PAPER NAME

ic3ina-evaluating excellence webometric s criteria weight using consistent fuzzy p reference relation

WORD COUNT

4396 Words

CHARACTER COUNT

22065 Characters

PAGE COUNT

5 Pages

FILE SIZE

606.8KB

SUBMISSION DATE

Aug 25, 2022 10:51 AM GMT+7

REPORT DATE

Aug 25, 2022 10:52 AM GMT+7

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Evaluating Excellence Webometric's Criteria Weight using Consistent Fuzzy Preference Relation Method

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ABSTRACT

Some methods in the world university ranking institutions still have weaknesses. Among the university rankings, Webometrics focused on quantitative studies related to website and content phenomena and is considered easy to measure because it bases ranking criteria on university activities on the internet. On the webometrics, the percentage of weight on the criteria of excellence which is quite high (40 %), makes the university pay attention to achieving that score. The existing method in weighting the criteria using the analytical hierarchy process (AHP) needs to include $=n(n-1)/2$ questions for each group of n-criteria paired comparisons. In this study, the Consistent Fuzzy Preference Relation (CFPR) method is used to study the factors/criteria to determine what strategy universities will take to improve the webometrics ranking in terms of excellence. The CFPR techniques are used to reduce expert assessment steps to only as much as n-1 to ensure consistency at the level with n criteria. Based on the calculation results, it can be concluded that the strategy for improving the excellence score is prioritized on three main criteria in sequence, namely improving scholarly rank (A), measuring the number of scientific papers (B), recognizing scholarly ranks (C). The weight of each criterion in the sequence is 0.51, 0.32, and 0.17. Some strategies to increase the excellence score based on the main priority of sub-criteria and sub-sub criteria are explained in this study.

KEYWORDS

Consistent Fuzzy Preference Relations, Webometrics, University rank, Excellence

ACM Reference Format:
Tenia Wahyuningrum, Condro Kartiko, and Teotino Gomes Soares. 2021. Evaluating Excellence Webometric's Criteria Weight using Consistent Fuzzy Preference Relation Method. In *IC3INA '21: The International Conference on Computer, Control, Informatics and its Applications (IC3INA 2021), October 05–06, 2021, Virtual/online conference, Indonesia.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3489088.3489112

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IC3INA '21, October 05–06, 2021, Virtual/online conference, Indonesia
© 2021 Association for Computing Machinery.
ACM ISBN 978-1-4503-8524-4/21/10…$15.00
https://doi.org/10.1145/3489088.3489112

1 INTRODUCTION

There are several world university ranking institutions such as the Academic Ranking World Universities (ARWU) from China, QS from the Quacquarelly Symonds Limited institution, Times Higher Education World Academic Ranking, Center of Science and Technology Studies (CWTS) from the Netherlands, Unirank from Australia, Webometrics from Spain, Eduroute from Georgia. Some of the weaknesses of these methods include the use of unrepresentative surveys on THE and QS, especially at universities in the UK and Australia, which are considered excessive [1], the criteria for the number of Nobel laureates in the ARWU ranking is considered unfair considering that most of them are given to the physical sciences and mathematics. Furthermore, the ranking does not consider whether the winner is still associated with the institution [3]. The difference in methodological terms can be seen in the ranking of CWTS, which has a policy of combining advanced universities, while organizations with low publications are not considered in the ranking [1]. Unirank has a weakness in the methodology that focuses only on the web site's popularity, while Eduroute does not have clarity in the ranking method and the tools used for data retrieval [8]. The weakness of the Webometrics method is the influence of bad practices in university web naming; having two or more domains; changes to the university web will reduce the assessment. Webometrics is closely related to the open-source policy of the university, so a solid institutional commitment is needed [8]. However, among the university rankings, the advantages of Webometrics is focuses on quantitative studies related to website and content phenomena, including links, search engine performance, and technical analysis from an information science perspective [5]. Since 2021, the Webometrics ranking method only consists of 3 criteria, namely visibility, transparency (or openness), and excellence (or scholar), with weights of 50 %, 10 %, and 40 %, respectively [9]. The increase in the percentage of weight on the excellence criteria makes universities pay attention to achieve this score.

