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Comparative Study of AHP and Potential Method in Supplier Selection Decision Making

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Abstract

Multi-Criteria Decision Making (MCDM) is used to tackle decision-making problem by evaluating and comparing different options based on several criteria. MCDM procedures need multiple inputs and generate outcomes as weights given to each options. Two commonly used MCDM methods are the Analytic Hierarchy Process (AHP) and the Potential Method (PM). AHP entails breaking down a decision problem into structured hierarchy, facilitating pairwise comparisons to determine weights for the options. On the other hand, PM utilizes a directed graph referred to as a preference structure, constructed via paired comparisons, to formulate a value function for the option. This study employs the Potential Method in a previously published case study of supplier selection that was analyzed earlier using the AHP. The objective is to analyse the outcomes from both methods, specifically focusing on the supplier's rankings. The findings showed that both AHP and PM recognized Supplier D1 as the top option, followed by Supplier D2 and then D3. The overall ranking remained consistent despite minor variations in the final weight values. This suggests that the PM produce results similar to those of AHP in tackling MCDM problems. Additionally, PM enhanced interpretability via its graphical representation, which make it a useful complementary tool to the conventional AHP for managing complex decision-making situations.

Keywords: Decision making, Multicriteria decision making, Analytical hierarchy process, Potential method, Supplier selection

Introduction

In today's world, people and organizations often encounter various decision making situations that involve several criteria. Although decisions can be made instinctively or without systematic approach, decision making techniques provide organized and trustworthy guidance for intricate assessments [1-2]. Multicriteria decision making (MCDM) has become essential in daily operations within numerous organizations. MCDM allow people to evaluate multiple factor at once, including cost, time, quality and risk [3].

This study emphasis on two commonly utilized MCDM techniques which are the Analytic Hierarchy Process (AHP) and the Potential Method (PM). The study focuses on improving the analysis of AHP matrices by utilizing the PM in a supplier selection case study that was evaluated earlier using AHP. The aim is to evaluate the decision results of both technique, especially regarding the resultant weights and rankings.

AHP was developed by Thomas L. Saaty during the 1970s, is a recognized technique for multicriteria decision making. It aids in decision making through pairwise comparisons to access the relative importance of different factors, while also verifying the consistency of



judgement [4-5]. Conversely, the PM is based on network analysis and effectively reveals inconsistencies in decision making data. PM works well even when the information is incomplete, concentrating on the relationships and preferences between options [6].

Literature Review

The PM is a method used in decision-making processes that make use of graphs. A structure created by comparison of a group of options or alternatives is called a preference graph. Preference graphs were employed by simulating pairwise comparisons of alternatives.

Assume that V is a collection of options or alternatives where some preferences are considered. A directed edge from vertex v to vertex u can be used to indicate that u is favoured over v (represented as $u \succ v$). The edge is denoted as (u, v) .

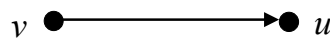


Figure 1: An alternative u is more preferred than alternative v

The PM converts pairwise comparison of options or alternatives into preference flow within a directed graph called preference graph. The preference graph contains vertex as option or alternative, and directed edge indicate preference between them. Each edge is assigned a weight that reflect to the strength of the preference. The definition of preference graph is given as follows:

Definition 1 [6]

A preference graph can be represented as a triple $G = (V, E, F)$, where $E \subseteq V \times V$ is a set of $m \in \mathbb{N}$ directed edges, V is a set of $n \in \mathbb{N}$ vertices and are representing alternatives, and $F : E \rightarrow \mathbb{R}$ is a preference flow that maps each edge (u, v) to the associated intensity $F(u, v)$.

Example 1

Assuming the preferences over A, B and C as follows:

- A to B with a weight of 3 indicates that A is preferred over B.
- B to C with a weight of 2 indicates that B is preferred over C.
- A to C with a weight of 5 indicates that A is preferred over C.

