O_1} & \dots & a_{C_j, O_k} & \dots & a_{C_j, O_l} & \dots & a_{C_j, O_n} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ C_m & a_{C_m, O_1} & \dots & a_{C_m, O_k} & \dots & a_{C_m, O_l} & \dots & a_{C_m, O_n} \end{array}$$

The next step is to apply the InterCriteria Analysis for calculating the evaluations. The result is a new index matrix M^* with intuitionistic fuzzy pairs $\langle \mu_{C_i, C_j}, \nu_{C_i, C_j} \rangle$ that represents an intuitionistic fuzzy evaluation of the relations between every pair of criteria C_i and C_j . In this way the index matrix M that interconnects the evaluated objects to the evaluating criteria can be transformed to another index matrix M^* that gives the relations among the criteria:

$$M^* = \begin{array}{c|ccc} & C_1 & \dots & C_m \\ \hline C_1 & \langle \mu_{C_1, C_1}, \nu_{C_1, C_1} \rangle & \dots & \langle \mu_{C_1, C_m}, \nu_{C_1, C_m} \rangle \\ \vdots & \vdots & \ddots & \vdots \\ C_m & \langle \mu_{C_m, C_1}, \nu_{C_m, C_1} \rangle & \dots & \langle \mu_{C_m, C_m}, \nu_{C_m, C_m} \rangle \end{array}$$

The last step of the algorithm is to determine the degrees of correlation between the criteria using the scale presented in Table 1, [4]. The correlations between the criteria are called “strong positive consonance”, “positive consonance”, “weak positive consonance”, “weak dissonance”, “dissonance”, “strong dissonance”, “weak negative consonance”, “strong negative consonance” or “negative consonance”.

<i>Degrees of Correlation</i>	<i>Type of consonance</i>
[0; 0,05]	Strong Negative Consonance (SNC)
[0,05; 0,15)	Negative Consonance (NC)
[0,15; 0,25)	Weak Negative Consonance (WNC)
[0,25; 0,33)	Weak Dissonance (WD)
[0,33; 0,43)	Dissonance (D)
[0,43; 0,57)	Strong Dissonance (SD)
[0,57; 0,67)	Dissonance (D)
[0,67; 0,75)	Weak Dissonance (WD)
[0,75; 0,85)	Weak Positive Consonance (WPC)
[0,85; 0,95)	Positive Consonance (PC)
[0,95; 1]	Strong Positive Consonance (SPC)

Table 1. Correlations between the criteria

Several comprehensive applications of the method have been already published [1–2, 4, 8–10, 12–22, 24–29, 33–35].

3 Applying ICA Approach over the university rankings of the Slovak Republic

In the current research work, the datasets of Slovak university rankings for seven years (2009–2015) are used. The ICA approach is applied to analyse the data in two directions. The first investigation determines the relationships between groups of criteria. The second application of ICA presents the degrees of correlation between faculties of Slovak universities. The received data will provide the possibility to observe dependencies between criteria and faculties. The pre-processing step is used before applying the ICA method.

Initially, the ICA is applied to discover the relationships between criteria estimating faculties. The groups of criteria used to evaluate faculties of the universities in the Slovak Republic are the following: (1) Education; (2) Attractiveness of education; (3) Science and research; (4) PhD students; (5) Successful grants.

The list of evaluated faculties is pre-processed to reduce the number of different faculties or remove faculties with incomplete information in the years. The eliminated faculties are:

- Slovak University Rankings – 2009, 2010: Technical Faculty of Agriculture in Nitra; Faculty of Mechatronics, Alexander Dubček University in Trenčín; Faculty of Special Engineering, University of Žilina;
- Slovak University Rankings – 2011: Technical Faculty of Agriculture in Nitra; Faculty of Mechatronics, Alexander Dubček University in Trenčín;
- Slovak University Rankings – 2012, 2013: Faculty of Informatics, Pan European University; Technical Faculty of Agriculture in Nitra;
- Slovak University Rankings – 2014, 2015: Faculty of Informatics, Pan European University; Faculty of Wood Technology, Technical university of Zvolen; Technical Faculty of Agriculture in Nitra.

