

Performance of Indonesia's World-Class University Efficiency with Bibliometrics (Scientific Strength) Approach and Data Envelopment Analysis

Cecep Ibrahim

Librarian, University Library, Universitas Al-Azhar Indonesia, Jakarta, Indonesia.

E-mail: cecep.ibrahim@uai.ac.id

Rahmat Fadhli*

Lecture, Faculty of Education, Yogyakarta State University, Yogyakarta, Indonesia.

E-mail: rahmat.fadhli@uny.ac.id

Received November 08, 2020; Accepted December 12, 2020

ISSN: 1735-188X

DOI: 10.14704/WEB/V18I1/WEB18003

Abstract

University efficiency is one of the scientific measurement methods for evaluating the effectiveness and use of educational resources available explicitly to the productivity of research publications. This study aims to determine the university's efficiency, between the number of researchers /authors owned by the university and the amount of Scientific Strength (publications and citations) produced by universities in Indonesia with the data envelopment analysis. The universities in this study are nine universities in the top 1000 Qs world universities in 2020. This research method consists of problem identification, data collection, data processing, results, and discussion. The research data obtained from Scopus.com metadata in publication and citation data and the year limited from 2017-2019. While the data of active university researchers/authors obtained from the Higher Education Science and Technology Index and actual student data obtained from PDDikti data. Data were analyzed using the bibliometric approach (scientific strength) and the data envelopment analysis approach. This study analyzed 41869 Indonesian scientific works indexed by Scopus with a bibliometric approach (scientific strength) and data envelopment analysis. This study indicates that the highest efficiency values are the University of Indonesia and Diponegoro University with an efficiency value of 1,000 while the lowest efficiency value is IPB University with an efficiency value of 0.060.

Keywords

Bibliometrics, Data Envelopment Analysis, Scientific Strength, Indonesian Publication.

Introduction

One indicator of the progress of science and technology at universities is research published and utilized. In Indonesia, this reflects in the tri dharma of higher education consisting of education, research, and community service. These three activities also refer to as the basis of all academic activities. One aspect is that research aims to be an initial step towards the implementation and development of science, where the results can be utilized in engineering, innovation, and technology diffusion (Nulhaqim et al., 2016). As an output of research activities, the university is currently increasing international publications from the academic community, students, lecturers, or staff. Even research publications are a measurement tool for lecturers' performance (Hamzah et al., 2010; Lian, 2019). Added by Azma (2010) related to university performance evaluation indicators, research, and scientific journals.

International publications have become a new concern for higher education in Indonesia. International publications can mean that the research carries out has been reviewed by reputable experts in their field so that the published research has been tested for its novelty and impact. This regulates by the Director-General of Higher Education in the Ministry of Education and Culture, which issues scientific publication policies for students or lecturers in the university. Based on data released by the Ministry of Research, Technology and Higher Education in 2016, it shows that the growth of Indonesian publications has increased from 2001 to 2015, with an average growth in the last five years of 24.69% and with a predicted growth of 25.251 publications in 2019 with contributors consisting of lecturers, researchers, and students (Kementerian Riset Teknologi dan Pendidikan Tinggi, 2016).

Indonesian research publications have begun to be published in many international journals indexed, including Scopus. Scopus is one of the most extensive indexing journals globally used as a reference and reference in making scientific work or research. Scopus is the world's largest abstract and citation database of peer-reviewed literature, including scientific journals, books, and conference proceedings, covering research topics across all scientific and technical disciplines, ranging from medicine and social sciences to arts and humanities. Further, with smart tools to track, analyze, and visualize research (Elsevier, 2020). If a scientific work or research is published in a Scopus indexed journal, the manuscript can be assumed as a quality manuscript. Both in terms of the origin of ideas and the complexity of contents to the writing system. In Indonesia, in measuring the performance of science and technology relating to scientific publications, SINTA (Science and Technology Index) launched by the Ministry of Research Technology and Higher

Education of the Republic of Indonesia in 2016, with experts from various institutions. This Web-based research information system delivers access to citations and expertise and offers fast access, comfortable and comprehensive to measure researchers, institutions, and journals in Indonesia. The system analyzed and showed citations, h-index, i-10 index, national and international journals, proceeding papers, books, and researchers' patent in Indonesia. It also provides benchmark and analysis, identifying each institution's research strength to develop collaborative partnerships, to analyze the trend of research and expert directories (Kementerian Riset dan Teknologi, 2017).