Several strategies were made to increase the acquisition of excellence scores based on several sub-criteria. Various criteria can be solved by using a multi-criteria decision making (MCDM) approach. Research on solving weighting and ranking problems using MCDM has been carried out [8] using the VIKOR and TOPSIS methods resulting in differences in ranking results due to differences in the normalization process. The method cannot be definitively accepted, but it can be acknowledged that the Webometrics ranking system is viewed differently by different stakeholders and therefore can be approached in different ways. Another investigation sampled 20 Master of Business programs at American universities using the

VIKOR extended weighting method. The results showed that the university's position fluctuated in the ranking list, the stability interval showed that the highest position in the ranking was sensitive to the weight of the criteria [12]. Another method used in weighting the criteria is the Analytical Hierarchy Process (AHP) [4], involving 40 professors from 19 universities to produce a web assessment benchmark for higher education institutions in Egypt using the composite index model. The application of the AHP method in assessing web presence [13] concluded that the final relative weight of each alternative at the last hierarchical level would produce the best choice. These results help decision-makers to find out what improvements are needed to increase effectiveness.

The methods described above involve subjective expert judgment in evaluating university websites so that the assessment contains ambiguity and uncertainty. Therefore, the analytic hierarchy process supports subjective human judgments (represented in crisp numbers, using a scale of 1 to 9). The assessment is then made a comparison matrix based on the hierarchy that has been built according to the problems to be solved and the calculation of priority weights. Along with the increasingly complex problems that must be solved, the use of fuzzy logic concepts is then used to overcome the lack of using a scale of 1 to 9, which is considered less representative, so that the numbers used are no longer crisp, but using fuzzy numbers. Applying the concept of fuzzy logic makes unclear and complex problems can be overcome [18].

The AHP method (Saaty, 1990) is generally used to solve problems involving multiple comparison criteria. If n is the number of criteria, then each questionnaire in the AHP method needs to include n(*n*-1)/2 questions for each group of n-criteria paired comparisons [2, 7, 10, 11, 15, 16]. As the number of n or groups of n criteria increases, pairwise comparisons also increases. This causes experts to be faced with unpredictable situations because there are too many questions and comparisons. The number of questions and comparisons was then overcome by [6], who proposed an improvement method on the AHP method in overcoming the inconsistency of expert judgment by reducing the number of pairwise comparisons to *n*-1. The improvement method is called Consistent Fuzzy Preference Programming (CFPR). The use of CFPR has advantages, namely 1) the number of questionnaire questions is more petite, 2) it reduces the frequency of comparisons and 3) avoids inconsistencies [2, 7, 16]. We then use the CFPR method to evaluate the weight of the excellence criteria in the Webometrics ranking so that each university can prioritize the appropriate strategy.

2 RESEARCH METHOD

The method used in this study consisted of four stages, namely [7],

(1) Determining the problem and the hierarchy of criteria and sub-criteria,
(2) Developing criteria comparison matrix using the CFPR method,
(3) Determining the weight and ranking,
(4) Concluding the calculation result.

Preference relations are usually in the form of a matrix with the level of importance between criteria. This assessment relationship can be in the form of a multiplicative preference relationship from a fuzzy preference relationship

$R \subseteq A \times A$, $R = (r_{ij})$, $\forall i, j \in \{1, 2, \ldots, n\}$, where A is the set of criteria or alternatives, r_{ij} is the ratio of importance of the criteria or alternatives between a_i to a_j, $a_{ij} \cdot a_{ji} = 1$, $\forall i, j \in 1, 2, \ldots, n$. Suppose A is a fuzzy pairwise comparison matrix; in the CFPR method, the experts fill in the level of importance between the criteria in a_{ij} above the main diagonal, while other elements in the matrix (z) will be calculated using Propositions 1 and 3 [14, 17].

$$A = \begin{matrix} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{matrix} C_1 & C_2 & \cdots & C_n \\ \end{matrix} \begin{pmatrix} 1 & a_{12} & \cdots & z \\ z & 1 & \cdots & z \\ \vdots & \vdots & \cdots & a_{n-1,n-1} \\ z & z & \cdots & 1 \end{pmatrix}$$

Next, the relationship will be represented by a pairwise matrix comparison $P = p_{ij}$, where the size is $n \times n$, $p_{ij} = \mu_p(a_i, a_j) = 1$, $\forall i, j \in \{1, 2, \ldots, n\}$ and the value of the fuzzy membership function.