The list of selected faculties for applying the ICA approach is presented below:

- 1) Faculty of Chemical and Food Technology, Slovak Technical University in Bratislava
- 2) Faculty of Electrical Engineering and Computer Science, Slovak Technical University in Bratislava
- 3) Faculty of Mechanical Engineering, University of Zilina
- 4) Faculty of Manufacturing Technologies, Technical University in Košice
- 5) Faculty of Metallurgy, Technical University in Košice
- 6) Faculty of Mechanical Engineering, Technical University in Košice
- 7) Electrical Engineering Faculty, University of Zilina
- 8) Faculty of Electrical Engineering and Computer Science, Technical University in Košice
- 9) Faculty of Civil Engineering, Slovak Technical University in Bratislava
- 10) Faculty of Mining, Ecology, Process Control and Geotechnology, Technical University in Košice
- 11) Faculty of Industrial Technology, Alexander Dubček University in Trenčín
- 12) Faculty of Informatics and Information Technologies, Slovak Technical University in Bratislava
- 13) Faculty of Management Science and Informatics, University of Žilina
- 14) Faculty of Aeronautics, Technical University in Košice
- 15) Faculty of Mechanical Engineering, Slovak Technical University in Bratislava
- 16) Faculty of Civil Engineering, Technical University in Košice
- 17) Faculty of Civil Engineering, University of Žilina
- 18) Faculty of Material Technology, Slovak Technical University in Bratislava
- 19) Faculty of Architecture, Slovak Technical University in Bratislava
- 20) Faculty of Environmental and Manufacturing Technology, Technical University in Zvolen
- 21) Faculty of Special Technology, Alexander Dubček University in Trenčín.

3.1. Applying InterCriteria Analysis approach to the university rankings in the Slovak Republic to discover relationships between the groups of criteria

The main concept of the ICA approach is to estimate the objects on the basis of several criteria. In the current study, we apply the ICA analysis to find intuitionistic fuzzy evaluations between the groups of criteria used in the Slovak university ranking. The number of the pairs of criteria and the type of their consonances are presented in Table 2.

<i>Degrees of consonance</i>		2015	2014	2013	2012	2011	2010	2009
[0,33; 0,43)	D	1	2	2	1	1	0	2
[0,43; 0,57)	SD	4	5	4	4	4	5	3
[0,57; 0,67)	D	5	0	2	4	4	4	3
[0,67; 0,75)	WD	0	3	1	1	1	1	2
[0,75; 0,85)	WPC	0	0	1	0	0	0	0

Table 2. Number of pairs of criteria per degree of consonance per year

The pairs of criteria in dissonance, strong dissonance, weak dissonance and weak positive consonance in 2009- 2015 for the ratings of universities are shown below.

<i>Degrees of correlation</i>		2015	2014	2013	2012	2011	2010	2009
[0,33; 0,43)	D	2-4	2-3 2-4	2-3 2-4	2-3	2-3		1-2 2-4
[0,43; 0,57)	SD	1-3 2-3 1-4 1-5	1-2 1-3 1-4 1-5 2-5	1-2 1-3 1-4 2-5	1-2 2-4 2-5 3-4	1-2 2-4 2-5 3-4	1-2 2-3 2-4 3-4 2-5	2-3 3-4 2-5
[0,57; 0,67)	D	1-2 3-4 2-5 3-5 4-5		1-5 3-5	1-3 1-4 1-5 3-5	1-3 1-4 1-5 3-5	1-3 1-5 3-5 4-5	1-3 3-5 4-5
[0,67; 0,75)	WD		3-4 3-5 4-5	4-5	4-5	4-5	1-4	1-4 1-5
[0,75; 0,85)	WPC			3-4				

Table 3. Pairs of criteria

Obviously, the pairs of criteria belong to the groups of dissonance, weak dissonance or strong dissonance. There is no change in the criteria in time despite the slight correction over the years. The first application of ICA approach to university rankings confirms the correctness of the selected criteria. The criteria are constantly independent in time. Only one pair of criteria “Science and research–PhD students” changes its behaviour in time: strong dissonance → weak positive consonance → weak dissonance → dissonance.

3.2. Applying InterCriteria Analysis approach to the university rankings in the Slovak Republic to discover relationships between the faculties of Slovak universities

The second investigation in the current research work presents an application of ICA approach to discover relationships between faculties. This observation can detect faculties with similar performance and similar profile of the faculty staff. The number of pairs of faculties and their correlation are presented in the Table 4.

In the case of the ICA method we are interested in the faculties that are in positive consonance. The result of the ICA approach gives the positive consonances for many pairs of faculties. The faculties with the highest correlation in 2009–2015 are presented in Table 5.

