Using weighted of ROC in analytical network process for decision making

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Abstract. The use of Analytic Network Process (ANP) with complex model sometimes makes it difficult to fill the numeral by using the pairwise comparison. Therefore, one alternative that can apply is ROC or Rank Order Centroid. ROC implemented in SMARTER and MAGIQ, thus for this study was done using ROC on ANP system. The results obtained in this study is that there is a difference in ranking on ANP by using pairwise Comparison in the previous research while comparing with ROC. The reason is many numbers that lead to the same ranking value in a cluster. Therefore, it can complicate the determination of the best alternative. However, ROC can help in quick counting and support validate the pairwise comparison weights on ANP.

1. Introduction

Making Decision can be said of consideration the positives and negatives of each the alternatives, with estimates of the outcome of each option as well for determining which one is the best for that situation. Some studies on making a decision such as [1]–[6].

Analytical Network Process (ANP) is one of the multicriteria making decision methods which its expansion from the Analytical Hierarchy Process (AHP). The system is more complicated than AHP (the reader can check it out AHP system to [7], [8] articles ) because of the method able to represent feedback and interaction clusters from inner independence elements and outer independence elements. Therefore, many researchers using ANP such as [9], [10], or [11] for decision-making because it can measure some aspects in the form of a hierarchy or network.

Selection of the best alternative for decision-making, ANP using supermatrix to give resolutions the influence of interdependence between clusters within the network hierarchy of decisions which the weights managed by supermatrix taken from the numeral of pairwise comparison. The weighting is considered based on eigenvectors which are consistent. However, the problem will happen to confuse us to fill the number when we compare elements within clusters. The more complex the model of ANP, the more puzzling to fill it.

The article of [12] is a complicated model for the example; it used for selection mining area which has disaster risk of an earthquake that it takes a long time for fill numeral and determine the weight of ANP; especially if the number is not consistent, then it needs to do a review. Because of the reason, we need to choose alternatives weight values, and ROC (Rank Order Centroid) is one of the alternatives weight for the multicriteria decision which is a consideration in this study.

The study of ROC had discussed in [13]–[15], before which had compared to another weighting method and it depends on the situation in a study case developed to deal with ranked weights by
consideration. Generally, ROC had an appealing theoretical rationale, and it had the choice accuracy of rank weights [15].

Therefore, ROC had been implemented in SMARTER [16], [17] (modification of SMART [18]) and MAGIQ [19] (modification of AHP). This study using ROC as a weight for ANP with use of previous data [20] from [12] which had been researching with pairwise comparison weighted of ANP. The Result will be comparing both pairwise comparison and ROC which one has better.

2. Methodology
Usage of weights for this study is ROC as mentioned earlier, the purpose of using ROC is to make the simple figuring without considering eigenvector while calculating pairwise comparison. The concept of ROC is to convert rank 1st, 2nd, and third (for this study until rank fourth), into their corresponding ratings [19] in numerical values, if n is some attributes, then the weight (W) of attribute k ($A_k$) is [21]:

$$W(A_k) = \left( \sum_{i=k}^{n} \frac{1}{i} \right) / n$$  \hspace{1cm} (1)

There is three steps process in ANP which is done to add weight in supermatrix formation, i.e., unweighted supermatrix, weighted supermatrix, and limit supermatrix. The first step, Weight of ROC inserted into the unweighted supermatrix ANP table, which then calculated for obtaining the weighted supermatrix components ($WS_c$) is the unweighted supermatrix components ($UWS_c$) multiply by cluster weights ($CW$), with the following formula:

$$WS_c = UWS_c \times CW$$ \hspace{1cm} (2)

Moreover, the result of $WS_c$ will be raised to powers until it converges for obtaining limit supermatrix. The concept is multiplying the same matrix by doing iteration until the matrix row has the same value. If limit supermatrix has reached convergence, then the worth will be normalized to gain the best alternative. The ROC of ANP had illustrated in figure 1 below:

![Figure 1. ROC on ANP System](image)

3. Result and Discussion
Based on the study earlier, ANP using the pairwise comparison to compute criteria for each of clusters to gain eigenvector and considering consistency ratio (CR) which CR $\leq 0.1$ will be accepted.
Therefore, to replace a pairwise comparison by using ROC as a weight on the unweighted supermatrix, as a note for the symbols on the tables below is an assumption:

### Table 1. Unweighted Supermatrix by ROC

| Alternatives | A      | B      |
|--------------|--------|--------|
|              | Alt 1  | Alt 2  | Alt 3  | Alt 4  | A1    | A2    | A3    | A4    | B1    | B2    | B3    |
| 1            | 0.062  | 0.270  | 0.270  | 0.062  | 0.062 | 0.520 | 0.062 |       |       |       |       |
| 2            | 0.270  | 0.145  | 0.145  | 0.145  | 0.270 | 0.270 | 0.145 | 0.062 | 0.062 | 0.270 | 0.520 |
| 3            | 0.062  | 0.270  | 0.145  | 0.145  | 0.270 | 0.270 | 0.145 | 0.062 | 0.062 | 0.270 | 0.520 |
| 4            | 0.520  | 0.145  | 0.520  | 0.270  | 0.111 | 0.277 | 0.611 | 0.145 | 0.062 | 0.145 |       |

For example illustrated, A’s value is taken based on the number of attributes or criteria on each cluster, e.g., column A1 with the cluster row A (or observed from range of rows A1 to A4) has 3 elements, i.e., rows of A2, A3, and A4 (A1 not included because it is null or not compared), therefore the weights (w) based on equation (1) with n=3 are 

\[
\begin{align*}
\text{w1} &= \frac{1 + \frac{1}{2} + \frac{1}{3}}{3} = 0.611111 \\
\text{w2} &= \frac{0 + \frac{1}{2} + \frac{1}{3}}{3} = 0.277778 \\
\text{w3} &= \frac{0 + 0 + \frac{1}{3}}{3} = 0.111111
\end{align*}
\]

illustrated in table 2:

### Table 2. ROC with 3 Elements

| Attributes | N=3 | Roc  |
|------------|-----|------|
| w1         | 0.611111 |
| w2         | 0.277778 |
| w3         | 0.111111 |

If the first-row rank is A4, the second is A3, and the third is A2, then the weighting rank are A4 = w1, A3 = w2, and A2 = w3. In other words, the top ranking is the highest weight. The weight of ROC in unweighted supermatrix which then the weights are calculated in the weighted supermatrix and limit supermatrix which the convergent achievement obtained as much as ten iterations.

### Table 3. Limit Supermatrix

| Alternatives | A      | B      |
|--------------|--------|--------|
|              | Alt 1  | Alt 2  | Alt 3  | Alt 4  | A1    | A2    | A3    | A4    | B1    | B2    | B3    |
|              |        |        |        |        | 0.520 | 0.520 | 0.520 | 0.520 | 0.520 | 0.520 | 0.520 |
|              |        |        |        |        | 0.611 | 0.611 | 0.611 | 0.611 | 0.611 | 0.611 | 0.611 |
|              |        |        |        |        | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 | 0.277 |
|              |        |        |        |        | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 | 0.111 |

For the purpose of convenience, the ROC value is determined as 0.25 and 0.75.
There is a difference between the rankings obtained pairwise comparison performed on the previous study with rank obtained by ROC, such as third position level is A2, and fourth is A3 on ANP using a pairwise comparison, whereas ANP by using ROC is opposite. The reason is there are many numerals filled with neutral values. The neutral value is at the same level of importance (scale one on pairwise comparison), while the ROC impose to select to be ranked. Therefore, there is a significant change which occurs from Alt 1 to A4 as illustrated in figures 2 and 3.

| Alternatives | Total Limiting Cluster | Normalized by cluster | Ideal | Rank |
|--------------|------------------------|-----------------------|-------|------|
| Alt1         | 0.038                   | 0.161491              | 0.237338 | 0.770144 | 3 |
| Alt2         | 0.049389                | 0.305829              | 0.992392 | 2    |
| Alt3         | 0.024007                | 0.428571              | 0.564087 | 1    |
| Alt4         | 0.049767                | 0.112004              | 0.261342 | 0.980051 | 3 |

Table 4 Normalized and Ranking

| Alternatives | Total Limiting Cluster | Normalized by cluster | Ideal | Rank |
|--------------|------------------------|-----------------------|-------|------|
| Alt1         | 0.038                   | 0.161491              | 0.237338 | 0.770144 | 3 |
| Alt2         | 0.049389                | 0.305829              | 0.992392 | 2    |
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As a whole from the results of the study that ROC can be used to reduce the complexity of ANP under certain conditions, in other words, the pairwise comparison will be used if there is an equivalent value or cannot decide the level of the criterion element. Moreover, ROC can also apply as a pairwise comparison’s support to validate weight quickly.

4. Conclusion
Based on the previously described discussion, it can conclude that ROC can be used as a supporter of ANP's weighting system because its calculation is swift, although ROC's weakness is not able to determine ranking if it has the same value. For example, it can notice from the data limit supermatrix or data normalized that the difference in rankings is on A2 and A3, while the worth of other attribute rankings of the weight pairwise comparison and ROC is the same. Despite there are weaknesses, ROC can use as validation for calculation on ANP.
References

[1] Dhika H Daengs GS A and Ambarsari E W, 2018 Forecasting Water Loss Due To Pipeline Leakage By Using ANFIS And BACKPROPAGATION Approach (Study Case At PDAM Tirta Kahuripan On District of Bogor) in Proceedings of the Joint Workshop KO2PI and The 1st International Conference on Advance & Scientific Innovation p. 119–125.