In the first step, matrix A is transformed into P matrix. $P_{n\times n} = p_{ij}; i = 1, 2, \ldots, n; j = 1, 2, \ldots, n$. For example, the number of criteria is 4, then the number of expert judgments is only $n-1 = 4-1 = 3$ comparisons, and the matrix entry is only calculated if $P(i, j+1)$; $i = 1, 2, \ldots, n-1; j = 1, 2, \ldots, n$.

$$P = \begin{pmatrix} 1 & P_{12} & P_{13} & P_{14} \\ P_{21} & 1 & P_{23} & P_{24} \\ P_{31} & P_{32} & 1 & P_{34} \\ P_{41} & P_{42} & P_{43} & 1 \end{pmatrix}$$

The P matrix shows that the pij element is a matrix element entry that is not filled in by the expert, consisting of fuzzy triangular numbers (l_{ij}, m_{ij}, u_{ij}). The CFPR method fills the p_{ij} value using Proposition 1 and Proposition 3 for each l, m and u so that the output matrix remains a fuzzy triangular number. The next step is to calculate the matrix entries on the main diagonal of the matrix, where the value of $i = j$ and the matrix entries above the main diagonal, where the value of $j = i+1$ is calculated using Proposition 1.

Proposition 1. For example, $X = \{x1, x2, \ldots, xn\}$ is an alternative set or criteria that correspond to the elements in the comparison matrix, $A = (a_{ij})$ with $a_{ij} \in [1/9, 9]$, then $P \in (pij)$ is called the corresponding reciprocal fuzzy preference relation, where $p_{ij} = [0, 1]$ corresponding to A is given as $p = g(A)$ that is,

$$P_{ij} = g(a_{ij}) = \frac{1}{2}(1 + log_9 a_{ij}) \quad (1)$$

where g is the transformation function, choose $log_9 a_{ij}$ because a_{ij} is between 1/9 and 9. If a_{ij} is between 1/7 and 7, then $log_7 a_{ij}$ is used.

Proposition 2. For any $P = g(A)$, where $P = (p_{ij})$, equations (2) and (3) are equivalent.

$$P_{ij} + P_{jk} + P_{ki} = \frac{3}{2}, \forall i, j, k \quad (2)$$

$$P_{ij} + P_{jk} + P_{ki} = \frac{3}{2}, \forall i < j < k \quad (3)$$

Proposition 3. For any $P = (p_{ij})$, equations (4) and (5) are equivalent.

$$P_{ij} + P_{jk} + P_{ki} = \frac{3}{2}, \forall i < j < k \quad (4)$$

or in general it can be written as

$$P_{i(i+1)}+P_{(j+1)(i+2)}+\cdots+P_{(i+k-1)(i+k)}+P_{(i+k)i}=\frac{k+1}{2},\forall i<j \quad (5)$$

Proposition 3 is essential because it can be used to form a consistent fuzzy interest relation from a set of $k-1$ values, with $\{p_{12}, p_{23}, \ldots, p_{n-1n}\}$. Therefore, the other elements of the matrix will be calculated using Proposition 3.

Experts are helped to express their level of importance in the decision process. If there is a comparison matrix with input not at interval $[0,1]$, but interval $[-k, 1+k]$, $k>0$ can be generated by performing transformations using functions that maintain reciprocity and additive consistency. This problem can be solved by using the function

$$f:[-k,1,+k]\rightarrow[0,1], f(x)=\frac{x+k}{1+2k} \quad (6)$$

The weight calculation is done using equations (7) and (8). Equation (7) calculates the overall score of each element in the row of pairwise comparison matrix, while the weight (W) of each criterion and sub-criteria is used by equation (8).

$$s_i=\frac{1}{n_c}\left(\sum_{j=1}^{n_c}P_{ij}\right) \quad (7)$$

$$W_i=\frac{s_i}{\sum_{i=1}^{n_c}S_i} \quad (8)$$

3 RESULT AND DISCUSSION

The first stage in the research is to determine the problem and criteria. We have summarized the criteria and sub-criteria used to improve the excellence indicator in Webometrics in Table 1. The main criteria consist of improving scholarly rank, measure the number of scientific papers, and recognize scholarly ranks. In contrast, the sub-criteria are used to detail the problems further to be solved. The goal is to determine the best strategy to increase the excellence score in Webometrics ranking. Hierarchy of criteria and sub-criteria are presented in tabular form.