On the other hand, the University world ranking is a ranking of universities worldwide with various criteria. At present, many institutions measure higher education performance globally and display reviews from various aspects of standards. One of the most popular systems that take measurements is the QS World University Ranking. The QS World University Rankings is an annual publication of university rankings which comprises the global overall and subject rankings (which name the world's top universities for the study of 48 different subjects and five composite faculty areas), alongside our independent regional tables (such as Asia, Latin America, Emerging Europe, and Central Asia and the Arab Region). The QS World University Rankings is the most widely read university rankings in the world. This institution uses several measurement indicators, including academic peer review, faculty/student ratio, citation per faculty, employer reputation, international student ratio, international staff ratio. By the measurement indicators, international publications also become one of the essential criteria in measuring World Class University, specifically research impact. Data published in 2020 from QS University World Ranking, data published in 2020 from QS University World Ranking, nine universities are included in 1000 top universities (shown in table 1.1).

Table 1 Indonesia Top QS World University Ranking

Rank	University
=296	Universitas Indonesia (UI)
=320	GadjahMada University (UGM)
=331	Bandung Institute of Technology (ITB)
601-650	IPB University (IPB)
651-700	Airlangga University (Unair)
751-800	UniversitasPadjadjaran (Unpad)
801-1000	Bina Nusantara University (BINUS)
801-1000	Diponegoro University (Undip)
801-1000	InstitutTeknologiSepuluhNopember (ITS)

Measurement of university efficiency is an important thing that universities must do for evaluation related to the allocation of effectiveness and utilization of educational

resources available at universities, especially related to research publications' productivity. Data envelopment analysis (DEA) is a method developed to evaluate university effectiveness (Gökşen et al., 2015). The effectiveness of universities is essential to determine how university resources are used, how the quality of outputs is obtained, and how the process is managed (Kuah & Wong, 2011).

Charnes, Cooper, and Rhodes first developed data envelopment analysis in 1978. According to Kuah & Wong (2011), data envelopment analysis is a simple yet powerful method used to measure the relative efficiency of a group of homogenous firms or decision-making units (DMUs). Therefore, DEA is a simple but powerful method to measure a company (university) or decision making. The field of DEA nowadays has enjoyed a vast growth in publications and research since introduced. It studied, resulting in a significant development in its methodologies, models, and real-world applications (Aldamak & Zolfaghari, 2014). Sherman (1988) defines efficiency as productivity's capability to produce output or services with a minimum of resources. This statement is similar to Farrell (1957) in his study of measuring efficiency productivity. It explained the importance of measuring how outputs can increase through higher efficiency without using additional resources (input). The DEA research model based on two input variables and one output variable: i) two input variables, including faculty staff from universities and the number of students from universities; ii) one output variable, concerning the impact on increasing knowledge produced by universities with the bibliometric indicator called scientific strength. Scientific strength (SS) is field-standardized citations received by publications authored by the research staff of the university (Abramo et al., 2011). Scientific strength defines as a standardized quote received by publications written by university researchers. In this case, the researcher will examine the efficiency performance of the university, between the number of researchers/authors owned by the university and the amount of Scientific Strength (publication and citations) produced. In this study, the universities to be studied are Indonesian universities and listed the World University Ranking 1000th, consists of nine universities with a data envelopment analysis approach.

This research will focus on university efficiency performance, between the number of researchers/authors owned by the university and the number of Scientific strength (publications and citations) produced by nine universities in Indonesia with the Data envelopment analysis approach. This study has scope by identifying each university's efficiency performance value based on the researcher/author's criteria and the scientific strength described in the next chapter.

Literature Review

Bibliometrics

Bibliometrics represent the statistical analysis regarding books, journals, scientific articles, and authors. The word frequency analysis, the citation analysis, or the number of authors' articles were the primary, initial metrics for such statistical analysis (Bailon-Moreno et al., 2005; Pritchard, 1969). After the '90s, bibliometric transformed from a pure statistical bibliography study to a separate and unique field of study, according to the Institute for Scientific Information (ISI), Science Citation Index (SCI) (Karanatsiou et al., 2017). Bibliometrics has a vital role because they represent the study's quality, such as the complete statistical analysis of research results, the distribution of research results, types of research, and others. The most critical aspect of bibliometrics is a citation. In this study, the bibliometric indicator used by researchers is scientific strength (SS). Scientific strength is field-standardized citations received by publications authored by the university's research staff (Abramo et al., 2011). It is used to analyze and measure the impact of university research publications.