<i>Degrees of consonance</i>		2015	2014	2013	2012	2011	2010	2009
[0; 0,05]	SNC	0	0	0	0	0	0	0
[0,05; 0,15)	NC	1	0	0	1	0	2	0
[0,15; 0,25)	WNC	4	7	2	1	0	3	1
[0,25; 0,33)	WD	9	11	8	3	1	9	11
[0,33; 0,43)	D	8	19	8	9	4	14	14
[0,43; 0,57)	SD	24	21	9	8	9	21	18
[0,57; 0,67)	D	35	26	17	24	12	36	28
[0,67; 0,75)	WD	35	34	24	35	21	48	45
[0,75; 0,85)	WPC	55	53	62	56	51	39	53
[0,85; 0,95)	PC	30	32	64	58	77	29	24
[0,95; 1]	SPC	9	7	16	15	35	9	16

Table 4. Number of pairs of faculties

	2015	2014	2013	2012	2011	2010	2009
Strong positive consonance (95-100)	7-8,	12-13,	8-9,	2-5,	2-7, 5-9,	9-15,	3-5, 2-3,
	7-15,	7-15,	5-10,	7-8,	2-10, 7-10,	9-16,	11-13, 3-8,
	8-15,	6-16,	9-10,	15-4,	2-16, 7-16,	15-16,	5-8, 19-16,
	5-18,	7-19,	8-18,	7-16,	10-16, 12-13,	7-6,	7-20, 19-18,
	1-19,	15-19,	9-18,	8-16,	15-19, 8-17,	12-18,	16-18,
	13-19,	8-17,	14-15,	15-19,	7-17, 10-17,	7-20,	19-17,
	17-20,	5-21	4-19,	4-19,	16-17, 15-4,	6-20,	16-17,
	5-21,		14-17,	17-14,	19-4, 2-6,	20-4,	4-21,
	18- 21		15-17,	17-6,	7-6, 10-6,	13-21	19-14,
			16-6,	14 -6,	16-6, 17-6,		16-14,
			14-20,	17-20,	2-20, 7-20,		18-14,
			15-20,	14-20,	10-20, 16-20,		17-14
			17-20,	6-20,	17-20, 6-20,		
			8-21,	9-21,	2-14, 7-14,		
			9-21,	13-21	10-14, 16-14,		
			18-21		17-14, 6-14,		
					20-14, 5-21,		
					9-21		

Table 5. Pairs of faculties in strong positive consonance

Obviously, there are many faculties that have highest correlation. The pairs of faculties in strong positive consonance and their appearances in the years have the following form:

- **In one year:** 8-15, 5-18, 1-19, 13-19, 6-16, 7-19, 8-9, 5-10, 9-10, 8-18, 9-18, 14-15, 15-17, 8-21, 18-21, 2-5, 8-16, 2-7, 5-9, 2-10, 7-10, 2-16, 10-16, 7-17, 10-17, 2-6, 7-6, 10-6, 2-20, 10-20, 16-20, 2-14, 7-14, 10-14, 9-15, 9-16, 15-16, 12-18, 20-4, 3-5, 2-3, 11-13, 3-8, 5-8, 19-16, 19-18, 16- 18, 19-17, 4-21, 19-14, 18-14.
- **In two years:** 7-8, 7-15, 5-21, 12-13, 8-17, 16-6, 15-4, 7-16, 17-6, 14 -6, 13-21, 16-17, 7-20, 16-14.
- **In three years:** 15-19, 4-19, 14-20, 9-21, 17-14, 6-20.
- **In four years:** 17-20, 14-17.

The greater part of the pairs of faculties is not constant in time. Only two pairs of faculties (from three universities) appear in four years: „Faculty of Civil Engineering, University of Zilina – Faculty of Environmental and Manufacturing Technology, Technical University in Zvo-len“ and „Faculty of Aeronautics, Technical University in Košice – Faculty of Civil Engineering, University of Zilina“.

The pairs of faculties in positive consonance in 2009-2015 are presented in Table 6.

