

LETTER TO THE EDITOR

Evaluating the scientific performance of institutions within the university: An example from the University of Belgrade leading institutions

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Abstract: Numerous studies have evaluated the publication performance of universities worldwide, but studies examining intra-institutional performance still remain scarce. In this paper, as a case study, we provide an in-depth quantitative–qualitative analysis of University of Belgrade (UB) leading institutions performance. The results show that the UB scientific institutes, faculties of sciences and mathematics, together with the Faculty of Medicine and several faculties of technology and engineering sciences exhibit excellent scientific results. The Faculty of Medicine and Institute Vinča lead the way in terms of number of published papers, while Institute of Physics excels when taking into account the quality of journals. Results pointed out that the Faculty of Technology and Metallurgy, besides the number of papers, has a strong showing in terms of citation metrics. In addition, using a network graph we present collaboration patterns within the UB. This analysis may be a step in the right direction towards a model for evaluating and ranking institutions within a particular university.

Keywords: bibliometric indicators; intra-institutional publication performance; collaboration patterns.

INTRODUCTION

An increasing number of studies elaborate rankings as crucial benchmarks for the performance evaluation of universities. The majority of ranking methodologies integrate different aspects of university performance¹ into a one-dimensional value which represents the measure of quality.² Although questions have been raised concerning the statistical solidity of the methodological frameworks which underpin these ranking systems³, the ranking lists produced tend to captivate a general audience and the benefits which accrue to well-placed institutions

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can be considerable. Among the many benefits, well-placed universities tend to attract better students and leading professors.⁴ Furthermore, government officials follow the rankings closely when evaluating whether the money invested in universities is delivering expected results.⁵ Consequently, universities strive to upgrade the indicators used in the ranking methodologies.⁶ Of particularly importance for all university ranking lists are bibliometric indicators.^{7,8} To enhance the indicators encompassing publications (both the quantitative and qualitative aspect) in world leading indexed bases, such as Web of Science and Scopus, has become the highest priority for a majority of universities and many have introduced tougher requirements for obtaining academic positions in terms of the number of papers published in Web of Science and Scopus.⁹

With the widespread implementation of the “publish or perish” paradigm, evaluating the publication performance of any particular university has become even more important. This is notably the case for universities from developing countries. One study¹⁰ has demonstrated that higher education institutions from Central and Eastern Europe “remain invisible in the international and European academic world”. In response, several studies have emerged on the evaluation of publication performance in Serbia and neighbouring countries.^{11–17}

Nevertheless, research on the publication performance of departments, institutes and faculties within a university remain scarce. Some authors¹⁸ have examined differences in performance between departments in Italian universities with special emphasis on the variability of the examined indicators. Others¹⁹ have turned their attention to the research potential of selected Russian universities at the level of departments and academic staff. In-depth analysis²⁰ has also been presented on the publication performance of the 31 faculties and 11 institutes which constitute the University of Belgrade. Further, authors²¹ have presented additional insight into the faculties belonging to the University of Belgrade. Their scientific performance was scrutinized by taking into account the number of academic staff employed at each faculty.

The intention here is to shed additional light on the performance of institutions within the University of Belgrade, by implementing percentile-based indicators (both at the article and journal level). This is essential since the impact factor of the journal and the citation count of each article cannot be compared directly²² because citation patterns in the fields of science differ.²³ For instance, in the Web of Science research field Clinical medicine, a paper on average receives 13.12 citations; while in Mathematics average citation per paper is 4.44.²⁴ Percentile-based indicators overcome this difficulty and allow for comparison between different fields of science, meaning that the journals and citations of each article can be compared no matter which Web of Science journals are being examined.

