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THE UNIVERSITY OF BELGRADE ON ARWU LIST - PART I: THE IMPACT OF INDIVIDUAL FACULTIES ON THE ACHIEVED POSITION USING PROMETHEE-GAIA METHOD

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Abstract

Since 2012, University of Belgrade (UB) has been ranked among the 500 best universities in the world on the prestigious Academic Ranking of World Universities (ARWU) list, also known as Shanghai list. These top 500 universities represent only 2% of all universities in the world. According to the most recent global ranking done in 2015, UB ranks between 201 and 300 place, and is the best ranked university in Southeast Europe.

UB consists of 31 faculties and 11 research institutes and each of these institutions in its own way contributes to the overall achieved position of UB on the ARWU list. This paper analyzes the impact of its certain faculties on the UB's ranking position through a number of papers indexed in Science Citation Index - SCIe and SSCI, the number of citations and the number of citations per paper and per researcher for the period 2011 - 2015. For data processing multi-criteria decision making method PROMETHEE-GAIA, was used. Obtained results revealed four clusters of faculties such as faculties – with the greatest impact, with a significant impact, medium and low impact on the overall ranking result on ARWU list.

Keywords: Ranking of faculties, University of Belgrade, ARWU list, PROMETHEE – GAIA method

1. INTRODUCTION

By definition, expert knowledge has been generated at faculties of prestigious universities in the world (Brew & Boud, 1995; Millot, 2015). There are four types of knowledge that define the quality characteristics of higher education institutions: internal and external, tacit and implicit knowledge reflected in the quality of teaching staff, internal resources, databases, textbooks, expertise and other things in a

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changing environment with growing requirements for continuous increase of the quality of their output (Wijetunge, 2002; Arsić et al., 2012). The quality of knowledge generated in higher education institutions is a reflection of the quality of scientific work which is measured by the number of publications and citations in refereed journals (Price & Cotton, 2006; Abramo et al., 2013; Metcalf et al., 2015; Saarela et al., 2016).

Ranking of universities has become extremely popular at the beginning of the 21st century and has been widely accepted as a measure of their success (Millot, 2015) There are global, regional and national rankings of higher education institutions and universities (Arsić et al., 2012; Altanopoulou et al., 2012; Chou et al., 2013; Da Silva et al., 2016). Most popular lists of university ranking in the world are (Sidorenko & Gorbatova, 2015; Millot, 2015; Olcay & Bulu, 2016):

- QS World University Rankings (published since 2000);
- Academic Ranking of World Universities (ARWU), Shanghai Ranking (published since 2003);
- Times Higher Education World University Ranking – Thomson Reuters (THE) (published since 2010) etc.

Ranking criteria for these lists, as well as for some other lists are: quality of teaching, quality of research, citation, quality of education, quality of a faculty, international outlook, industry income and other (Docampo, 2013; Olcay & Bulu, 2016), although with respect to the ranking results, there may be some shortcomings, such as the size of the university or scientific field, due to different possibility for publishing (Lin et al., 2013; Daraio et.al., 2015). The most popular and most commonly used for comparison of individual institutions is ARWU list also known as the Shanghai list published by Shanghai Cijao Tong University once a year, since 2003.

ARWU ranking list every year presents the best 500 universities in the world. The top 100 universities are ranked, and the remaining 400 are arranged by alphabetical order into four clusters, each cluster consisting of 100 universities. Since ARWU list includes less than 2% of all universities it is considered the best quality indicator of the university (Zornić et al., 2014).

The ranking is done according to the following criteria of the quality of education: (a) the number of graduates who are winners of the Nobel Prize and Medal in scientific fields (Alumni) - 10%; (b) -quality of the faculty: the number of employees who won the Nobel Prize or Medals in scientific fields (Award) - 20%; (c) - number of highly cited scientists from 21 scientific fields (HiCi) - 20%; (d) - results of scientific research: number of papers published in the journals Nature and Science (N&S) - 20%; (e)- number of papers published in SCIe and SSCI journals (PUB)- 20%; (f) - Per capita academic performance of an institution (PCP)- 10% (Docampo, 2013; Olcay & Bulu, 2016).

From South-East Europe on the ARWU list in 2015 are only the following universities: University of Belgrade (Serbia) in the cluster 201-300; the University of Ljubljana (Slovenia) in the cluster 401-500 and Eötvös Lorand University and the University of Szeged (Hungary), also in a cluster 401-500.

The University of Belgrade, Serbia (UB) first time appeared on ARWU list in 2012, in a cluster 401-500 where it also stayed in 2013. In 2014, UB moved to a cluster 301-400 and currently is in cluster 201-300.

Position of UB on ARWU list is a result of scientific work at 31 faculties and 11 institutes. From these criteria, approximately 50% belong to the number of papers published in journals on SCIe and SSCI lists, the number of citations and the number of results per researcher which has a predominant influence on the position of UB on ARWU list (Zornić et al., 2014).

2. EXPERIMENTAL (RESEARCH)

This paper presents the results of ranking of the UB's faculties by following criteria: number of papers published in journals on SCIe and SSCI lists per researcher as well as the number of citations per published work and researcher at each faculty. Faculties are grouped in four scientific fields: (1) Social Sciences and Humanities, (2) Medical Sciences, (3) Science and Mathematics and (4) Technology and Engineering Sciences (Please see Table 1).

Data on the number and titles of the faculties' staff were taken from the official website of the University. A search of academic databases Scopus (www.scopus.com) came up to the data that these researchers published 19023 scientific papers in period (2011 – 2015.), and that in this five-year period, their papers were cited 36579 times. Also, it should be emphasized that only papers published in scientific journals on SCI and JCR lists were discussed. Papers from seminars and conferences are not included. Also, as for the citations, self-citations are not included. It should be noted that this search of Scopus database was conducted in January 2016, and these results, presented in the paper, correspond to the data for that period.