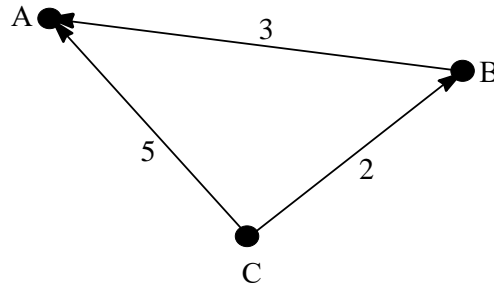


Figure 2: An example of Preference Graph of Example 1

The PM determines the ‘potential’ values of each alternative by balancing the incoming and outgoing preference flows at each vertex. The potential values are used to rank the options or alternatives, where higher potentials signify more preferred or desirable options. In summary, the PM employs graph theory and pairwise comparison to systematically evaluate and rank alternatives.

Ranking by Potential Method

The inputs are the preference value obtained by pairwise comparison [7]. These values are presented as the entries for a preference flow matrix. The edge’s orientation is listed as an incidence matrix, A . The procedure of ranking with the PM is outlined as follows:

Step 1: For a given problem construct $G = (V, E, F)$. The V is a set of vertices, E is the set of edges and F is the corresponding preference flow.

Step 2: Construct the incidence, A and preference flow, F matrices. An $m \times n$ incident matrix is given

$$A_{\alpha,v} = \begin{cases} -1, & \text{if the edge } \alpha \text{ leaves } v \\ 1, & \text{if the edge } \alpha \text{ enters } v \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

The preference flow, F of size $m \times 1$ is the associated intensity value.

Step 3: Build the laplacian matrix, L . The laplacian matrix is given by $L = A^T A$ and its entries are defined as:

$$L_{i,j} = \begin{cases} -1, & \text{if there is an edge } (i, j) \text{ or } (j, i), \\ \text{deg}(i), & \text{if } i = j, \\ 0, & \text{else.} \end{cases} \tag{2}$$

Step 4: Compute the flow difference matrix D . Let $D = A^T F$ be the flow difference. The following is the component of D .



$$\begin{aligned}
 D_v &= \sum_{\alpha=1}^m A_{v,\alpha}^T F_\alpha \\
 &= \sum_{\alpha \text{ enters } v} F_\alpha - \sum_{\alpha \text{ leaves } v} F_\alpha
 \end{aligned}
 \tag{3}$$

In this case, D represents the difference between the total flow entering v and the total flow leaving v .

Step 5: Solve for potentials. Potential, X is a Laplacian system solution.

$$LX = \nabla \tag{4}$$

In a way, that $\sum X_v = 0$ on its linked parts.

Step 6: Check consistency degree $\beta < 12^\circ$. The definition of the measure of inconsistency is

$$\text{Inc}(F) = \frac{\|F - AX\|_2}{\|AX\|_2} \tag{5}$$

where $\beta = \arctan \text{Inc}(F)$ is the angle of inconsistency and $\|\cdot\|_2$ indicates the 2-norm. When $\beta < 12^\circ$, the ranking is acceptable.

Step 7: Calculate weights, w . The weight is calculated using the following formula.

$$w = \frac{a^x}{\|a^x\|_1}, \quad a > 0 \tag{6}$$

where the parameter a is set to 2 and $\|\cdot\|_1$ stands for the l_1 -norm.

Step 8: Rank the items according to the corresponding weights.

Implementation on supplier selection case study

Czech manufacturing company is needed to find the best supplier [8]. The company is seeking a new supplier for a particular item. There are 10 criteria to be evaluated to find the best suppliers. The company has three potential suppliers and is using a structured, multi-criteria decision-making approach to evaluate them.

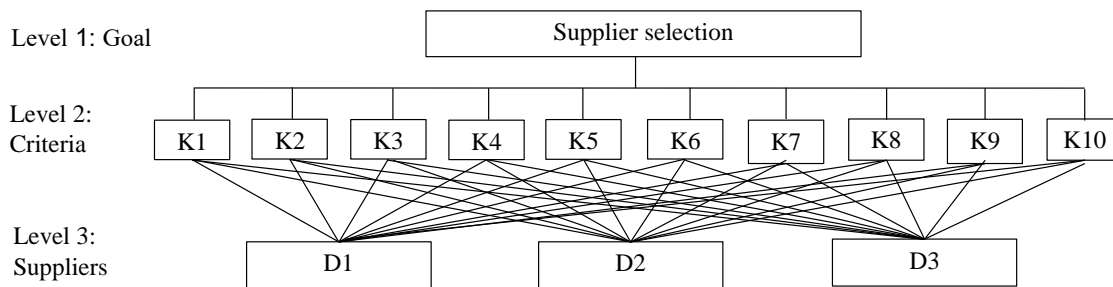


Figure 3: Hierarchy of problem.



