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EXPEDITED ANALYTICAL HIERARCHICAL PROCESS FOR MULTICRITERIA DECISION MAKING

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Abstract. *In this study, a procedure to overcome analytical hierarchical process (AHP) limitations was developed and tested, and a tool created via pairwise comparison chart and weighted sum method hybridization was introduced. In addition, a multicriteria decision-making software was selected to validate the constructed hybrid decision-making tool. The software was formulated based on an established decision-making technique. Data for the comparison analysis were obtained from an ongoing research, and output from the comparison analysis provided evidence for the accuracy of the constructed tool. The proposed hybridized method aligned with AHP reasoning but demonstrated a faster process; hence, it was called 'expedited AHP'.*
Keywords: Multiple criteria decision making (MCDM), Hybrid MCDM, Analytical hierarchical process (AHP), Weighted sum method (WSM), Pairwise comparison chart (PCC)

1. **Introduction.** The analytical hierarchical process (AHP) is an effective multiple-criteria decision-making (MCDM) technique employed in a wide range of applications [1-3]. According to Leal [1], the AHP begins by organizing a decision-making problem similar to an upside-down tree, with the decision goal at the top. The decision criteria that will obtain the goal are assigned to the middle level; thus, the criteria are ranked via pairwise comparison. At the lower level of the tree, the decision alternatives are presented and evaluated pairwise based on their contribution to the attainment of each criterion, as another part of the AHP. The alternatives are evaluated pairwise based on their contribution to the attainment of each criterion. Next, the AHP determines the ranking of the alternatives via a set of mathematical calculations. All comparisons are typically conducted on a nine-point scale.

Despite the advantages of the AHP, it has two major disadvantages. Firstly, the data collection procedure is time consuming, as drawing an AHP conclusion necessitates a large number of comparisons [1]. Secondly, the comparison and decision-making procedures involve complex mathematics [4]. Owing to these disadvantages, the AHP is not used in many cases. Hence, this article proposes an expedited AHP (EAHP) to overcome the aforementioned disadvantages.

Th rest of this article is organized as follows. Section 2 presents the case of a current MCDM study, which will be used as the benchmark for comparison with the proposed EAHP. Section 3 describes the construction of the hybrid MCDM, which will be called

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'EAHP'. Section 4 compares the proposed procedure's output with the benchmark output, and Section 5 provides the conclusion.

2. **Benchmark Case.** The COVID-19 pandemic and Industry 4.0 provided a massive impetus for the digitalization [5] of many industries, including tourism. However, some tourism sectors are less prepared than others for the immediate digital shift. Recently, the authors were involved in a project comparing tourism clusters in terms of digitalization readiness during and after the pandemic [6,7]. In this regard, three criteria were selected to ascertain industry digitalization change readiness and used to implement a technique for ranking various tourism forms (alternatives).

The study used a group-based approach to MCDM, as in most situations, groups outperform individuals in estimating, judging, selecting and problem solving. MCDM is typically implemented via a panel requiring collaboration in multiple-criteria decision environments, because a panel can make smarter estimates and choices compared with a single decision maker. In addition, a panel has access to different depths of knowledge, expertise, experience and information assets, thereby placing it in a better position to outperform single decision makers in a variety of activities [8].

MCDM tools can be used in group decision making and to convert qualitative designs into quantitative analysis [9]. The AHP was the first choice for the study, and the alternative method was preference ranking organization method for enrichment evaluations (PROMETHEE) or TOPSIS. As explained above, the amount of data required for the AHP is substantially greater than that required for other methods. Additionally, the more the data required, the higher the likelihood of failure in attaining consistency if the decision makers are with different schools of thought. This issue is highly significant when long-range scales for pairwise comparison are used.

Thus, though the AHP is one of the most prominent MCDM techniques, alternative methods (e.g., PROMETHEE or TOPSIS) for designing the data collection tool (and analysis) are employed owing to the limitations of the AHP. The received inputs from the decision-making panels are presented in Table 1.

Table 1. Data for MCDM

	Criterion 1 (demand response)	Criterion 2 (industry response)	Criterion 3 (technology readiness)
Cultural tourism (Cu. T.)	0.9	0.3	3
Rural tourism (Ru. T.)	−0.1	−1.2	0
Adventure tourism (Ad. T.)	−0.7	−0.1	1
Event tourism (Ev. T.)	1.5	0.5	4
Entertainment tourism (En. T.)	−0.4	0.3	2

The decision criterion weight provided by the expert panel was 35 for criterion 1 (demand response), 17 for criterion 2 (industry response) and 48 for criterion 3 (technology readiness) on a 100 scale range.