2.1. Structure of UB

UB is the oldest and the largest university in Serbia. It was founded in 1808. Today the UB consists of 31 independent faculties and 11 research institutes. More than 4000 professors and teaching assistants are employed and over 80000 students are studying at UB. Regarding the scientific fields which it covers and achieved results in education and scientific research UB is an institution of great national importance and it represents a national brand in Serbia. Table 1 presents the number and structure of employees at UB faculties, at the end of 2015.

3. RESULTS

3.1. Papers published in journals indexed in SCIe and SSCI

Since 2005, with introduction of standards for accreditation of faculties and universities in Serbia, criteria for promotion of teachers and scientists as well as the formal application for defense of the doctoral dissertation, the predominant requirements for all these activities are scientific papers published in journals on Thomson Reuters SCIe, SSCI and ARTS & HUMANITIES lists. This requirement has contributed that teachers at universities and scientists in institutes started to publish their work in journals on the above mentioned list, which brought UB in 2012 on ARWU list, and it has maintained its position to this day.

Papers published in journals on SCIe and SSCI list are not always a reliable indicator of the quality of scientific research because of the problematic quality of certain journals. Among these journals there are those who

Table 1. Number and structure of employees for each faculty in 2015.

Faculty	Full professor	Associate professor	Assistant professor	Teaching assistant	Total
Social sciences and humanities					
Faculty for Special Education and Rehabilitation - **FSER**	34	16	11	32	93
Faculty of Philology - **FP**	53	43	63	58	217
Teacher Education Faculty - **TEF**	16	9	23	15	63
Faculty of Economics - **FE**	36	25	23	28	112
Faculty of Philosophy - **FPhy**	80	71	98	21	270
Faculty of Low - **FL**	36	20	28	20	104
Faculty of Security Studies - **FSS**	12	9	10	9	40
Faculty of Sport and Physical Education - **FSPE**	17	14	15	15	61
Faculty of Orthodox Theology - **FOT**	11	12	15	11	49
Faculty of Political Sciences - **FPS**	38	14	20	27	99
Medical sciences					
Faculty of Medicine - **FM**	68	63	58	65	254
Faculty of Pharmacy - **FPh**	47	23	40	34	144
Faculty of Dental Medicine -**FDM**	45	16	34	0	95
Faculty of Vetenary Medicine - **FVM**	38	28	29	32	127
Science and mathematics					
Faculty of Biology - **FB**	25	36	42	12	115
Faculty of Mathematics - **FMath**	17	14	27	53	111
Faculty of Geography - **FGeo**	19	9	25	11	64
Faculty of Chemistry - **FCh**	19	14	20	20	73
Faculty of Physics - **FPhys**	19	17	18	5	59
Faculty of Physical Chemistry - **FPhyChe**	9	8	10	14	41
Technology and engineering sciences					
Faculty of Civil Engineering - **FCEng**	18	25	50	65	158
Faculty of Agriculture - **FAg**	97	44	73	47	261
Faculty of Mechanical Engineering - **FMEng**	77	33	49	55	214
Faculty of Technology and Metallurgy - **FTM**	51	31	31	39	152
Faculty of Organizational Sciences - **FOS**	41	24	39	58	162
Faculty of Electrical Engineering - **FEENG**	51	28	44	40	163
Faculty of Architecture - **FAr**	18	26	36	40	120
Technical Faculty in Bor - **TFB**	20	17	26	18	81
Faculty of Forestry - **FF**	38	18	32	17	105
Faculty of Transport and Traffic Engineering - **FTTEng**	32	17	53	40	142
Faculty of Mining and Geology - **FMG**	42	31	23	14	110

charge fees for publishing regardless the quality of submitted papers. The consequences of such a policy were that these journals lost their impact factor (IF) and received the status of predatory journals (TTEM, Metalurgia International, HOLTMED, etc.). Also, there is a practice of "mutual agreement" to list co-authors on scientific papers who did not contributed in a research process at all, and there are frequent cases that co-authors are not even familiar with that particular scientific field. Single-author papers are very rare, so sometimes it is very difficult to determine the right number of publications in a single institution. Therefore, expressing the number of published papers per researcher employed at the institution (faculty) represents a more objective picture on the volume of published papers in that institution (faculty) and its impact on the overall rating of the university whom it belongs.

Figure 1 shows the trend of published works at UB for all four field groups for the period 2011 - 2015 as well as the number of papers per researcher for each year. This method gives us the opportunity to compare the results by fields of science, which are very different in methodology and scope of research, possibilities for publishing and overall achieved level of development of scientific research work.

The obtained results indicate that the quality of work by the number of published papers per researcher criterion is the lowest in the field of social sciences and humanities, than, in ascending order, it is followed by faculties in the field of technology and engineering sciences and medical sciences whereas the best results were achieved in the field of science and mathematics. In the field of SM (Figure 3) the best result have achieved FCh and FPhyChe, in the field of MS - FM and FPh, in the field of TES, FTM, and in the field of SSH - FSPE, FE and FSER.

Ascending trend in the number of publications in journals on SCIe and SSCI lists in the period 2011-2015 is the most evident at faculties: FSPE, FM, FPh and FTM.