METHODS

On November 14th 2017, from the database Web of Science, for the period 2009–2016, we acquired data concerning the publications (type Articles) published in the SCIE and SSCI indexed journals, where the reprint author is from the University of Belgrade. We opted for the reprint authors²⁵⁻²⁸ as the filter since the reprint author²⁹ “is more likely to be closely connected to the research” than other co-author(s).³⁰ Consequently, papers with huge numbers of co-authors (CERN collaborations in physics, in particular) have been excluded from the analysis (since reprint/corresponding authors were not from the University of Belgrade). As shown,³¹ these papers can have a significant impact on bibliometric ranking indicators, and it is fair to ask whether a co-authorship among what can often amount to more than 200 names, should be counted when analysing the performance of a certain university. The Article was selected as the publication type since it is the only one assessed by the ARWU ranking list of leading universities.³²

In total, we obtained and analysed 13702 papers. For each paper, among other data, we obtained information about the journals impact factor and citation count. In order to make it possible to compare journals across different fields of research, Web of Science implemented the average journal impact factor percentile (AVG_JIF_PERCENTILE).^{33,34} The journal impact factor percentile transforms the journals’ rank in certain category into a percentile value ($JIF_{\text{PERCENTILE}}$), enabling us with possibility for a more meaningful cross-category comparison.³⁴ It is calculated as:

$$JIF_{\text{PERCENTILE}} = \frac{N - R + 0.5}{N}$$

where N is the number of journals in certain category, while R is the descending rank. The average journal impact factor percentile takes into account $JIF_{\text{PERCENTILE}}$ for each category in which certain journal is classified and calculates the average from those values.³³

In accordance with the decision of Serbia’s National Council for Higher Education*, we assigned an AVG_JIF_PERCENTILE from the Journal Citation Reports (JCR) list to each analysed paper, whether for the year in which the paper was published, a year or two before, or a year after, depending on which option was best for the paper under consideration**. The indicator AVG_JIF_PERCENTILE has a value which ranges from zero to one-hundred, with larger values representing better journals. We also assigned each analysed paper with a percentile group (percentile rank classes) based on the citation count of the paper and its respective research field.³⁵ This approach enables us to compare the citation count of articles published in different research fields. For this section of the work, papers published between 2009 and 2014 were scrutinized since this analysis requires a three-year window for the analysis to provide meaningful results.²⁰ The dataset obtained was augmented by assigning each of the 13 702 papers to institutions within the University of Belgrade (31 faculties and 11 institutes). Since a paper can be the result of collaboration between faculties and institutes within the UB, such papers are affiliated to all institutions that participated in its authorship. If the authors of the certain paper belong to, for instance Faculty of Medicine and Vinča Institute of Nuclear

* Similar practise can be found in many countries, such as Croatia, available at: https://narodne-novine.nn.hr/clanci/sluzbeni/2017_03_28_652.html

** We determined the average journal impact factor percentile for 13476 papers. The remaining 226 were not included in the analysis since they were published in the journals without impact factor (the majority of those were journals which had been included in the SCIE/SSCI list in the year when the observed paper was published).

Science, that paper is counted both for Faculty of Medicine and Vinča Institute of Nuclear Science.

RESULTS AND DISCUSSION

As we can see from Table I*, the Faculty of Medicine and Institute Vinča lead the way with the number of published papers, with 2456 and 2100 SCIE/SSCI papers, respectively. In addition, the quality of journals in which researchers from Institute Vinča published their papers is quite high. The median value of the indicator AVG_JIF_PERCENTILE for this institute is 66.309, meaning that half of the Vinča papers were published in journals which are in the top 33.691% in their respective JCR subject category.

TABLE I. Overview of University of Belgrade institutions which published at least 800 (100 per year) articles in SCIE/SSCI indexed journals with median AVG_JIF_PERCENTILE

Institution	Number of papers	Median AVG_JIF_PERCENTILE
Institute of Physics	954	74.423
Vinča Institute of Nuclear Science	2100	66.309
Faculty of Technology and Metallurgy	1343	63.333
Institute of Chemistry, Technology and Metallurgy (ICTM)	1163	63.057
Faculty of Chemistry	974	63.057
Institute for Biological Research "Siniša Stanković"	1109	55.195
Faculty of Biology	950	44.031
Faculty of Medicine	2456	40.256