Criteria weight determination

The initial step in analyzing hierarchical decision problem is find the weight of criteria. Table 1 show the comparison matrix of 10 criteria taken form [8]. Table 1 represent the pairwise comparison of criteria in consideration to selection of suppliers and the combination of weight and ranking for criteria which is measured AHP and PM.

Table 1: Pairwise comparison matrix of criteria.

Criteria	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10
K1	1	3	5	5	7	8	8	6	5	5
K2	1/3	1	5	5	7	8	8	6	5	5
K3	1/5	1/5	1	1/3	5	6	7	5	3	4
K4	1/5	1/5	3	1	4	3	7	5	1	5
K5	1/7	1/7	1/5	1/4	1	4	1/5	1/7	1/3	3
K6	1/8	1/8	1/6	1/3	1/4	1	5	1/5	1/3	3
K7	1/8	1/8	1/7	1/7	5	1/5	1	1/3	1/3	3
K8	1/6	1/6	1/5	1/5	7	5	3	1	1	3
K9	1/5	1/5	1/3	1	3	3	3	1	1	3
K10	1/5	1/5	1/4	1/5	1/3	1/3	1/3	1/3	1/3	1

The pairwise comparisons among 10 criteria are transformed into a preference graph as in Figure 4.

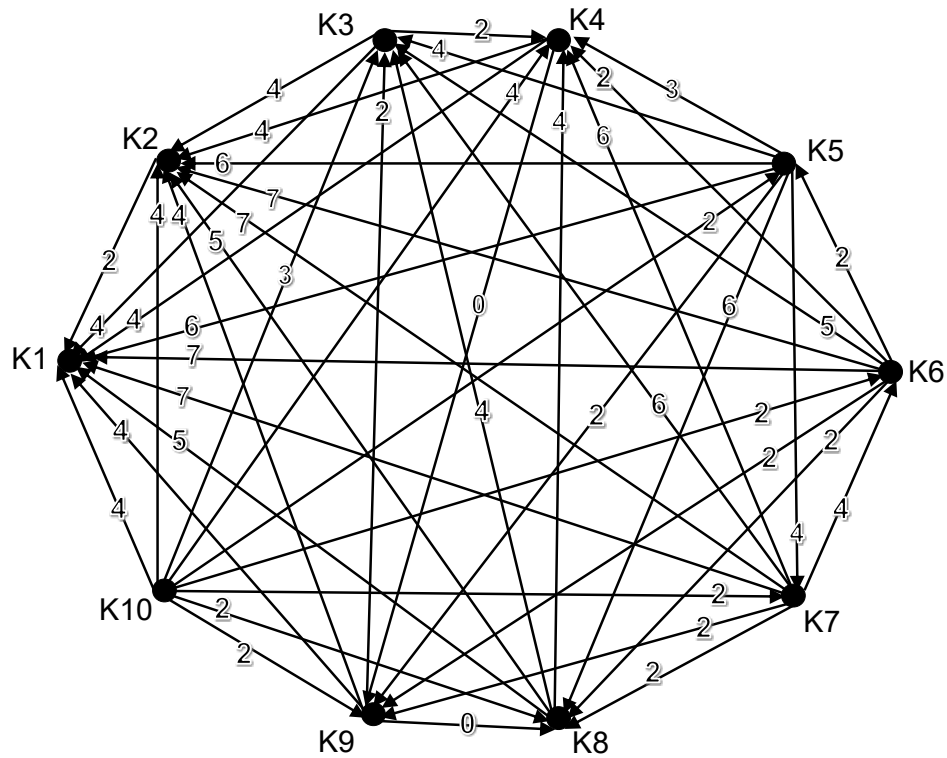


Figure 4: The preference graph of criteria.