Ranking of individual faculties by the criterion number of papers per researcher in journals on SCIe and SSCI lists for the period 2011-2015, is shown in Table 2. The impact of this criterion can be expressed in three clusters regarding the number of papers per researcher greater than 10 (a major impact - A cluster) in the range 5 - 10 (medium impact- Cluster B), and in the range 0-5 (low impact - Cluster C), Cutting point for clusters are chosen by authors themselves, and are only there to give more clear presentation regarding the number of

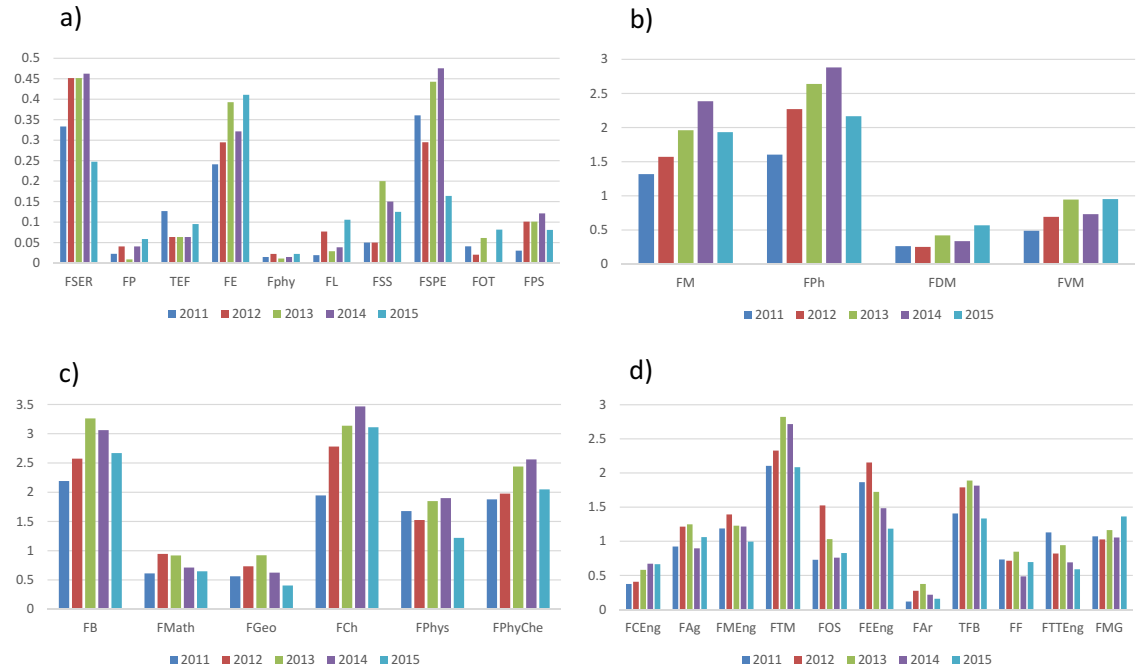


Figure 1. The number of papers per researcher for the group of faculties: a) within Social Sciences and Humanities; b) within Medical Sciences; c) within Science and Mathematics; d) within Technology and Engineering Sciences

Table 2. Ranking of individual faculties by the criterion number of papers per researcher for the period 2011-2015.

Faculty	Number of papers/number of researchers	Cluster	Scientific field
Faculty of Chemistry - **FCh**	15.04		SM
Faculty of Biology - **FB**	13.00		SM
Faculty of Physical Chemistry - **FPhyChe**	11.68	A	SM
Faculty of Technology and Metallurgy - **FTM**	11.48		TES
Faculty of Pharmacy - **FPh**	11.41		MS
Faculty of Agriculture - **FAg**	9.28		TES
Faculty of Medicine - **FM**	9.19		MS
Faculty of Electrical Engineering - **FEENG**	8.73		TES
Technical Faculty in Bor - **TFB**	8.27		TES
Faculty of Physics - **FPhys**	7.31	B	SM
Faculty of Transport and Traffic Engineering - **FTTEng**	6.25		SM
Faculty of Mechanical Engineering - **FMEng**	5.83		TES
Faculty of Organizational Sciences - **FOS**	5.38		TES
Faculty of Mathematics - **FMath**	5.36		SM
Faculty of Mining and Geology - **FMG**	4.88		TES
Faculty of Vetenary Medicine - **FVM**	3.78		MS
Faculty of Forestry - **FF**	3.31		TES
Faculty of Civil Engineering - **FCEng**	3.27		TES
Faculty of Geography - **FGeo**	3.25		SM
Faculty of Dental Medicine -**FDM**	2.19		MS
Faculty for Special Education and Rehabilitation - **FSER**	2.03		SSH
Faculty of Sport and Physical Education - **FSPE**	1.76		SSH
Faculty of Economics - **FE**	1.56	C	SSH
Faculty of Architecture - **FAr**	1.19		TES
Faculty of Security Studies - **FSS**	0.55		SSH
Faculty of Political Sciences - **FPS**	0.49		SSH
Teacher Education Faculty - **TEF**	0.38		SSH
Faculty of Low - **FL**	0.25		SSH
Faculty of Orthodox Theology - **FOT**	0.21		SSH
Faculty of Philology - **FP**	0.17		SSH
Faculty of Philosophy - **FPhy**	0.06		SSH

papers per researcher at different faculties. The real ranking was done at the end of the paper, using PROMETHEE-GAIA methodology.

3.2. The impact of number of citations

A paper published in a journal on SCIe and SSCI lists is necessary, but not sufficient requirement in order to be able to give a reliable assessment of the quality of that published work and its impact on the rating of the faculty which author wrote as his affiliation. If the published work does not cause any reaction of the scientific community through citation in journals on Thomson Reuters list, then the quality of such papers cannot be highly appreciated. In this study the number of citations was determined based on the Scopus database which does not give a complete and reliable information but with a high probability defines the order of ranking. Figure 2 shows the results of the number of citations per researcher for each faculty within UB for the period 2011-2015. It must be emphasized

that here only citations of papers published in 2011 and later are presented.

The obtained results shown in Figure 2 present a descending trend of citations after 2012-2013, which indicates that the quality of published papers at most faculties decline. Having in mind that only citations of papers published in 2011 and later were considered in this study, it must be clear that the number of citations will be larger if citations of all papers were included.

Table 3 shows the ranking list of faculties according the number of citations per researcher for the period 2011-2015 criterion. Faculties are divided into three clusters in terms of the number of citations per researcher greater than 10 (major impact - A cluster) in the range 5 - 10 (medium impact- Cluster B) and in the range 0-5 citation (low impact - Cluster C).