Data Envelopment Analysis (DEA)

Data envelopment analysis (DEA) was first introduced by Farrell in 1957 and developed by Charnes, Cooper, and Rhodes in 1978, known as the CCR model (Charnes et al., 1978). DEA is defined as a widely used technique for evaluating the performance of peer decision-making units (DMUs) that consume multiple inputs to produce multiple outputs. Unlike the data envelopment analysis introduced by Banker, Charnes, and Cooper, known as the BCC model in 1984. According to Ray (2004), BCC extended the CCR model to accommodate technologies that exhibit variable returns to scale in what turned out to be a significant breakthrough. So that the BCC model appears to expand the CCR model, it accommodates unstable technology. CCR uses the constants' assumption returns to scale (CRS) while the BCC uses the assumption of a variable return to scale (VRS). The CRS model is used if it assumes that the comparison of a company's input and output is the same, namely Constant Return to Scale (CRS). That is, if there are additional inputs by x times, the output will increase by x times, too (Rusydia & TIM Smart Consulting, 2013). Whereas the VRS model assumes that the ratio between the addition of input and output is not the same, namely VRS (Variable Returns to Scale), which means the addition of inputs by x times, can be smaller or even more significant (Rusydia & TIM Smart Consulting, 2013). DEA is a non-parametric methodology based on linear programming. It was initially developed for performance measurement, and now the DEA

application has been used as a measurement in various scientific disciplines and various operational activities(Cooper et al., 2011).

Application of Data Envelopment Analysis Method

Data envelopment analysis methods can apply to various sectors of the sector, such as schools, hospitals, restaurants, US Air Force, and banking (Avkarin, 2011). Measurement using the DEA method requires input variables and output variables as measurement data. Previous studies regarding university evaluations related to university research include Abramo et al.(2011), a field-standardized DEA application to national-scale research assessment of universities. In the Abramo et al. study (2011),the variables used include

Table 2 DEA model; The input variable and the output variable (Abramo et al., 2011)

Variable	Category
Staff-years of full professors	Input
Staff-years of associate professors	Input
Staff-years of assistant professors	Input
Scientific Strength Output SS	Output

Another study related to DEA isGökşen et al. (2015), which mentions A data envelopment analysis application for measuring university departments' efficiency. In the research of Gökşen et al. (2015), the variables used include:

Table 3 DEA models- Input variable and output variable (Gökşen et al., 2015)

Variable	Category
Outdoor-indoor area university	Input
Academic Staff	Input
Administrative staff	Input
Number of Publication	output
Number of Graduate student	output

The following are some studies that use the Data envelopment analysis model that has been applied to universities to measure the level of university efficiency (Özden, 2008).

Table 4 University efficiency research studies using the DEA method (Kadilar, 2015)

Author	Used Input Variables	Used Output Variables
Tomkins & Green (1988)	Number of Full-time employees Personnel Costs Operating Costs Other Costs	Number of University Students Number of Ph.D. Students Total Income Number of Publications
Beasley (1995)	Research income Operating Costs Personnel Costs	Number of Undergraduate Students and Postgraduate Students Number of Publications that take part in indexes
Abbott & Doucouliagos(2003)	Number of Academic Staff Number of Non-Academic Staff Operating Costs Fixed Assets	Number of Students Number of graduate students from the Associate degree, Undergraduate and Postgraduate degree Amount of research
Flegg et al. (2004)	Number of Faculty Members Number of Undergraduate Students Number of Postgraduate Students Total Expenses	Research and Consultancy income Number of graduate students from Undergraduate degree Number of graduate students from Postgraduate degree
Warning (2004)	Personnel Costs Other Costs	Number of Publications that take part in indexes Number of Students
Kutlar & Kartal (2004)	Number of Academic Staff Number of Administrative Staff Personnel, Service Procurement, and Consumption Expenses Average	Number of Students Student Fees Projects Number of Postgraduate Students
Baysal et al.(2005)	Personnel Costs Other Current Expenditures Investment Expenses Transfers	Number of Undergraduate Students Number of Postgraduate Students Number of Ph.D. Students Number of publications
Babacan et al. (2007)	General Budget Expenditures Expenditures out of budget Number of Professor Number of Associate Professor Number of Assistant Professor Number of Assistant Instructor Number of Administrative Staff	Number of Publications that take part in indexes University Income Number of Undergraduate Students Number of graduate students from Undergraduate degree Number of Postgraduate Students Number of graduate students

		from Postgraduate degree
Kutlar & Babacan(2008)	General Budget Expenditures Expenditures out of budget Number of Professor Number of Associate Professor Number of Assistant Professor Number of Assistant Instructor Number of Administrative Staff	Number of Publications that take part in indexes University Income Number of Undergraduate Students Number of graduate students from Undergraduate degree Number of Postgraduate Students Number of graduate students from Postgraduate degree
Özden (2008)	Number of Faculty Member Number of Other Academic Staff Total Expenses	Number of publications Number of Graduate Students Number of Associate and Undergraduate Students Other Educational Income
Bal (2013)	Number of Faculty Member Number of Other Academic Staff	Number of Students/ Number of Faculty members SCI, SSCI, Scanned by AHC Total Articles and Citations in Magazines