	2015	2014	2013	2012	2011	2010	2009
Positive consonance (85-95)	2-3,	3-2,	5-8, 5-9, 2-14,	2-7, 7-5,	2-5, 5-7, 2-9,	5-7,	3-7,
	3-6,	8-7,	7-14, 8-14,	3-18, 2-8,	7-9, 2-8, 7-8,	7-13,	5-7,
	6-8,	7-9,	4-14, 9-14,	5-8, 7-10,	3-18, 2-18,	7-8,	8-7,
	7-9,	5-12,	8-10, 8-12,	8-10, 2-11,	7-18, 2-15,	9-19,	2-4,
	8-9,	7-12,	4-12, 9-12,	5-11, 2-9,	7-15, 5-10,	15-19,	3-4,
	6-10,	5-13,	5-18, 14-18,	5-9, 9-13,	9-10, 8-10,	19-16,	19-4,
	9-13,	7-13,	10-18, 12-18,	15-13,	18-10, 15-10,	9-12,	7-4,
	9-14,	8-15,	8-13, 9-13,	12-13,	5-16, 8-16,	15-12,	4-16,
	6-15,	9-15,	12-13, 18-13,	13-4, 2-16,	18-16, 15-16,	16-12,	3-20,
	9-15,	12-15,	2-15, 7-15,	5-16, 10-16,	5-12, 9-12,	5-6,	5-20,
	10-15,	10-6,	8-15, 4-15,	13-19, 7-17,	15-12, 5-13,	13-6,	8-20,
	5-17,	10-16,	9-15, 18-15,	8-17, 10-17,	9-13, 15-13,	8-6,	4-20,
	7-17,	9-19,	14-19, 12-19,	9-17, 15-17,	2-19, 7-19,	9-10,	4-18,
	8-17,	12-19,	15-19, 5-16,	4-17, 16-17,	10-19, 16-19,	7-10,	4-17,
	13-17,	13-19,	7-16, 14-16,	19-17, 4-17,	12-19, 13-19,	15-10,	2-21,
	15-17,	7-17,	14-16, 15-16,	7-14, 8-14,	5-17, 9-17,	16-10,	3-21,
	16-17,	15-17,	2-1, 7-17,	10-14, 9-14,	8-17, 18-17,	6-10,	19-21,
	17-18,	19-17,	8-17, 4-17,	15-14, 4-14,	15-17, 19-17,	9-18,	7-2,
	9-19,	5-20,	9-17, 18-17,	16-14,	2-4, 7-4, 10-4,	15-15,	16-2,
	17-19,	8-20,	16-17, 5-6,	19-14,	16-4, 12-4,	16-18,	20-21,
	5-20,	7-20,	7-6, 14-6,	7-16, 8-6,	13-4, 17-4, 5-6,	5-20,	18-21,
	7-20,	15-20,	10-6, 15-6,	10-6, 9-6,	9-6, 8-6, 18-6,	13-20,	17-21,
	8-20,	6-20,	17-6, 2-20,	15-6, 4-6,	15-6, 19-6, 4-6,	8-20,	4-14,
	13-20,	16-20,	7-20, 8-20,	16-6, 19-6,	5-10, 9-20,	10-20,	21-14
	15-20,	19-20,	4-20, 9-20,	7-20, 8-20,	8-20, 18-20,	10-4,	
	16-20,	14-20,	18-20, 19-20,	10-20, 9-20,	15-20, 19-20,	7-21,	
	18-20,	17-20,	16-20, 6-20,	15-20, 4-20,	4-20, 5-14,	6-21,	
	19-20,	12-21,	5-21, 14-21,	16-20,	9-14, 18-14,	20-21,	
	17-21,	13-21,	10-21, 12-21,	19-20, 2-21,	15-14, 19-14,	4-21	
	20-21	20-21	13-21, 15-21,	5-21, 17-21,	4-14, 2-21,		
			17-2, 20-21	14-21, 6-21,	7-21, 10-21,		
				20-21	16-21, 12-21,		
					13-21, 17-21,		
					6-21, 20-21,		
					14-21		

Table 6. Pairs of faculties in positive consonance

Some of the pairs of faculties that have are in positive consonance are shown below.

- **In one year:** 3-6, 8-9, 13-17, 7-12, 14-20, 17-20.
- **In two years:** 2-3, 9-5, 5-17, 7-20, 13-20, 7-8, 5-12, 5-13, 7-13, 8-15, 6-20, 12-21.
- **In three years:** 7-9, 10-15, 15-17, 16-17, 17-18, 9-19, 18-20, 8-15, 10-16, 12-19, 13-19, 13-21.
- **In four years:** 6-8, 9-13, 9-14, 6-15, 7-17, 8-17, 17-19, 5-20, 15-20, 16-20, 17-21,
- **In five years:** 19-20, 20-21, 6-10.
- **In six years:** 20-21.
- **In seven years:** 8-20.