3.3. The impact of ratio number of citations and number of papers per researcher

The criterion number of citations per published paper and per researcher can be one of the most suitable criteria for assessing the overall quality of scientific research at the university. Table 4 shows the results of ranking the UB faculties by the number of citations per published paper and researcher criterion.

In summary, the impact of individual faculties of UB by criteria the number of published papers, the number of citations and the number of citations per published paper per professors and assistants employed at faculties, is shown in Figure 3. According to this figure we can identify four clusters of influence:

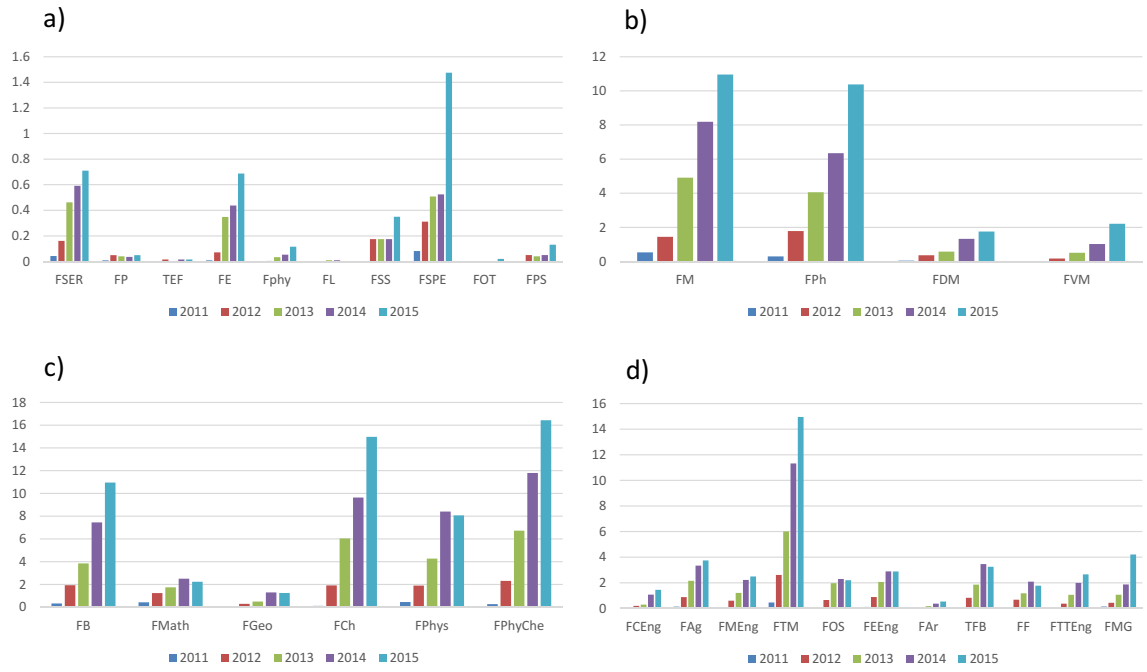


Figure 2. The number of citations per researcher for the group of faculties a) within Social Sciences and Humanities; b) within Medical Sciences; c) within Science and Mathematics; d) within Technology and Engineering Sciences

Table 3. Ranking of individual faculties by the number of citations per researcher in period 2011-2015 criterion

Faculty	Number of citations/number of researchers	Cluster	Scientific field
Faculty of Physical Chemistry - **FPhyChe**	39.93	A	SM
Faculty of Chemistry - **FCh**	33.56		SM
Faculty of Technology and Metallurgy - **FTM**	33.36		TES
Faculty of Medicine - **FM**	25.97		MS
Faculty of Biology - **FB**	23.54		SM
Faculty of Pharmacy - **FPh**	22.19		MS
Faculty of Physics - **FPhys**	20.87		SM
Faculty of Mathematics - **FMath**	12.58		SM
Technical Faculty in Bor - **TFB**	9.44	B	TES
Faculty of Electrical Engineering - **FEENG**	9.05		TES
Faculty of Organizational Sciences - **FOS**	8.56		TES
Faculty of Mechanical Engineering - **FMEng**	6.34		TES
Faculty of Mining and Geology - **FMG**	6.34		TES
Faculty of Forestry - **FF**	5.08		TES
Faculty of Agriculture - **FAg**	4.95	C	TES
Faculty of Transport and Traffic Engineering - **FTTEng**	4.68		TES
Faculty of Vetenary Medicine - **FVM**	3.84		MS
Faculty of Civil Engineering - **FCEng**	3.69		TES
Faculty of Geography - **FGeo**	3.10		SM
Faculty of Sport and Physical Education - **FSPE**	2.98		SSH
Faculty for Special Education and Rehabilitation - **FSER**	1.72		SSH
Faculty of Economics - **FE**	1.44		SSH
Faculty of Architecture - **FAr**	1.14		TES
Faculty of Dental Medicine -**FDM**	0.98		MS
Faculty of Security Studies - **FSS**	0.74		SSH
Faculty of Political Sciences - **FPS**	0.19		SSH
Faculty of Philosophy - **FPhy**	0.18		SSH
Faculty of Philology - **FP**	0.11		SSH
Teacher Education Faculty - **TEF**	0.05		SSH
Faculty of Low - **FL**	0.02		SSH
Faculty of Orthodox Theology - **FOT**	0.02		SSH

a) Cluster 1 – the cluster of great impact: FphyChe, FB, FCh, FTM, FPh, FM and FPhys.

b) Cluster 2 – the cluster of significant impact: FMath, FOS, FMG, FMEng, TFB, FEEng, FTTEng and FAg.

c) Cluster 3 – the cluster of medium impact: FP, FSPE, FF, FSS, FCEng, FVM, FPhy, FAr, FE, FSER and FGeo.

d) Cluster 4 – the cluster of low impact: FDM, FPS, TEF, FOT and FL.