The table above illustrates the development of university efficiency performance research by the DEA method. There are various decision-making units (DMUs) used for input variables or output used in each study, such as operating cost, number of faculty members, number of academic staff, total expenses, personnel cost, number of publications, and number of graduates students, and others. For this study, the DMUs variables used were adapted to the research focus.

Methods

This study aims to determine the efficiency of university performance, between the number of researchers/authors owned by universities and the number of Scientific Strength (publications and citations) produced by universities in Indonesia with the Data Envelopment Analysis approach.

The research data obtained from the Scopus.com metadata in publication data and research citations from nine universities in Indonesia in 2017-2019. While the researcher/author data obtained from SINTA (Science and Technology Index) data, and student data obtained from PDDikti data (Indonesian Higher Education Database). Due to limited data access to the study, researchers only use data based on databases developed by the National Research and Innovation Agency and the Ministry of Education and

Culture, especially the SINTA database and PDDikti data that can be accessed openly by the public. Research data collection was conducted in February-March 2020 by identifying the amount of data according to this study's criteria. The research stages are available in Figure.1 below.

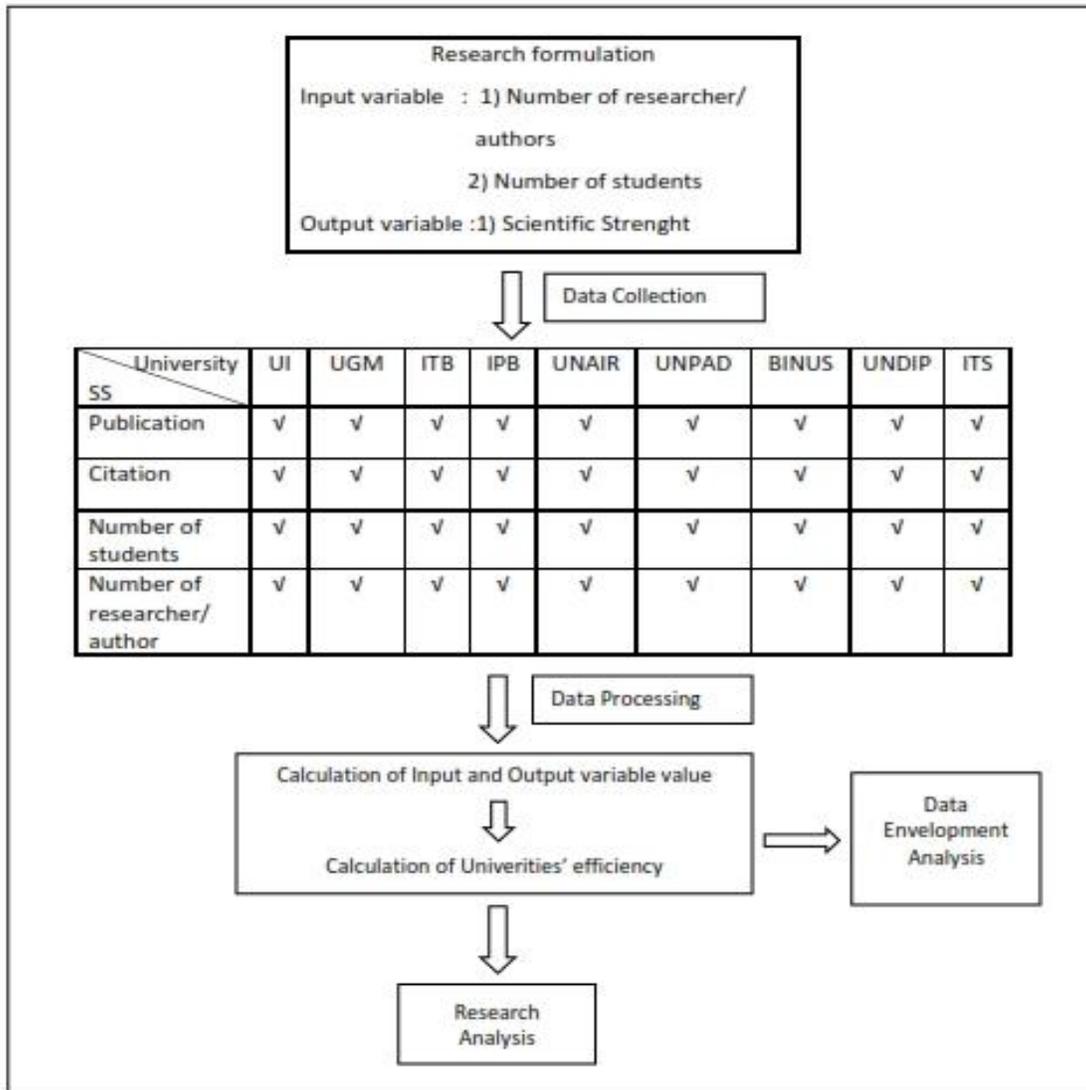


Figure 1 Research Stages

This research focuses on measuring the efficiency of nine universities in Indonesia. This study begins by identifying the problem that is determining the data envelopment analysis model. The data envelopment analysis model used in the study consisted of input variables and output variables where the input variable and the output variable divided into two parts.

Table 5 Research input and output variables

Variable	Category
Number of researcher/author	Input
Number of Students	Input
Scientific Strength (SS)	Output

Based on the table above, the decision-making units (DMUs) variable consist of the number of researcher/author, number of students, and scientific strength. The input variable consists of the number of researchers/authors and the number of students. The determination of variable DMUs is based on previous research that assesses the importance of researchers, authors, and students, but in this paper, researchers only limit human resources, especially researchers and students at universities. Besides, the selection of student elements as DMUs variables at universities, because researchers or lecturers conduct research, but there is also students' contribution to producing research publications while the output variable consists of scientific strength. While in this study, the DMUs variable for the output element uses only one analysis unit, namely scientific strength. This is because the publication's total variable and the