The Faculty of Medicine had the largest number of published papers (2456), but they appeared in journals with lower AVG_JIF_PERCENTILE values than those of their colleagues from Institute Vinča. A remarkable result was achieved by the Institute of Physics. Half of its papers were published in journals placed in the top 25.577 % in the respective JCR subject category. The Institute of Chemistry, Technology and Metallurgy (ICTM) and the Institute for Biological Research "Siniša Stanković" published similar numbers of papers (1163 vs. 1109). However, the quality of the journals in which these papers appeared is somewhat better for ICTM (63.057 vs. 55.195) than for "Siniša Stanković". In the group of faculties of science and mathematics, the Faculty of Chemistry and the Faculty of Biology excelled, with 974 and 950 published papers, respectively, while among the faculties of technology and engineering sciences, the Faculty of Technology and Metallurgy leads the way with more than 1300 published papers, half of which were published in the top 36.667 % of journals.

In addition to the indicator which represented the quality of journals in which academics from the University of Belgrade published their papers, we

*The remaining results are presented in the Supplementary material to this letter.

performed percentile-based analysis of the quality of published papers in 2009–2014. All of the JCR indexed journals are classified in one of the 22 research fields, and for each field the baseline number of the article citation score was determined so the paper could be classified into a particular percentile group (percentile rank classes^{36–38}) for the year in which it is published.³⁹ According to Web of Science³⁵ 7 groups were determined: I) Top 0.01 %, II) Top 0.01–0.1 %, III) Top 0.1–1 %, IV) Top 1–10 %, V) Top 10–20 %, VI) Top 20–50 % and VII) bottom-half. Our results showed that the University of Belgrade does not have a single paper in the first percentile group (meaning that no papers were classified in the Top 0.01 % of papers in a particular research field), only four papers fell into group two, while 26 papers are in percentile group three. For this reason, we merged the first three groups and presented the results (Table II and Supplementary material) as: I) Top 1 %, II) Top 1–10 %, III) Top 10–20 %, IV) Top 20–50 % and V) bottom-half.

TABLE II. Percentage of institution' published papers by percentile group (institutions which published at least 800 articles)

Institution	Top 1 %	Top 1–10 %	Top 10–20 %	Top 20–50 %	Bottom-half
Institute of Physics	0.16	5.37	8.21	26.07	60.19
Vinča Institute of Nuclear Science	0.20	5.10	7.82	29.93	56.94
Faculty of Technology and Metallurgy	0.43	7.04	9.61	28.82	54.11
ICTM	0.12	3.72	7.55	31.89	56.71
Faculty of Chemistry	0.30	3.50	6.69	31.61	57.90
Institute for Biological Research "Siniša Stanković"	0.26	3.28	6.55	27.00	62.91
Faculty of Biology	0.00	2.30	4.29	23.28	70.14
Faculty of Medicine	0.12	2.34	4.86	22.93	69.75

As we see in Table II, researchers from Institute Vinča have performed much better in citation score than its peers from Faculty of Medicine. Namely, 0.2 % of Vinča papers are in the group of highly-cited papers (Top 1 %), 5.1 % papers are in second group (papers rated as Top 1-10 % by citation in a certain research field for a particular year), 7.82 % of papers are in the group of Top 10–20%, and 29.93% of papers are in category Top 20–50 %, while 56.94 % are, in the bottom-half according to citations. In contrast, the Faculty of Medicine is far from these results with almost 70 % of its papers ranked in bottom-half. A similar conclusion can be reached for the Faculty of Biology, with 70.14% of its papers falling within the bottom-half of the citation metric. On the other hand, the Faculty of Technology and Metallurgy is shown to have both a large number of published papers and a high citation score for those papers. In particular, 0.43 % of papers are in the group of best papers (Top 1 %), 7.04 % of papers are in

second group, 9.61 % of papers published by researchers from the Faculty of Technology and Metallurgy are in the Top 10–20 %, and 28.82 % of papers are in Top 20–50 %, while 54.11 % of papers are placed in the bottom-half.