3.4. Evaluating the importance of each faculty by multi-criteria model

In order to evaluate and rank the partial contribution of each faculty on the position of UB on ARWU list, the following three indicators with their importance weights in multi-criteria model were used:

1) The number of published papers in journals index in SCIe and SSCI per researcher – 20%

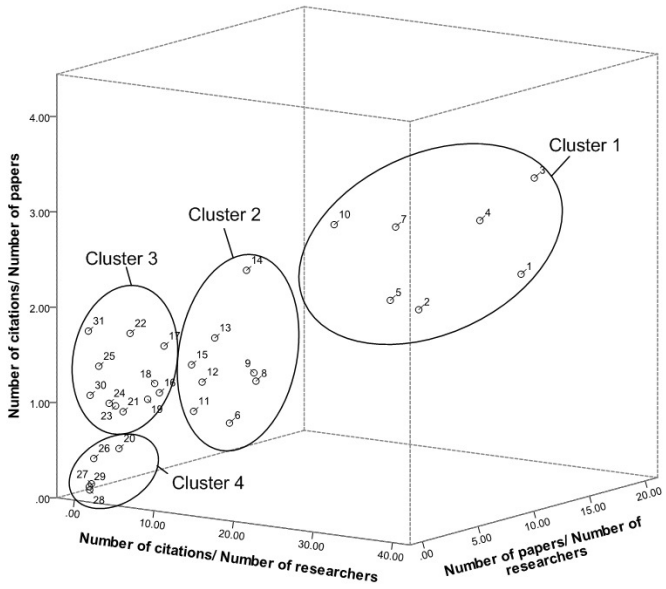
Table 4. Ranking of impact of individual faculties by number of citation and number of papers per researcher criterion

Faculty	Number of citations/number of papers	Cluster	Scientific field
Faculty of Physical Chemistry - **FPhyChe**	3.41	A	SM
Faculty of Technology and Metallurgy - **FTM**	2.90		TES
Faculty of Physics - **FPhys**	2.85		SM
Faculty of Medicine - **FM**	2.82		MS
Faculty of Mathematics - **FMath**	2.34		SM
Faculty of Chemistry - **FCh**	2.23		SM
Faculty of Pharmacy - **FPh**	1.94		MS
Faculty of Biology - **FB**	1.81		SM
Faculty of Philosophy - **FPhy**	1.73		SSH
Faculty of Sport and Physical Education - **FSPE**	1.69		SSH
Faculty of Organizational Sciences - **FOS**	1.59		TES
Faculty of Forestry - **FF**	1.53		TES
Faculty of Security Studies - **FSS**	1.36	B	SSH
Faculty of Mining and Geology - **FMG**	1.30		TES
Technical Faculty in Bor - **TFB**	1.14		TES
Faculty of Civil Engineering - **FCEng**	1.12		TES
Faculty of Mechanical Engineering - **FMEng**	1.08		TES
Faculty of Philology - **FP**	1.06		SSH
Faculty of Electrical Engineering - **FEENG**	1.03		TES
Faculty of Vetenary Medicine - **FVM**	1.01		MS
Faculty of Geography - **FGeo**	0.95	C	SM
Faculty of Architecture - **FAr**	0.95		TES
Faculty of Economics - **FE**	0.92		SSH
Faculty for Special Education and Rehabilitation - **FSER**	0.84		SSH
Faculty of Transport and Traffic Engineering - **FTTEng**	0.74		TES
Faculty of Agriculture - **FAg**	0.53		TES
Faculty of Dental Medicine -**FDM**	0.44		MS
Faculty of Political Sciences - **FPS**	0.38		SSH
Teacher Education Faculty - **TEF**	0.12		SSH
Faculty of Orthodox Theology - **FOT**	0.09		SSH
Faculty of Low - **FL**	0.06		SSH

2) The number of citations per researcher, according to SCOPUS database - 30% and

3) The number of citations per published paper and researcher – 50%.

Based on the data for quality indicators of scientific research at 31 faculties of UB in the period 2011 - 2015, an initial table for the evaluation and ranking of the impact of these faculties using PROMETHEE / GAIA methodology was created (Brans et al., 1984; Brans & Vincke, 1985). This well-known multi-criteria methodology was applied in this study because of its advantages, which are primarily reflected in the way of structuring the problem, the amount of data that can be processed, ability to quantify qualitative values, good software support



Legend: 1 - FPh; 2 - BF; 3 - FPhyChe; 4 – FTM; 5 - FPh; 6 - FAg; 7 - FM; 8 - FEEng; 9 - TFB; 10 - FPhys; 11 - FTTEng; 12 - FMEng; 13 - FOS; 14 - FMath; 15 - FMG; 16 - FVM; 17 -FF; 18 – FCEng; 19 - FGeo; 20 -FDM; 21 - FSER; 22 - FSPE; 23 - FE; 24 - FAr; 25 -FSS; 26 - FPS; 27 - TEF; 28 - FL; 29 - TOS; 30 - FP; 31 - FPhy.

Figure 3. The impact of individual faculties by the following criteria: the number of papers, the number of citations and the ratio number of citations and number of papers per researcher

and graphical presentation of the results on GAIA plane (Macharis et al., 2004; Behzadian et al., 2010).

Detailed procedures of PROMETHEE II methodology, which was used in this study, is described in the literature (Ishizaka & Nemery, 2011).

For the data presented in Table 5, the initial parameters necessary for the implementation of PROMETHEE II complete ranking were defined, whereby for all three criteria, in multicriteria model,. V-shape function of preferences with preference threshold p = 100%., was selected (Vego et al., 2008).