The pairs of faculties in positive consonance and weak positive consonance are numerous. This event can be explained by the possibility of part-time lecturers working in several faculties. Another important mark is the equality of the faculties as estimation.

4 Analysis of the results for the research period (2009–2015)

By comparing the results from the first application of ICA approach during the period of research (2009–2015), the following conclusions can be drawn:

- 1) From the obtained results, it is seen that there are no strong dependences between the groups of criteria. The correlations between them are in “weak dissonance”, “dissonance”, or “strong dissonance”;
- 2) Only one pair of criteria “Science and research–PhD students” changes its behaviour over time. It is in weak dissonance in 2009-2012 and in 2014, in weak positive consonance in 2013 and in dissonance in 2015;
- 3) The dependence between the pair of criteria “PhD students–Successful of grants” is in weak dissonance in 2011-2014 and in dissonance in 2009, 2010, 2015;
- 4) The dependence between the pair of criteria “Science and research–Successful of grants” appears in weak dissonance in 2014 and in dissonance 2009-2013 and 2015;
- 5) The dependence between the pair of criteria “Education–Successful of grants” is in weak dissonance in 2009, the correlation decreases in dissonance in 2010-2013 and in strong dissonance in 2014, 2015;
- 6) The dependence between the pair of criteria “Education–PhD students” decreases from weak dissonance (2009, 2010) to dissonance (2011, 2012) and strong dissonance (2013-2015);
- 7) The dependence between the pair of criteria “Education–Science and research” decreases from dissonance (2009-2012) to strong dissonance (2013-2015);
- 8) The dependence between the pair of criteria “Attractiveness of education–Successful of grants” increases from strong dissonance (2009-2014) to dissonance (2015);
- 9) The dependence between the pair of criteria “Education–Attractiveness of education” is in dissonance in 2009, 2015 and in strong dissonance in 2010-2014;
- 10) The dependence between the pair of criteria “Attractiveness of education–Science and research” appears in dissonance (2011-2014) and in strong dissonance (2009, 2010, 2015);
- 11) The dependence between the pair of criteria “Attractiveness of education–Science and research” is in dissonance (2009, 2013-2015) and in strong dissonance (2010-2012).

With the comparison of the results from the second application of ICA method during the period of research (2009–2015), we obtain the following results:

- 1) In strong positive consonance are 16 pairs of faculties in 2009, 9 pairs of faculties in 2010, 35 pairs of faculties in 2011, 15 pairs of faculties in 2012, 16 pairs of faculties in 2013, 5 pairs of faculties in 2014 and 9 pairs of faculties in 2015. According to the distribution over time there are 39 pairs of faculties appearing in strong positive consonance for one year, 14 pairs of faculties appearing in strong positive consonance for two years, 6 pairs of faculties appearing in strong positive consonance for three years and 2 pairs of faculties appearing in strong positive consonance for four years. The greater part of the pairs of the faculties is not constant in time. Only two pairs of faculties (from three universities) appear in four years: „Faculty of Civil Engineering, University of Zilina–Faculty of Environmental and Manufacturing Technology, Technical University in Zvolen“ and „Faculty of Aeronautics, Technical University in Košice–Faculty of Civil Engineering, University of Zilina“;
- 2) In positive consonance are 24 pairs of faculties in 2009, 32 pairs of faculties in 2010, 77 pairs of faculties in 2011, 58 pairs of faculties in 2012, 64 pairs of faculties in 2013, 32 pairs of faculties in 2014 and 30 pairs of faculties in 2009;
- 3) Some of the pairs appear in more than two, three or four years. For example the pair of faculties "Faculty of Electrical Engineering and Computer Science, Technical University in Košice-Faculty of Environmental and Manufacturing Technology, Technical University in Zvolen" appears in 7 years.
- 4) In weak positive consonance are 53 pairs of faculties in 2009, 39 pairs of faculties in 2010, 51 pairs of faculties in 2011, 56 pairs of faculties in 2012, 62 pairs of faculties in 2013, 53 pairs of faculties in 2014 and 53 pairs of faculties in 2009.

The results from the research show that there are no dependencies between the groups of criteria used in the Slovak university rankings but most of the faculties have dependencies.

Conclusion

In the current research, the ICA method for discovering hidden patterns in data using Ratings of Slovak Universities was used. The best correlations between the groups of criteria/faculties and dependent and independent groups of criteria/faculties and the relationship between them were identified by applying the ICA approach.

There are no dependencies between the groups of criteria used in the Slovak university ranking system. The selected faculties give us positive correlation.

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