After data collection, decision making was performed using the PROMETHEE MCDM technique. This method is an established technique examined and used by numerous academicians and researchers [10,11]. A few software are available for this technique, and the online trial version of the D-Sight collaborative decision making (CDM) tool from http://www.d-sight.com was chosen for data analysis. The D-Sight CDM tool is

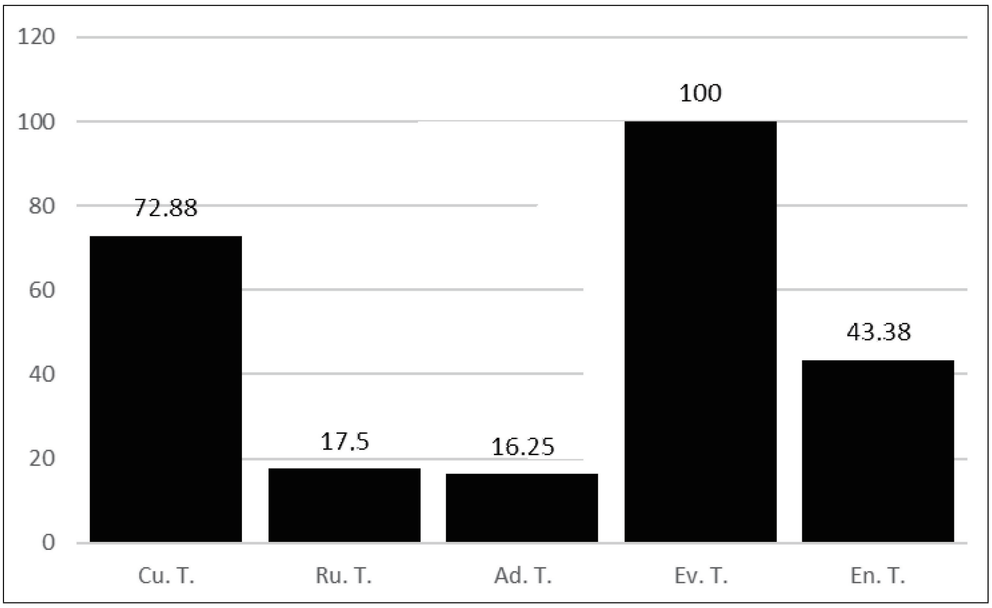

FIGURE 1. Scores and ranking of tourism clusters

programmed via Java and was developed in the University of Brussels (Université Libre de Bruxelles), Belgium [12]. Figure 1 depicts the tourism ranking of the five tourism forms examined in the study, which will be used to validate the proposed EAHP.

3. **Method.** In this section, the hybridization of two MCDM techniques is proposed to achieve the objective of this study. Although not used together by many studies, the hybridization of two simple techniques, namely, a pairwise comparison chart (PCC) and the weighted sum method (WSM), resulted in an abridged easy-to-use decision-making tool. The procedure is visualized in Figure 2.

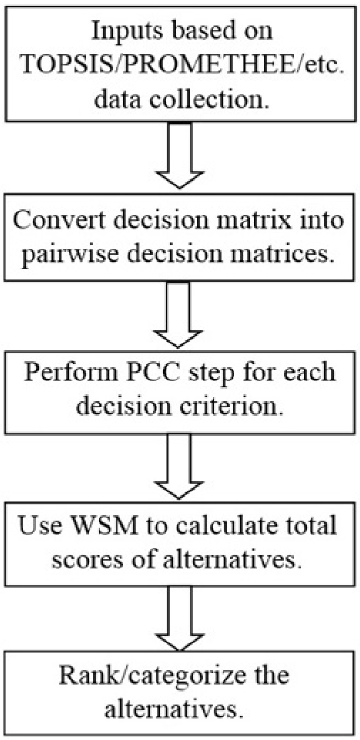

FIGURE 2. Multicriteria group decision-making procedure

Given that the data were collected using a different scoring method, they must be converted for pairwise comparison to perform the PCC step. A pairwise comparison rates decision alternatives in a set on a pair-by-pair basis, that is, two at a time before all permutations are exhausted. In a PCC, the winner of each comparison receives 1 point, but in the absence of a winner, both pairs receive 0.5 point.

Thus, the data from the decision matrix in Table 1 were converted in the three comparison matrices shown in Tables 2, 3 and 4. A few examples were provided to explain the transformation of the data. In Table 2, Cu. T. received 1 point in its comparison with Ru. T., because the values of criterion 1 (demand response) from Table 1 are 0.9 and -0.1, where $0.9 > -0.1$. Similarly, Cu. T. versus Ev. T. received 0 point, as the values of criterion 1 from Table 1 are 0.9 and 1.5, where $0.9 < 1.5$. However, in Table 3, En. T. against Cu. T. and Cu. T. against En. T. received 0.5 point, as the values of criterion 2 (industry response) for the two tourism forms are equal, that is, 0.3.

Table 2. Pairwise comparison based on demand response (criterion 1)

	Cu. T.	Ru. T.	Ad. T.	Ev. T.	En. T.
Cu. T.	0	1	1	0	1
Ru. T.	0	0	1	0	1
Ad. T.	0	0	0	0	0
Ev. T.	1	1	1	0	1
En. T.	0	0	1	0	0

Table 3. Pairwise comparison based on industry response (criterion 2)

	Cu. T.	Ru. T.	Ad. T.	Ev. T.	En. T.
Cu. T.	0	1	1	0	0.5
Ru. T.	0	0	0	0	0
Ad. T.	0	1	0	0	0
Ev. T.	1	1	1	0	1
En. T.	0.5	1	1	0	0

Table 4. Pairwise comparison based on technology readiness (criterion 3)

	Cu. T.	Ru. T.	Ad. T.	Ev. T.	En. T.
Cu. T.	0	1	1	0	1
Ru. T.	0	0	0	0	0
Ad. T.	0	1	0	0	0
Ev. T.	1	1	1	0	1
En. T.	0	1	1	0	0

The points awarded to each alternative (row) of the comparison matrix were then added, and the ranking was obtained by listing the elements in order of the points accrued, which is known as a PCC [13]. The total scores were calculated and presented in Table 5.