The second stage is to determine the level of importance of each criterion based on expert judgment. The experts we invited were academics from 3 universities who handled the activities of lecturers (education, research and community service). Table 2 shows the membership function of the linguistic scale to assist experts in determining the assessment of importance between criteria.

The elements of the pairwise comparison matrix on main criteria can be shown at Table 3.

The original data yield an average interval value. For Table 3, the $A\rightarrow B$ comparison is $(6,7,8)$, and the average is $(1/2\times(6+8)) = 7$. Based on Table 3, the value of p_{13} is not filled by experts. The Proposition 1 will calculate the value of p_{ij} when $i=j$ or $j=i+1$. The elements on main diagonal ($i=j$) can be shown as bellow. $p_{11}=1/2(1+log_9(1))=0.5$; $p_{22}=1/2(1+log_9(1))=0.5$; $p_{33}=1/2(1+log_9(1))=0.5$. The elements above the main diagonal can be calculated as $p_{12}=1/2(1+log_9(7))=0.94$; $p_{23}=1/2(1+log_9(5))=0.86$; The values below the main diagonal are calculated using Proposition 3 for each element as follows: $p_{21}=1-p_{12}=1-0.94=0.06$; $p_{32}=1-p_{23}=1-0.86=0.13$; $p_{31}=1.5-p_{21}-p_{32}=1.5-0.94-0.86=-0.31$; $p_{13}=1-(-0.31)=1.31$. Based on calculation, it can be seen that the p_{13} and p_{31} element is 1.31 and -0.31 where the value is not in the interval [0.1], then the criterion matrix is changed using equation (6), which $k=0.31$. $f(x)=f(p_{12}) = f(0.94) = (0.94+0.31/1+(2\times0.31)) = 0.77$ $f(x)=f(p_{23})=f(0.86)$

Table 1: Multi-Criteria of Excellence

Main Criteria	Notation	Sub Criteria
A. Improving scholarly rank	A1	Go open access
	A2	Get listed OA directory
	A3	Encourage staff and postgrads to increase visible publications
	A3a	Support by citation culture
	A3b	Support by publication strategy
	A3c	Support by training in publishing
	A3d	Support by portofolio profiles
	A4	Get indexed by Google Scholar or Scopus
	A5	Make existing publications visible
	A5a	All staff must put their abstract online
	A5b	Convert non electric journals to pdf and upload them
	A5c	Get data existing repository
B. Measuring the number of scientific papers	B1	Google Scholar
	B2	Scimago Journal Rank/Scopus/Web Of Science (WOS)
C. Recognizing scholarly ranks	C1	Individuals
	C2	Others (Google Scholar, Scopus)

Table 2: Membership Function Linguistic Scale

Importance level	Definition
(1, 1, 1)	Equal
(1, 2, 3)	Equal-moderate
(2, 3, 4)	Moderate
(3, 4, 5)	Moderate-fairly strong
(4, 5, 6)	Fairly strong
(5, 6, 7)	Fairly strong-very strong
(6, 7, 8)	Very strong
(7, 8, 9)	Very strong-absolute
2, 3, 4, 8 values between two adjacent asessment	

Table 3: Pairwise comparison matrix on the main criteria

Scholar	A	B	C
A	1	7	p_{13}
B	p_{21}	1	5
C	p_{31}	p_{32}	1

$= (0.86 + 0.31/1 + (2 \times 0.31)) = 0.73$. The other matrix elements are recalculated using Proposition 1 and Proposition 3. The weight of each criterion calculated using equation (7) and equation (8). The transformation matrix calculated using the CFPR model can be seen in full in Table 4.