Researchers often emphasize the importance of presenting the results of collaboration patterns^{40–42} within a particular university as a network.⁴³ It is possible to visualize^{44,45} this network through a graph with the nodes' sizes representing the average value of indicator average journal impact factor percentile of papers produced by institutions and the edges' widths representing the numbers of papers produced in collaboration (Fig. 1). The results identified those institutions particularly interesting for the network of intra-university collaboration. One can notice a strong collaboration between Faculty of Chemistry and ICTM, ICTM and Faculty of Technology and Metallurgy, Institute Vinča and Faculty of Technology and Metallurgy, the Institute for Biological Research “Siniša Stanković” and Faculty of Biology, *etc.*

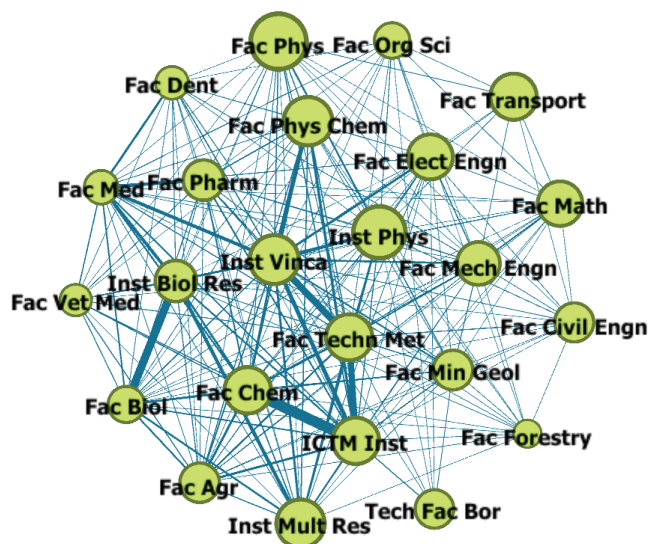


Fig. 1. Network graph of the institutions' scientific performance and cooperation.

In addition to a visualisation, a network can be analysed in terms of its structure^{46–48} which focuses on identifying the most influential members.⁴⁹ The different types of influence in a network are usually described with various centrality analyses, through: degree centrality, eigenvector centrality, closeness centrality and betweenness centrality (see Table III). In our study, degree centrality⁵⁰ will identify the institutions (such as Inst. Vinča, Faculty of Technology and Metallurgy, Institute of Physics) with many collaborations. Eigenvector centrality⁵¹ will be higher among influential institutions in the network.⁵⁰ Closeness centrality measures the average distance to all other nodes from each node,⁵²

looking for the node that is closest to all other nodes, indicating who is at the heart of a social network.⁵⁰ For our network, the similarly defined harmonic closeness centrality indicator produces different values, but exactly the same order. Betweenness centrality measures the number of times that a particular node is the member of the shortest path between two other nodes⁵². In our study, betweenness centrality describes how much an institution connects to the circles of other institutions. The hyperlink-induced topic search (HITS) provides a measure of how valuable the information stored by a particular node is, and what the quality of the links to and from that particular node are.⁵¹ In our study, it will serve to pinpoint the institutions playing a hub role. Clustering coefficients measure the level at which nodes are grouped together. Higher Clustering Coefficient scores reflect membership of tightly-knit social groups or clubs (cliques), while lower scores reflect the institutions out of cliques (in our example, Faculty of Organizational Sciences).