Subsequently, to encapsulate the PCC findings, utilizing the most common MCDM technique [14,15], the WSM ranked the tourism clusters, considering the criterion weights resulting from the PCC output. The final ranking based on the comparison of the weighted sums is presented in Table 6, which shows that the value of Cu. T. for criterion 1 was calculated based on ($3 \times 35 = 105$), the value of Cu. T. for criterion 2 was calculated based on ($2.5 \times 17 = 42.5$) and the value of Cu. T. for criterion 3 was calculated based

TABLE 5. PCC scores

	Criterion 1	**Criterion 2**	**Criterion 3**
Cu. T.	3	2.5	3
Ru. T.	2	0	0
Ad. T.	0	1	1
Ev. T.	4	4	4
En. T.	1	2.5	2

TABLE 6. WSM add-ons

	Criterion 1	Criterion 2	Criterion 3	**Weighted Sum**	**Rank**
Cu. T.	105	42.5	144	291.5	2
Ru. T.	70	0	0	70	4
Ad. T.	0	17	48	65	5
Ev. T.	140	68	192	400	1
En. T.	35	42.5	96	173.5	3

on ($3 \times 48 = 144$); therefore, the weighted sum for Cu. T. was ($105 + 42.5 + 144 = 291.5$). Similarly, the value of Ru. T. for criterion 1 was calculated based on ($2 \times 35 = 70$). The value of Ru. T. for criterion 2 was calculated based on ($0 \times 17 = 0$), and the value of Ru. T. for criterion 3 was calculated based on ($0 \times 48 = 0$); therefore, the weighted sum for Ru. T. was ($70 + 0 + 0 = 70$).

4. **Results.** The outcome obtained via the MCDM software (presented in the Introduction) is used as the benchmark to test the accuracy of the hybridized PCC-WSM, and the outcome scores are presented in Table 7.

TABLE 7. Scores from the two methods

Tourism cluster scores	Cu. T.	Ru. T.	Ad. T.	Ev. T.	En. T.
From benchmark case	72.88	17.5	16.25	100	43.38
From hybrid PCC-WSM	291.5	70	65	400	173.5

Normalization is used to provide comparable data [16]. Hence, sum-based normalization by dividing each score by its column summation value [16] is used to convert the values in Table 7 into comparable values, which are reported in Table 8. The comparison of the resulting normalized values provides evidence for the similarity of the output results from the benchmark case (using the MCDM software) and hybrid PCC-WSM.

TABLE 8. Normalized comparison

	Cu. T.	Ru. T.	Ad. T.	Ev. T.	En. T.
Benchmark software	0.2	0.2	0.2	0.2	0.2
Hybrid PCC-WSM	$4 \times$ (0.2	0.2	0.2	0.2	0.2)

According to [17], comparisons and experimental results can confirm the validity of methods. Therefore, the results show the validity of the PCC-WSM combination. Moreover, the steps of the PCC-WSM calculations are similar to the AHP but with less data required and less mathematical complexity. Compared with the lengthy data collection procedure of the AHP for pairwise comparison matrices, the proposed PCC-WSM combination can expedite AHP, as it requires approximately 70% less data (questions from the panel) and significantly less stress for detailed comparisons owing to its simple comparison technique (using 0, 0.5 and 1). As the AHP is one of the most popular MCDM techniques and a well-known tool [15], the EAHP, with less complexity challenges, has the potential to break the record as a possible replacement.

5. **Conclusion.** This study used an abridged decision-making process by hybridizing a PCC and the WSM. In addition, this work utilized a PROMETHEE-based tool to address MCDM concerns specific to data from an expert panel. The proposed hybrid technique demonstrated the fast collection of data from the decision-making panels. This augmented procedure was used to compare the change preparedness for digitalization of tourism clusters. The results from both approaches showed that the evaluated tourism clusters appeared to have different levels of readiness for digital transformation. The outcome obtained via the hybrid PCC-WSM was similar to the outcome obtained by the MCDM software. The hybrid method also followed the same logit as the AHP, but expedited it; thus, it was called 'expedited AHP' or 'EAHP'.

The proposed EAHP performed well in this study, and the outcomes suggested the reliability and feasibility of the formulated decision-making procedure. Additionally, the EAHP is predicted to be capable of minimizing the problem of reaching a general consensus in panels. However, because the pursuit of the ultimate decision-making methodology should be continuous and unceasing, further research in this area is essential. Future studies are invited to comment on this research to improve the EAHP.

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