Table 4: CFPR matrix comparison on the main criteria

	A	B	C	Weight	Rank
A	0.5	0.77	0.99	0.51	1
B	0.23	0.5	0.73	0.32	2
C	2.82E-05	0.27	0.5	0.17	3

Table 4 explains that the ranking on the main criteria is A>B>C. This shows that improving scholarly rank (A) is the essential factor in improving the excellence score on Webometrics. The following criterion measuring the number of scientific papers (B), and the last is to recognizing scholarly ranks (C). The elements of the pairwise comparison matrix on the other sub-criteria are shown in Table 5-9.

Table 5: Pairwise comparison matrix on the criteria of improving scholarly rank (A)

	A1	A2	A3	A4	A5
A1	1	0.2	p_{13}	p_{14}	p_{15}
A2	p_{21}	1	0.2	p_{24}	p_{25}
A3	p_{31}	p_{32}	1	7	p_{35}
A4	p_{41}	p_{42}	p_{43}	1	0.33
A5	p_{51}	p_{52}	p_{53}	p_{54}	1

Table 6: Pairwise comparison matrix on the sub-criteria encourage staff and postgrads to increase visible publications (A3)

	A3a	A3b	A3c	A3d
A3a	1	3	p_{13}	p_{14}
A3b	p_{21}	1	5	p_{24}
A3c	p_{31}	p_{32}	1	5
A3d	p_{41}	p_{42}	p_{43}	1

Table 7: Pairwise comparison matrix on the sub-criteria make existing publications visible (A5)

	A5a	A5b	A5c
A5a	1	3	p_{13}
A5b	p_{21}	1	5
A5c	p_{31}	p_{32}	1

Using proposition 1 and proposition 3, Table 10-14 is a pairwise comparison matrix of CFPR resulting from weight and ranking calculations.

Based on table 10, it can be seen that the highest ranking in the sub-criteria of improving scholarly rank is encourage staff and

Table 8: Pairwise comparison matrix on the criteria of measure the number of scientific papers (B)

	B1	B2
B1	1	0.143
B2	p_{21}	1

Table 9: Pairwise comparison matrix on the criteria of recognized scholarly ranks (C)

	C1	C2
C1	1	0.143
C2	p_{21}	1

Table 10: CFPR matrix comparison on the criteria of improving scholarly rank (A)

	A1	A2	A3	A4	A5	Weight	Rank
A1	0.5	0.250	9.04E-06	0.30	0.13	0.07	5
A2	0.75	0.5	0.25	0.55	0.38	0.19	3
A3	0.99	0.74	0.5	0.80	0.63	0.31	1
A4	0.69	0.44	0.19	0.5	0.32	0.16	4
A5	0.86	0.61	0.36	0.67	0.5	0.25	2

postgrads to increase visible publications (A3). In contrast, the lowest ranking is going to open access (A1). In general, the ranking in sub-criteria A can be written as A3>A5>A2>A4>A1.

Table 11: CFPR matrix comparison on the sub-criteria encourage staff and postgrads to increase visible publications (A3)

	A3a	A3b	A3c	A3d	Weight	Rank
A3a	0.5	0.62	0.81	0.99	0.35	1
A3b	0.37	0.5	0.68	0.87	0.30	2
A3c	0.18	0.31	0.5	0.68	0.22	3
A3d	6.7E-06	0.12	0.31	0.5	0.14	4

Table 12 describes the highest ranking in the A5 sub-criteria, namely the all staff must put their abstract online sub-sub-criteria (A5a), and the lowest ranking is the get data existing repository sub-sub-criteria (A5c).

Referring to Table 13, it can be seen that the criterion of measure the number of scientific papers prioritizes measurements on ScimagoJurnal rank/Scopus/WOS (B2) than Google Scholar (B1).