Supplier weight with respect to K1

Once the weights for the criteria are obtained, the third level is analyzed. This section discusses the analysis of suppliers with respect to criterion, K1. Table 3 presents the pairwise comparison of suppliers based on K1. The information from Table 3 are then transformed into preference graph, as illustrated is Figure 5. In this graph, the directed edges from D3 to A2 signifies that D2 is preferred over D3 by a factor of 4.

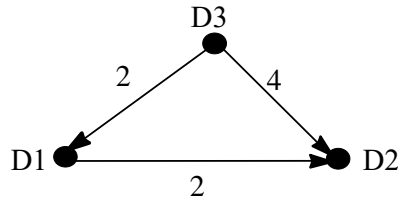


Figure 5: The preference graph of suppliers with respect to K1.

Table 3 shows the comparative weights of suppliers based on criterion K1, as determined by both AHP and PM. The PM ranks the suppliers in the order D2>D1>D3, which consistent with the ranking obtained from AHP.

Table 3: Weightage for supplier with respect to K1.

Suppliers	D1	D2	D3	AHP		PM	
				weight	rank	weight	rank
D1	1	1/3	3	0.2583	2	0.1905	2
D2	3	1	5	0.6370	1	0.7619	1
D3	1/3	1/5	1	0.1047	3	0.0476	3

Conclusion

Table 4 shows the comparison of final weight and ranking between the AHP and PM. The AHP find outs that D1 holds the highest priority with a weight of (0.4785), followed by D2 (0.4397), while D3 has the lowest weight which is 0.0816. Similarly, the PM analysis ranks D1 highest (0.5753), then D2 (0.4050), and lastly D3 (0.0197). This alignment in ranking across both methods confirms a consistent order of alternatives as D1 > D2 > D3.

Table 4: Final weights of suppliers using AHP and PM.

Suppliers	AHP		PM	
	weight	rank	weight	rank
D1	0.4785	1	0.5753	1
D2	0.4397	2	0.4050	2
D3	0.0816	3	0.0197	3

In conclusion, both AHP and PM rank the supplier identically with D1 first, D2 second and D3 third. The final weight values between these two methods are differed slightly, but the order



of preference was the same. This shows that PM is stable and consistent, thus comparable to the AHP.

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References

- [1] Taherdoost, H., & Madanchian, M. (2024). Decision making: Models, processes, techniques. *Cloud Computing and Data Science*, 1-14.
- [2] U-Dominic, C. M., Ujam, J. C., & Igbokwe, N. (2021). Applications of analytical hierarchy process (AHP) and knowledge management (km) concepts in defect identification: a case of cable manufacturing. *Asian Journal of Advanced Research and Reports*, 9-21.
- [3] Taherdoost, H., & Madanchian, M. (2023). Multi-criteria decision making (MCDM) methods and concepts. *Encyclopedia*, 3(1), 77-87.
- [4] Huang, J. J. (2021). Analytic Hierarchy Process with The Correlation Effect Via Wordnet. *Mathematics*, 9(8), 872. <https://doi.org/10.3390/math9080872>.
- [5] Schiavon, L. L. P., Lima, P. A. B., Crepaldi, A. F., & Mariano, E. B. (2023). Use of The Analytic Hierarchy Process Method in The Variety Selection Process for Sugarcane Planting. *Eng*, 4(1), 602–614. <https://doi.org/10.3390/eng4010036>
- [6] Čaklović, L., & Kurdija, A. S. (2017). A Universal Voting System Based on the Potential Method. *European Journal of Operational Research*, 259(2), 677–688. <https://doi.org/10.1016/J.EJOR.2016.10.032>
- [7] Johar, K. A., Mohd Amin, M. A. H. N., Tuah, M. F., & Mamat, S. S. (2025). The graphical representation of clothing store location and its application with potential method. *Journal of Administrative Science*, 22, 34-46.
- [8] Hruška, R., Průša, P., & Babić, D. (2014). The Use of AHP Method for Selection of Supplier. *Transport*, 29(2), 195–203. <https://doi.org/10.3846/16484142.2014.930928>