[2] Parwatininetyas D Ambarsari E W and Mariko S, 2017 The calculation of the highest leak level of water pipe lines region at PDAM Tirta Kahuripan using fuzzy C-means and ArcGIS method analysis AIP Conf. Proc. 030196.

[3] Lestari M Irwany A Rahayu W and Parwati N W, 2018 Ethnomathematics elements in Batik Bali using backpropagation method in Journal of Physics: Conference Series 1022 p. 012012.

[4] Rahim R et al., Jun. 2018 TOPSIS Method Application for Decision Support System in Internal Control for Selecting Best Employees J. Phys. Conf. Ser. 1028, 1 p. 012052.

[5] Ahmar A S et al., 2018 Lecturers’ understanding on indexing databases of SINTA, DOAJ, Google Scholar, SCOPUS, and Web of Science: A study of Indonesians in Journal of Physics: Conference Series 954.

[6] Ahn B S, 2017 Aggregation of ranked votes considering different relative gaps between rank positions J. Oper. Res. Soc.

[7] Nasution M D T P et al., 2018 Decision Support Rating System with Analytical Hierarchy Process Method Int. J. Eng. Technol. 7, 2.3 p. 105–108.

[8] Saaty T L, Mar. 2004 Decision making — the Analytic Hierarchy and Network Processes (AHP/ANP) J. Syst. Sci. Syst. Eng. 13, 1 p. 1–35.

[9] Jharkharia S and Shankar R, Jun. 2007 Selection of logistics service provider: An analytic network process (ANP) approach Omega 35, 3 p. 274–289.

[10] Cheng E W I, Li H and Yu L, Jun. 2005 The analytic network process (ANP) approach to location selection: a shopping mall illustration Constr. Innov. 5, 2 p. 83–97.

[11] Aragonés-Beltrán P Pastor-Ferrando J P García-García F and Pascual-Agulló A, May 2010 An Analytic Network Process approach for siting a municipal solid waste plant in the Metropolitan Area of Valencia (Spain) J. Environ. Manage. 91, 5 p. 1071–1086.

[12] Parwatininetyas D Ambarsari E W Marlima D and Wiratomo Y, 2014 Disaster risk management in prospect mining area Blitar district, East Java, using microtremor analysis and ANP (analytical network processing) approach AIP Conf. Proc. 1589, 1 p. 76–80.

[13] Saeid M Ghani A A A and Selamat H, 2011 Rank-order weighting of web attributes for website evaluation Int. Arab J. Inf. Technol. 8, 1 p. 30–37.

[14] Ahn B S, Aug. 2011 Compatible weighting method with rank order centroid: Maximum entropy ordered weighted averaging approach Eur. J. Oper. Res. 212, 3 p. 552–559.

[15] Roszkowska E, 2013 Rank Ordering Criteria Weighting Methods – a Comparative Overview Optimum. Stud. Ekon. 5(65) p. 14–33.

[16] Barron F H and Barrett B E, Sep. 1996 The efficacy of SMARTER — Simple Multi-Attribute Rating Technique Extended to Ranking Acta Psychol. (Amst). 93, 1–3 p. 23–36.

[17] Rasim Rahman E F Dewi N F and Riza L S, Mar. 2017 Decision Support Systems for Performance and Evaluation of Teachers in General-English Course by using the SMARTER and TOPSIS Methods IOP Conf. Ser. Mater. Sci. Eng. 180, 1 p. 012283.

[18] Siregar D Arisandi D Usman A Irwan D and Rahim R, Dec. 2017 Research of Simple Multi-Attribute Rating Technique for Decision Support J. Phys. Conf. Ser. 930, 1 p. 012015.

[19] McCaffrey J D, 2009 Using the Multi-Attribute Global Inference of Quality (MAGIQ) technique for software testing in ITNG 2009 - 6th International Conference on Information Technology: New Generations p. 738–742.

[20] Ambarsari E W and Herusantoso K, 2018 Bentonite Mining Appropriateness Analysis of East Java Province with ANP in Seminar Nasional Teknologi Informasi 2011 p. 17–21.

[21] Yahlali M and Chouarfia A, 2014 SCAE: Software component assembly evaluation Int. J. Softw. Eng. its Appl. 8, 3 p. 255–268.
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