Based on Table 14, it can be seen that the weights on the criteria (Google Scholar, Scopus) are higher than for individuals. Some strategies to increase the score of excellence based on the main priority of each criterion are,

(1) Universities need to pay attention to increasing scientific rankings by encouraging staff and postgraduates to increase visible publications. Publication visibility is done by increasing the number of citations on scientific works. The scientific works of a lecturer and researcher include published research results, patents or Intellectual Property Rights, and articles

Table 12: CFPR matrix comparison on the sub-criteria make existing publications visible (A5)

	A5a	A5b	A5c	Weight	Rank
A5a	0.5	0.70	1.00	0.49	1
A5b	0.297	0.5	0.79	0.35	2
A5c	0.000	0.20	0.5	0.16	3

Table 13: CFPR matrix comparison on the sub-criteria make existing publications visible (A5)

	B1	B2	Weight	Rank
B1	0.5	0.05	0.27	2
B2	0.94281	0.5	0.72	1

Table 14: CFPR matrix comparison on the sub-criteria recognizing scholarly ranks

	C1	C2	Weight	Rank
C1	0.5	0.05	0.27	2
C2	0.94281	0.5	0.72	1

that are presented in scientific journals, both National and International Seminars. The number of citations (shown in the h-index) in the publication indicates the quality of the paper. For a lecturer or researcher, the h-index is very important because the h-index greatly affects the research sponsorship funds to conduct the next research. Another way to make publications more visible is for all staff to put their abstracts online.

(2) The improvement in the excellence score is also supported by an additional strategy, namely measuring the number of scientific papers. Every lecturer and student is encouraged to take as many research publications as possible. In addition, the results of the student thesis are required to be published in journals and proceedings. Therefore, incentives need to be given to lecturers and students who can publish papers in reputable journals.

(3) Improving excellence scores by recognizing academic rank can encourage all lecturers to have accounts on Google Scholar and Scopus. Both are scientific articles indexing websites that Webometrics uses to retrieve data in university rankings.

4 CONCLUSION

In this study, we investigate the factors/criteria to determine what strategy universities will take to improve the Webometrics ranking on the excellence side. Based on the calculation results, it can be seen that the strategy for improving the excellence score is prioritized on three main criteria in sequence, namely improving scholarly rank (A), measure the number of scientific papers (B), recognize scholarly ranks (C). The sub-criteria for increasing scholar ranking can be prioritized on activities that support an increase in the number of citations, and the existing publications are undoubtedly visible.

ACKNOWLEDGMENTS

This research was supported by an LPPM research grant from the Institut Teknologi Telkom Purwokerto for Tenia Wahyuningrum (No. IT Tel1764 / LPPM-000 / Ka. LPPM / VII / 2020).

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i, j {1

Emi Iryanti, Ridwan Pandiya. "Evaluating the quality of e-learning using consistent fuzzy preference relations...

P (i, j

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i = 1, 2, . . . , n; j = 1, 2, . . . , n. For example, the

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are equivalent.Pij +Pjk +Pki

Chao, R.J.. "Evaluation of the criteria and effectiveness of distance e-learning with consistent fuzzy prefer...

Pij Pjk Pki , i < j < k++=32(4

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can be

E. Herrera-Viedma, F. Herrera, F. Chiclana, M. Luque. "Some issues on consistency of fuzzy preference relati...

A2A3A3aA3b

Western Governors University on 2017-12-29

5)Proposition 3 is

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the functionf :[−k,1,+k] [0,1],f(x

Wang, T.-C.. "Applying consistent fuzzy preference relations to partnership selection", Omega, 200708 interval [0, 1], but interval [−k, 1 + k], k > 0 can be

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1, 2, 3)Equal-moderate(2, 3, 4

The University of Manchester on 2014-08-30

Importance levelDefinition(1, 1, 1

Emi Iryanti, Ridwan Pandiya. "Evaluating the quality of e-learning using consistent fuzzy preference relations...

Moderate

Universiti Teknologi Petronas on 2013-09-08

Table 2: Membership Function Linguistic Scale

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Heriot-Watt University on 2010-08-29

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1Table 9: Pairwise comparison matrix

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main criteriaABCWeight RankA0

citeseerx.ist.psu.edu

Table 8: Pairwise comparison matrix

link.springer.com

A1A2A3A4A5

studentsrepo.um.edu.my

Table5

Kingston University on 2013-11-21

p31p32p41p42p51p52p13p14

University of Adelaide on 2018-10-19

A1A2A3A4A5A1A2A3A4A510

konan-u.repo.nii.ac.jp

1Table 6: Pairwise comparison matrix

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A3aA3bA3cA3dA3aA3bA3cA3d1

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A3aA3bA3cA3d

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1Table 7: Pairwise comparison matrix

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