TABLE III. Centrality measures and other network nodes' description measures – Top five institutions

Degree centrality	Eigenvector centrality	Closeness centrality	Betweenness centrality	HITS	Clustering Coefficients
Inst Vinča (23)	Inst Vinča (1)	Inst Vinča (1)	Inst Vinča (7.895)	Inst Vinča (0.244)	Fac Org Sci (0.747)
Fac Techn Met (22), Inst Phys (22)	Fac Techn Met (0.981) Inst Phys (0.965)	Fac Techn Met (0.958) Inst Phys (0.958)	Inst Phys (6.570) Fac Techn Met (5.275)	Fac Techn Met (0.240) Inst Phys (0.236)	Inst Vinča (0.751) Inst Phys (0.766)
Fac Biol (21), Fac Agr (21), ICTM (21), Fac Mech Engn (21)	Fac Biol (0.964) Fac Agr (0.964)	Fac Biol (0.92), Fac Agr (0.92), Fac Mech Engn (0.92)	Fac Elect Engn (5.250) Fac Mech Engn (4.787)	Fac Biol (0.235), Fac Agr (0.235)	Fac Elect Engn (0.779) Fac Mech Engn (0.790)

CONCLUDING REMARKS

Bibliometric indicators are becoming established as the crucial measure of scientific performance. Consequently, this study aimed at providing an in-depth analysis of the publication performance of institutions within the University of Belgrade. The results clearly demonstrated the impressive performance of several scientific institutes (the Vinča Institute of Nuclear Science, the Institute of Chemistry, Technology and Metallurgy, the Institute for Biological Research “Siniša Stanković” and the Institute of Physics), along with a number of faculties (Faculty of Medicine, Faculty of Chemistry, Faculty of Technology and Metallurgy, Faculty of Biology). Our approach could be easily employed on other universities, as well.

One of the subjects that we would like to put forward in future directions of the study is the efficiency and productivity measurement⁵³⁻⁵⁵ of institutions within university. Since currently the number of employed academic staff/researchers at faculties and institutes is not visible in University of Belgrade's profile, it is not possible to provide a sound per researcher performance evaluation of faculties/institutes. Moreover, majority of Serbian researchers/professors have not created the ResearcherID⁵⁶ account⁵⁷ on Web of Science (only 1606 do have ResearcherID account), thus making it even more difficult to provide methodologically sound per researcher evaluation of academic performance. With different government measures which restrict the number of employed staff at state-owned Universities in Serbia,^{58,59} this subject becomes even more important. In that sense, it is our genuine belief that with additional effort by the officials of the University of Belgrade a new set of indicators depicting the scientific performance of institutions per staff/researchers would immensely contribute to the University of Belgrade road towards the world-class research university. We hope this research will trigger additional efforts towards formalisation of a framework for evaluating and ranking institutions within a particular university.

SUPPLEMENTARY MATERIAL

Additional data are available electronically on the pages of the journal's website: <http://www.shd.org.rs/JSCS/>, or from the corresponding author on request.

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ИЗВОД

ЕВАЛУАЦИЈА НАУЧНЕ ПРОДУКЦИЈЕ ИНСТИТУЦИЈА У ОКВИРУ УНИВЕРЗИТЕТА: ПРИМЕР ВОДЕЋИХ ИНСТИТУЦИЈА УНИВЕРЗИТЕТА У БЕОГРАДУ

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Аутори бројних студија су анализирали научноистраживачке резултате светских универзитета, међутим мали број истраживања се односио на институције које су саставни део одређеног универзитета. У раду смо представили дубинску квантитативно-квалитативну анализу научноистраживачких резултата водећих институција Универзитета у Београду (УВ). Анализа је показала да институти, факултети групације природно-математичких наука, Медицински факултет и поједини факултети групације техничко-технолошких наука имају одличне показатеље научноистраживачке продукције. Медицински факултет и Институт Винча се истичу по броју објављених радова, док се Институт за физику издваја по квалитету часописа у којима истраживачи са овог института објављују своје радове. Резултати су указали на то да Технолошко-металуршки факултет, поред значајног броја објављених радова, има изврсне цитатне показатеље. Такође, коришћењем графова, у раду је приказан степен сарадње институција у оквиру

UV. Приказani rezultati mogu biti korak u dobrom smeru ka formiranju okvira za vrednovanje i rangiranje institucija u okviru određenog univerziteta.

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