number of citations have been analyzed into one main unit in scientific strength or analyzed earlier. Also, researchers included scientific strength because the impact of publication was calculated not only from the total publication but also from the citations, which significantly impacted scientific development. The analysis data on variable DMUs differs from previous research for the uniqueness of research and research limitations. However, this research stage refers to similar studies on research efficiency in universities such as Abramo & D'Angelo (2014); Günay & Yüksel Haliloğlu (2018).

Data collection in this study focused on universities in Indonesia and entered the World University Ranking the world ranking in the QS version of the world as many as nine universities. Other metadata collected included the number of researchers/authors (from SINTA), the number of students (from PDDikti), scientific strength (bibliometrics). Data on the number of publications is 41.869, indexed by Scopus with 54.418 citations. While the total number of researchers/authors is 15.421, and the total number of active students is 331.596 students.

Data processing starting with taking data from university publications and research sites in Indonesia in 2017-2019 on the Scopus website. Current university researchers/authors data from SINTA and active students data from PDDikti. After the data is collected, then it is processed by the data envelopment analysis method with two stages are:

Table 6 Statistics on total university publications for 2017-2019

Publication year	University								
	UI	UGM	ITB	IPB	ITS	Unair	Unpad	Undip	Binus
2017	2499	1422	1847	783	1069	472	582	1053	551
2018	3562	1959	2173	1058	1412	875	977	1730	865
2019	3832	2247	2204	1383	1597	2006	1239	1541	931
Total	9893	5628	6224	3224	4078	3353	2798	4324	2347

Table 7 Total university citations for 2017-2019

Citation year	University								
	UI	UGM	ITB	IPB	ITS	Unair	Unpad	Undip	Binus
2017	9154	3928	5099	2756	2890	1216	1517	2255	997
2018	3700	2783	2863	1425	1807	1276	1420	1567	1003
2019	1676	1061	953	531	517	733	560	426	305
Total	14530	7772	8915	4712	5214	3225	3497	4248	2305

Table 8 Researchers/authors and students of each university

University	Researchers/ authors	Students
UI	3.025	46.357
UGM	2.930	56.255
ITB	1.513	17.787
IPB University	1.290	31.818
ITS	1.002	22.549
Unair	1.875	36.237
Unpad	2.097	32.480
Undip	1.689	48.493
Binus	8.18	39.620

Based on these data, a total number of publications, citations, and active researchers are the University of Indonesia (UI) with a total of 9.893 publications, 14.530 citations, and 3.025 researchers, while the highest total number of active students in Universitas Gadjah Mada as many as 46.357 students.

Analysis of Research Publications

This bibliometric approach analysis uses the formula of scientific strength. It analyzes and measures the impact of university research publications in Indonesia based on published data and citations. The following are the scientific strength scores for each university analyzed, shown in table 9.