Also, authors defined the percentage of importance of each of the criteria in the model, where the greatest importance, 50%, was given to ratio (criteria 3-C3) the number of citations / number of papers, while the remaining 50% was distributed to the other two criteria C1 and C2 with the percentage of importance 30% and 20%, respectively.

Based on the initial table for faculty evaluation, positive (φ +) and negative flow of preferences (φ-) were determined as well as the value of net flows (φ) for each faculty, respectively. Results of PROMETHEE II rankings are shown in Table 6.

Based on the results shown in Table 6, the first group of 8 faculties can be extracted, which has high levels of net flows (φ value greater than 0.5), and top-ranked among them is the Faculty of Physical Chemistry from the group of Sciences and Mathematics with the value of the net-flow of preferences 0.8590. Furthermore, it can be concluded that in this group the best ranked 5 out of 8 faculties are the faculties from SM group. In addition, in this first group there are also two faculties from group of Medical Sciences (FM and FPh) as well as very high-ranked

Table 5. The initial table for evaluation of 31 faculties of UB

No.	Name of faculty	Faculty label in PROMETHEE model	Scientific field*	Criterion C1-Number of papers/number of researchers	Criterion C2- Number of citations/number of researchers	Criterion C3-Number of citations/number of papers
1.	Faculty of Chemistry	Fac_1	SM	15.04	33.56	2.23
2.	Faculty of Biology	Fac_2	SM	13.00	23.54	1.81
3.	Faculty of Physical Chemistry	Fac_3	SM	11.68	39.93	3.42
4.	Faculty of Technology and Metallurgy	Fac_4	TES	11.48	33.36	2.91
5.	Faculty of Pharmacy	Fac_5	MS	11.41	22.19	1.95
6.	Faculty of Agriculture	Fac_6	TES	9.28	4.95	0.53
7.	Faculty of Medicine	Fac_7	MS	9.19	25.97	2.83
8.	Faculty of Electrical Engineering	Fac_8	TES	8.73	9.05	1.04
9.	Technical Faculty in Bor	Fac_9	TES	8.27	9.44	1.14
10.	Faculty of Physics	Fac_10	SM	7.31	20.87	2.86
11.	Faculty of Transport and Traffic Engineering	Fac_11	TES	6.25	4.68	0.75
12.	Faculty of Mechanical Engineering	Fac_12	TES	5.83	6.34	1.09
13.	Faculty of Organizational Sciences	Fac_13	TES	5.38	8.56	1.59
14.	Faculty of Mathematics	Fac_14	SM	5.36	12.58	2.35
15.	Faculty of Mining and Geology	Fac_15	TES	4.88	6.34	1.30
16.	Faculty of Veterinary Medicine	Fac_16	MS	3.78	3.84	1.01
17.	Faculty of Forestry	Fac_17	TES	3.31	5.08	1.53
18.	Faculty of Civil Engineering	Fac_18	TES	3.27	3.69	1.13
19.	Faculty of Geography	Fac_19	SM	3.25	3.10	0.95
20.	Faculty of Dental Medicine	Fac_20	MS	2.19	0.98	0.45
21.	Faculty for Special Education and Rehabilitation	Fac_21	SSH	2.03	1.72	0.85
22.	Faculty of Sport and Physical Education	Fac_22	SSH	1.76	2.98	1.69
23.	Faculty of Economics	Fac_23	SSH	1.56	1.44	0.92
24.	Faculty of Architecture	Fac_24	TES	1.19	1.14	0.96
25.	Faculty of Security Studies	Fac_25	SSH	0.55	0.74	1.36
26.	Faculty of Political Sciences	Fac_26	SSH	0.49	0.19	0.39
27.	Teacher Education Faculty	Fac_27	SSH	0.38	0.05	0.12
28.	Faculty of Low	Fac_28	SSH	0.25	0.02	0.06
29.	Faculty of Orthodox Theology	Fac_29	SSH	0.21	0.02	0.10
30.	Faculty of Philology	Fac_30	SSH	0.17	0.18	1.06
31.	Faculty of Philosophy	Fac_31	SSH	0.06	0.11	1.74

** Legend: University of Belgrade within has 31 faculties that are organized in 4 groups: social sciences and humanities - SSH, medical sciences- MS, sciences and mathematics –SM, and technology and engineering sciences- TES)*

Faculty of Technology and Metallurgy, as the only representative from the group of Technology and Engineering Sciences.

One of the advantages of using PROMETHEE II method is the possibility of graphic interpretation with the assistance of

Table 6. The results of PROMETHEE II final ranking

Rank	Name of Faculty	Faculty label in PROMETHEE model	Scientific field	Φ	Φ^+	Φ^-	Cluster*
1.	Faculty of Physical Chemistry	Fac_3	SM	0.8590	0.8617	0.0027	
2.	Faculty of Technology and Metallurgy	Fac_4	TES	0.7971	0.8051	0.0080	
3.	Faculty of Chemistry	Fac_1	SM	0.7405	0.7663	0.0258	
4.	Faculty of Medicine	Fac_7	MS	0.7397	0.7671	0.0274	A
5.	Faculty of Physics	Fac_10	SM	0.6880	0.7461	0.0582	
6.	Faculty of Pharmacy	Fac_5	MS	0.6160	0.6818	0.0658	
7.	Faculty of Biology	Fac_2	SM	0.5966	0.6679	0.0713	
8.	Faculty of Mathematics	Fac_14	SM	0.5183	0.6548	0.1365	
9.	Faculty of Organizational Sciences	Fac_13	TES	0.2856	0.4964	0.2108	
10.	Technical Faculty in Bor	Fac_9	TES	0.1967	0.4443	0.2476	
11.	Faculty of Electrical Engineering	Fac_8	TES	0.1577	0.4269	0.2693	
12.	Faculty of Forestry	Fac_17	TES	0.1273	0.4142	0.2869	B
13.	Faculty of Mining and Geology	Fac_15	TES	0.1246	0.4051	0.2805	
14.	Faculty of Mechanical Engineering	Fac_12	TES	0.0685	0.3766	0.3081	
15.	Faculty of Sport and Physical Education	Fac_22	SSH	0.0512	0.4000	0.3488	
16.	Faculty of Civil Engineering	Fac_18	TES	-0.0673	0.3163	0.3836	
17.	Faculty of Veterinary Medicine	Fac_16	MS	-0.0922	0.3072	0.3994	
18.	Faculty of Transport and Traffic Engineering	Fac_11	TES	-0.1269	0.3164	0.4433	C
19.	Faculty of Geography	Fac_19	SM	-0.1636	0.2851	0.4487	
20.	Faculty of Agriculture	Fac_6	TES	-0.1864	0.3216	0.5079	
21.	Faculty of Security Studies	Fac_25	SSH	-0.2403	0.2635	0.5038	
22.	Faculty of Philosophy	Fac_31	SSH	-0.2440	0.2814	0.5254	
23.	Faculty of Economics	Fac_23	SSH	-0.3260	0.2262	0.5522	
24.	Faculty for Special Education and Rehabilitation	Fac_21	SSH	-0.3280	0.2326	0.5606	
25.	Faculty of Architecture	Fac_24	TES	-0.3375	0.2176	0.5551	
26.	Faculty of Philology	Fac_30	SSH	-0.4470	0.1614	0.6084	D
27.	Faculty of Dental Medicine	Fac_20	MS	-0.5685	0.1729	0.7414	
28.	Faculty of Political Sciences	Fac_26	SSH	-0.7190	0.1162	0.8351	
29.	Teacher Education Faculty	Fac_27	SSH	-0.8487	0.0629	0.9116	
30.	Faculty of Orthodox Theology	Fac_29	SSH	-0.9232	0.0178	0.9410	
31.	Faculty of Low	Fac_28	SSH	-0.9480	0.0111	0.9591	

**In column Cluster faculties are grouped in 4 clusters (A, B, C, D) in accordance with the GAIA plan, presented in Figure 4*

GAIA plane (Brans & Mareschal, 1994). The aim of GAIA plane is to give 2D or 3D presentation of preferences of the decision makers in respect to each considered alternative in the model. Criteria in GAIA plane are presented as vectors, while the alternatives are shown with corresponding points, where the distance of these points from the center of GAIA plane, as well as their positioning in relation to the most important criteria in the model, determines their priority during GAIA ranking. In addition, the length of each criteria vector determines the criteria "ability" to make the differentiation between the alternatives, where the longer a criterion vector is in the GAIA plane, it has the more discriminating power.

It is possible in GAIA plane to design vector weight criteria, whereby this vector is called a decision stick pi. In this way, the decision maker in this analysis can have relevant information on the aspects of conflicting criteria, as well as on the impact of the weight criteria on the final decision (Figure 4).

4. DISCUSSION

Based on the GAIA plane and 2D presentation (U-V axis reference plane view) for the given model of ranking of faculties, which is shown in Figure 4, it can be concluded that 4 clusters could be extracted, which include 31 faculties of UB from 4 scientific fields (SM, MS, SSH, and TES). Cluster A, in Figure 4, consists of 8 faculties, which were previously best ranked using the PROMETHEE II complete ranking (see