Table 9 Universities'scientific strength (SS)

University	Scientific Strength (SS)
UI	7072636
UGM	1061271
ITB	924013
IPB University	180517
ITS	200739
Unair	69785
Unpad	120059
Undip	260071
Binus	29140

Based on bibliometric approach analysis (scientific strength), the highest value of scientific strength is the University of Indonesia worth 7072636, while the one with the lowest value is Bina Nusantara University with a value of 29140. It concluded that the University of Indonesia had the most significant impact on scientific publications it produced compared to other universities. Scientific strength is one of the methods offered to measure productivity that includes the quality and quantity of research production and can be done at different organizational levels (Abramo & D'Angelo, 2014).

Analysis of University Efficiency Performance

Analysis of the data envelopment analysis approach is the constant return to scale (CRS) method and the variable return scale (VRS) method, in particular, calculating the value of Technical efficiency (TE) using DEAP 2.1. It measures the university's efficiency between the number of researchers/authors owned by the university and the number of students owned by the university and the amount of Scientific Strength (publications and citations) produced by each University. The category is that the highest efficiency is equal to 1 or 100%.

Table 10 shows the calculation of the value of efficiency (technical efficiency) with the data envelopment analysis method with input variables, namely the number of researchers/authors and the number of students, while the output variable is scientific strength (bibliometrics). The analysis was carried out to determine the level of efficiency of each university.

Table 10 Analysis of data envelopment analysis universities in Indonesia

University	Input		Output	DEA value
	Researchers/ authors	Students	Scientific Strength (SS)	
UI	3.025	46.357	7072636	1,000
UGM	2.930	56.255	1061271	0,155
ITB	1.513	17.787	924013	0,340
IPB Univ.	1.290	31.818	180517	0,060
ITS	1.002	22.549	200739	0,086
Unair	1.875	36.237	69785	0,359
Unpad	2.097	32.480	120059	0,689
Undip	1.689	48.493	260071	1,000
Binus	818	39.620	29140	0,231

The table above shows the technical efficiency values that are the result of the analysis using the DEA. Based on these data that the highest efficiency values are Indonesian university and Diponegoro University with an efficiency value (TE) of 1,000. It concluded that the number of educational resources owned by the university, in this case, is the number of researchers/authors and the number of students efficient in producing Scopus-indexed research publications both in terms of the number of publications and citations. Simultaneously, the one with the lowest efficiency value is IPB University, with a value of 0,060.

Based on this study's results, the efficiency performance of universities in Indonesia is still low, especially those who have entered The QS World University Ranking 2020. Only two of the nine universities have achieved an efficiency score of 1,000 or the highest efficiency score of 100%. Meanwhile, the other seven universities still far reach 100% or 1,000. In this study, efficiency was based on human resources' productivity, especially lecturer (researcher/authors) and student on the effect of the output and outcome of publications seen from the number of publications and the number of citations. Based on the data, researchers suspect the results are in line with Indonesia's low funding of research. According to data from the Ministry of Research, Technology, and Higher Education in Indonesia, in 2017, the research budget was only 0.2% of Gross Domestic Product and the lowest in Southeast Asia (Badan Riset dan Inovasi Nasional, 2017). In addition to research funding, according to Ramadhan (2019), researchers in Indonesia are still focused on applied research, where research competencies are still low because researchers have not been able to create new ideas to encourage new methods so that national researchers lose out to compete with other countries. While according to Muljo

(2012), the low number of lecturers researching universities in Indonesia is due to two factors, one of them is the research funds.

In other research conducted by Kotrlik et al. (2002), the cultural factor of the organization and faculty support is the main factor in the productivity of research in higher education. Further research Henry et al. (2020) mentioned that personal, environmental, management, and behavioral factors support research productivity in higher education. In this study, researchers did not discuss or identify factors that cause universities' inefficiencies with variables that have been determined due to research limitations. Researchers are only focused on uncovering efficiency values to be used for further research by other researchers.

Conclusions

This study has obtained the value of scientific strength and the value of TE (Technical efficiency) based on the number of publications, citations, researchers/authors, and students owned by universities in Indonesia. This study has obtained the value of scientific strength and the value of TE based on the number of publications, citations, researchers /authors, and students owned by universities in Indonesia. The highest scientific strength value is the University of Indonesia worth 7072636, while the one with the smallest value is Bina Nusantara University, with a value of 29140. It concluded that the University of Indonesia has the most significant impact related to the scientific publications it produces compared to other universities. While the results of the data envelopment analysis test showed the highest level of efficiency with the highest TE are the University of Indonesia and Diponegoro University with a TE value of 1,000. It concluded that the University of Indonesia and Diponegoro University are effective and efficient in using their educational resources regarding the publications produced. Second is Universitas Padjadjaran, with a TE value of 0,689. Third, Airlangga University with a TE value of 0,359 Following by Bandung Institute of Technology with 0,340, Bina Nusantara University with 0,231. Then followed by Universitas Gadjah Mada with 0,1555, Institut Teknologi Sepuluh Nopember with 0,086, and the last is IPB University with a TE value of 0,060. It concluded that IPB University is less efficient and effective in using its educational resources. In this case, we believe that this paper is preliminary research for universities in Indonesia to measure research efficiency with multiple variable DMUs. These results may change as data is more diverse, and more data or universities are analyzed in the future.

Acknowledgment

No grant from any public, commercial, or non-profit funding agency was offered for the conduct of this research.

References

- Abbott, M., & Doucouliagos, C. (2003). The efficiency of Australian universities: a data envelopment analysis. *Economics of Education Review*, 22(1), 89–97. [https://doi.org/10.1016/S0272-7757\(01\)00068-1](https://doi.org/10.1016/S0272-7757(01)00068-1)
- Abramo, G., Cicero, T., & D'Angelo, C.A. (2011). A field-standardized application of DEA to national-scale research assessment of universities. *Journal of Informetrics*, 5(4), 618–628. <https://doi.org/10.1016/j.joi.2011.06.001>
- Abramo, G., & D'Angelo, C.A. (2014). How do you define and measure research productivity? *Scientometrics*, 101(2), 1129–1144. <https://doi.org/10.1007/s11192-014-1269-8>
- Aldamak, A., & Zolfaghari, S. (2014). An improved ranking for decision making units using optimistic and pessimistic approaches. *Data Envelopment Analysis and Performance Measurement*, 35–43. <https://doi.org/10.13140/RG.2.1.3353.2966>
- Andersen, P., & Petersen, N.C. (1993). A procedure for ranking efficient units in data envelopment analysis. *Management Science*, 39(10), 1261–1264. <https://doi.org/https://doi.org/10.1287/mnsc.39.10.1261>
- Azma, F. (2010). Qualitative indicators for the evaluation of universities performance. *Procedia Social and Behavioral Sciences*, 2(2), 5408–5411. <https://doi.org/10.1016/j.sbspro.2010.03.882>
- Babacan, A., Kartal, M., & Bircan, ve H. (2007). Comparison of Cumhuriyet University's efficiency with public universities: An application of DEA technique. *C.Ü. Journal of Faculty of Economics and Administrative Sciences*, 8(2), 97–114.
- National Research and Innovation Agency. (2017). Research budget is still minimal in Indonesia. Deputy for Strengthening Research and Development. <https://risbang.ristekbrin.go.id/publikasi/berita-media/anggaran-ri-set-masih-minim-di-indonesia/>
- Bailon-Moreno, R., Jurado-Aalameda, E., Ruiz-Banos, R., & Courtial, J.P. (2005). Bibliometric laws: Empirical flaws of fit. *Scientometrics*, 63(2), 209–229.
- Bal, V. (2013). Determining effectiveness with data envelopment analysis in foundation universities. *Manas Journal of Social Research*, 2(1), 1–20.
- Baysal, M.E., Alçılar, B., Framioğlu, H., & Toklu, B. (2005). Comparison of Cumhuriyet University's efficiency with public universities: An application of DEA technique. *Sakarya University Journal of the Institute of Science*, 9(1), 67-73.
- Beasley, J.E. (1995). Determining teaching and research efficiencies. *Journal of the Operational Research Society*, 46, 441–452.
- Charnes, A., Cooper, W.W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, 2, 429–444.