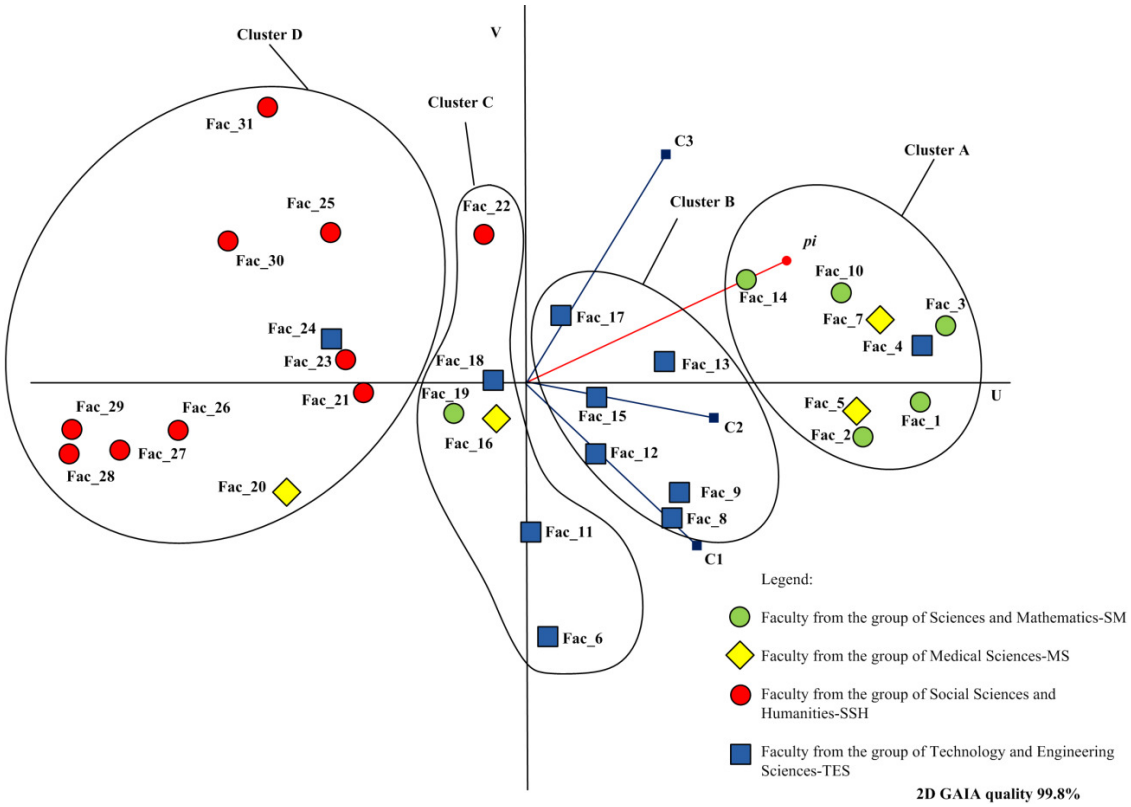


Figure 4. The GAIA plane

Table 6). Within this cluster can be distinguished group of 5 faculties can be distinguished (FPhyChe-Fac_3, FTM-Fac_4, FM- Fac_7, FPhys - Fac_10 FMath-Fac_14), whose performance (a high ranking position) can be explained with the best ratio of the number of citations to the number of papers, and in Figure 4 their position and proximity in relation to this criterion C3 in the model is evident. As for the remaining three faculties from cluster A (FCh- Fac_1, FB- Fac_2 FPh- Fac_5), their belonging to a group of best faculties can be attributed to good results in relation to the criteria C1 and C2 in the model.

The second cluster B consists of 6 faculties from the group of Technology and Engineering Sciences (FOS-Fac_13, TFB-Fac_9, FEEng - Fac_8, FF-Fac_17, FMG-Fac_15, FMEng-Fac_12).

The third cluster C, consists of faculties with lower achieved results according to all three criteria in the model, which can be determined based on their position in the GAIA plane. What's more, these 6 faculties (FAg -Fac_6, FTTEng- Fac_11, FCEng-Fac_18, FVM-Fac_16, FGeo - Fac_19 and FSPE-Fac_22) are located in positions with apparent distance from the direction of all three vectors criteria but much closer to the center of GAIA plane compared to the group of faculties from cluster D, which includes faculties with significantly weaker results of the publication of papers in journals with SCIe and SSCI compared to the previous three clusters of faculties respectively (A, B and C).

Regarding the cluster D, this cluster consists of UB faculties, which have a significantly weaker achieved results in publishing papers in journals indexed in SCIe and SSCI according to the criteria considered in this model, so their position in GAIA plane is such that they are positioned opposite of vectors of all three criteria and significantly away from the center of GAIA plane. In this cluster together with 9 faculties from the group Social Science and Humanities, there are also two more faculties, one from the group Technology and Engineering Sciences (FAr- Fac_24) and FDM- Fac_20 from group of Medical Sciences.

5. CONCLUSIONS

Although the first faculty ranking appeared almost 10 years ago, the methodology is still not fully developed. There are some deficiencies in the current methodology, depending on which of the criteria researcher consider important for evaluating scientific research. As a result, there are different ranking lists of universities, which are different in many ways. Future research should go in the direction to establish a uniform methodology of ranking of higher education institutions.

In this paper authors attempted to overcome some of the limitations of current methodologies, primarily the size of the faculty and the different areas of research, whit respect to each individual group of faculty. The achieved improvements that are evident in the last few years at most discussed faculties of UB, indicate that the process of approaching the Shanghai list started with certain resistance of part of the University which do not react to the fact that changes have already become part of reality. Defined clusters point to a particular group of faculty who are more sensitive to changes and those who are less sensitive.

The results obtained in this study indicate that the impact of certain faculties to the

overall position of UB on ARWU list is different regarding the scientific field. Given that the main criteria used for ranking the impact of certain faculties is the same as the ranking of the university on ARWU list, such as: papers published in journals indexed in SCIe and SSCI lists and the number of citations, it is evident that at many faculties of UB have not built a practice for publications of this kind, which resulted in the fact that in these groups, but also at individual faculties within the same group at the UB, specific criteria for promotion of a researcher, for doctoral dissertation, for mentoring and more, were defined.

In the analyzed period big improvements can be seen, regarding the results achieved by the studied criteria, at many faculties of UB. In order to continuously improve the quality of scientific work at UB, by introducing the same standards also in the field of social sciences and humanities as in other three fields of science, it is realistic to expect that in the future period UB can be found among the first 100 universities on ARWU list.

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УНИВЕРЗИТЕТ У БЕОГРАДУ НА “ARWU” LISTИ - ДЕО I: АНАЛИЗА УТИЦАЈ ПОЈЕДИНАЧНИХ ФАКУЛТЕТА НА ДОСТИГНУТУ ПОЗИЦИЈУ ПРИМЕНОМ “PROMETHEE-GAIA” МЕТОДЕ

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Извод

Још од 2012. године, Универзитет у Београду (УБ) је рангиран међу 500 најбољих универзитета у свету, на престижној листи Академског Рангирања Светских Универзитета (“ARWU”), која је такође позната и као Шангајска листа. Ових 500 универзитета представљају свега 2% укупног броја универзитета на свету. Према најновијем глобалном рангирању, спроведеном 2015. године, УБ је рангиран између 201-ог и 300-тог места, и најбоље је рангиран универзитет у региону Југоисточне Европе.

УБ се састоји од 31 факултета и 11 истраживачких института и свака од ових институција, на свој начин доприноси укупно достигнутој позицији УБ на овој листи. Овај рад анализира утицај појединачних факултета на позицију на којој се рангира УБ на “ARWU” листи, преко броја радова индексираних у “Science Citation Index - SCIe” и “SSCI”, узимајући у обзир број цитата и број цитата по раду и по истраживачу за период 2011 - 2015. За обраду података коришћена је метода вишекритеријумског одлучивања “PROMETHEE-GAIA”. Добијени резултати су издвојили четири кластера факултета, где спадају: факултети са највећим утицајем, факултети са значајним утицајем, са средњим и ниским утицајем на укупне резултате рангирања на “ARWU” листи.

Кључне речи: Рангирање факултета, Универзитет у Београду, “ARWU” листа, “PROMETHEE – GAIA” метода.

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