- Cooper, W.W., Seiford, L.M., & Zhu, J. (2011). *Handbook on data envelopment analysis*. Springer US. <https://doi.org/10.1007/978-1-4419-6151-8>
- Elsevier. (2020). *What is Scopus about?* Scopus: Access and Use Support Center.
- Farrell, M.J. (1957). *The Measurement of productive efficiency*. University of Cambridge.
- Flegg, A.T., Allen, D.O., Field, K., & Thurlow, T.W. (2004). Measuring the efficiency of British universities: a multi-period data envelopment analysis. *Education Economics*, 12(3), 231–249. <https://doi.org/10.1080/0904529042000258590>
- Gökşen, Y., Doğan, O., & Özkarakabac, B. (2015). A data envelopment analysis application for measuring efficiency of university department. *Procedia Economics and Finance*, 19, 226–237. [https://doi.org/10.1016/S2212-5671\(15\)00024-6](https://doi.org/10.1016/S2212-5671(15)00024-6)
- Günay, A., & Yüksel Haliloğlu, E. (2018). A case study on measuring research efficiency of public universities in Turkey. *Journal of University Studies*, 1(2), 36–42.
- Hamzah, H., Suyoto, S., & Mudjihartono, P. (2010). Decision support system for lecturer performance appraisal using the balanced scorecard method (case study: Universitas Respati Yogyakarta). *Proceedings of the Informatioka National Seminar*, 82–90.
- Henry, C., Md Ghani, N.A., Hamid, U.M.A., & Bakar, A.N. (2020). Factors contributing towards research productivity in higher education. *International Journal of Evaluation and Research in Education*, 9(1), 203–211. <https://doi.org/10.11591/ijere.v9i1.20420>
- Kadılar, G.Ö. (2015). Activities Analysis of Foundation University in Turkey. *Education and Science*, 40(177), 31–41. <https://doi.org/10.15390/EB.2015.1813>
- Karanatsiou, D., Misirlis, N., & Vlachopoulou, M. (2017). Bibliometrics and altmetrics literature review comparison analysis. *Performance Measurement and Metrics*, 18(1), 16–27. <https://doi.org/10.1108/PMM-08-2016-0036>
- Ministry of Research and Technology. (2017). About Sinta. Sinta Indonesia.
- Ministry of Research, Technology and Higher Education. (2016). Strengths of 50 Indonesian scientific institutions: profiles of scientific publications indexed by Scopus (L. Lukman (ed.)). *Ministry of Research, Technology and Higher Education*.
- Kotrlik, J.W., Bartlett, J.E., Higgins, C.C., & Williams, H.A. (2002). Factors associated with research productivity of agricultural education faculty. *Journal of Agricultural Education*, 43(3), 1–10.
- Kuah, C.T., & Wong, K.Y. (2011). Procedia Computer Science Efficiency assessment of universities through data envelopment analysis. *Procedia Computer Science*, 3, 499–506. <https://doi.org/10.1016/j.procs.2010.12.084>
- Kutlar, A., & Babacan, A. (2008). CCR activity-scale efficiency analysis in public universities in Turkey: DEA technique application. *Kocaeli University Journal of Social Sciences*, 15 (1), 148-172.
- Kutlar, A., & Kartal, M. (2004). Productivity Analysis of Cumhuriyet University: An Application at Faculty Level with Data Envelopment Method. *Kocaeli University Journal of Social Sciences Institute*, 8(2), 49–79.
- Lian, B. (2019). The responsibility of higher education tridharma answers the needs of society. *Proceedings of the National Seminar on Education for the Postgraduate Program of the PGRI University of Palembang*, 100–106.

- Muljo, H.H. (2012). The effect of funding and lecturer time on research interest: a case study of Bina Nusantara University. *Binus Business Review*, 3(1), 173–182. <https://doi.org/10.21512/bbr.v3i1.1293>
- Nulhaqim, S.A., Heryadi, R.D., Pancasilawan, R., & Fedryansyah, M. (2016). The role of universities in improving the quality of education in Indonesia to face the 2015 ASEAN Community. *Share: Social Work Journal*, 6(2), 154–272.
- Özden, Ü.H. (2008). Data envelopment analysis to measure the effectiveness of their foundation university in Turkey. *Istanbul University Faculty of Business Journal*, 37(2), 167–185.
- Pritchard, A. (1969). Statistical bibliography or bibliometrics. *Journal of Documentation*, 25(4), 348–349.
- Ramadhan, F. (2019). *Atmosfer riset Indonesia belum optimal*. Kompas. <https://kompas.id/baca/humaniora/ilmu-pengetahuan-teknologi/2019/12/03/atmosfer-riset-indonesia-belum-optimal/>
- Ray, S.C. (2004). *Data envelopment analysis: theory and techniques for economics and operations research*. Cambridge University Press.
- Rusydiana, A.S., & TIM Smart Consulting. (2013). *Measure the level of efficiency with data envelopment analysis*. Smart Publishing.
- Sherman, H.D. (1988). *Service Organization Productivity Measurement*. The Society of Management Accountants of Canada.
- Tomkins, C., & Green, R. (1988). An experiment in the use of data envelopment analysis for evaluating the efficiency of UK university departments of accounting. *Financial Accountability & Management*, 4(2), 147–164.
- Warning, S. (2004). Performance differences in German higher education: empirical analysis of strategic groups. *Review of Industrial Organization*, 24(4), 393–408.