A Multi-Criteria Decision Analysis Framework for Prioritizing Customer Loyalty Strategies : Integrating SCM and CRM Perspective

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Abstract— Particularly in the age of e-commerce, customer loyalty is a crucial component in assessing the viability of a firm. A Multiple-Criteria By combining the viewpoints of supply chain management and customer relationship management, a decision analysis framework is suggested to determine strategic priorities for boosting customer loyalty. 10 criteria weights and 10 alternative solutions are ranked using the Fuzzy Analytic Hierarchy Process (AHP) and TOPSIS (Fuzzy Analytic Hierarchy Process) techniques. Product availability, delivery timeliness, product/service quality, service flexibility, process efficiency, customer satisfaction, customer trust, customer engagement, service recovery, and loyalty program & personalization are among the criteria employed in fuzzy AHP. Consistency is demonstrated by the pairwise comparison matrix's Consistency Ratio of 0.002. Alternative approaches to improving customer loyalty are ranked using the TOPSIS method. Service quality improvement, delivery and tracking optimization, quicker handling of complaints and returns, tiered loyalty programs, data-driven offer personalization, omnichannel customer experience, customer engagement though community and digital media, price, stock, delivery, and policy tranperancy, customer referrals, and word-of-mouth initiatives are scenarios of alternative strategies. With a closeness coefficient value of 0.611, the TOPSIS calculation techniques indicates that omnichannel customer experience is the top priority. Price,stock, delivery and, policy transperancy rank second with the closeness coefficient value of 0.601. Delivery and tracking optimization stand in third with a closeness coeficient score of 0.564. in order to improve customer loyalty, supply chain management and customer relationship managemnet must work well together, according to the results of the alternatives strategy rankings.

Keywords— CRM, customer loyalty, Fuzzy AHP, SCM, TOPSIS

I. INTRODUCTION

A customer commitment to continually and repeatedly using, repurchasing, and recommending a business's services or goods is knowing as cuatomer royalty. Beyond only making a purchase, a customer's loyalty also includes their propensity to stick around, make additional purchases, and resist readily switching to competitors. Customer loyalty is essential in today's corporate environment since keeping current clients is more critical than acquiring new ones. According to Brusch et al., client loyalty is linked to consumer pleasure and purchasing behavior and is vital to a business's success, especially in the present e-commerce era[1].

Customer loyalty is influenced by several factors, including service quality. When a company is able to provide friendly, fast, reliable, and consistent service, customers will be more loyal. Omnichannel customer experience also influences customer loyalty. Service quality and perceived value also influence customer satisfaction. This is related to online delivery services[2]. Marcos dan Coelho menjelaskan bahwa service quality, customer satisfication dan customer value berhubungan erat dengan loyalty. Tak kalah penting juga adalah word-of-mouth. Molinillo et al.'s paper reveals that perceived

value plays a crucial influence in driving client loyalty on social commerce websites. Customers tend to be loyal if the benefits they receive outweigh the time, expense, or effort required [3].

In addition to customer quality, perceived value, service quality, customer satisfaction, and customer value, customer trust is also an important foundation for building long-term loyalty. If customers trust a company, they are more likely to make repeat transactions [4, 5].

In digital transactions, in addition to assessing the purchased product, customers will also assess the delivery process, communication, returns, and refunds. Customer experience and the effectiveness of after-sales service will influence customer loyalty because companies that are able to restore service well, then customer trust can be well maintained [6]. On the other hand, Chen et al. the effectiveness of customer loyalty programs is influenced by customer service program design, context and customer characteristics [7]. his shows that customer loyalty is the result of a multidimensional construct. Customer loyalty is not only due to repeat purchases but also depends on customer behavior and attitudes, good word of mouth, retention, referrals, advocacy and strategies aimed at increasing value creation.

II. METHOD

The choice of strategies to increase customer loyalty to a product/service involves various conflicting criteria and is complex, thus requiring a systematic decision-making framework. To address this complexity, this study integrates the fuzzy Analytical Hierarchy Process (Fuzzy AHP) and the Technique for Others Preference by Similarity to Ideal Solution (TOPSIS) to balance qualitative assessments that lead to the selection of strategies to increase customer loyalty. The hybridization of the Fuzzy AHP and TOPSIS methods is one method used to assist in decision-making related to the many alternative choices for problem solving and the criteria that must be considered in selecting these alternatives. The use of this hybrid method includes determining a strategy for sustainable, effective, affordable, and acceptable smart waste processing with environmental, technical, economic, and social variables [8], selecting the most attractive ports for container operators with six evaluation dimensions and 24 attractiveness criteria for operators [9], manufacturing relocation decisions considering cost, quality, time, flexibility, innovation, and sustainability, and 13 types of relocations [10], determining hotels' green practice scores [11], measuring the level of lecturer performance by conducting evaluations based on teaching performance, research performance and service [12], selection of sustainable materials based on environmental impact criteria, resource depletion and energy consumption in construction [7].

2.1 Fuzzy Analitycal Hierarchy Process

Fuzzy AHP is a combination of the AHP decision-making method with the Fuzzy concept approach. The Fuzzy AHP method can overcome uncertainty and ambiguity in the problems faced [13]. This model involves human judgment, which is subjective and difficult to measure precisely. Figure 1 shows a hierarchical structure formed from a complex multi-criteria problem [14].

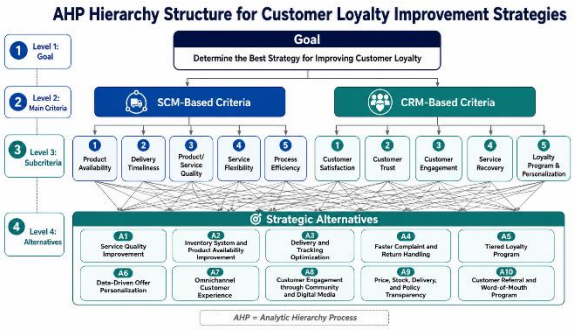

Figure 1. The AHP hierarchical structure of prioritizing customer loyalty strategies

Table 1 shows the criteria used in this case. The criteria for determining customer loyalty are divided into two categories: Supply Chain Management and Customer Relationship Management. Each criterion is divided into five sub-criteria.

Table 1. Criteria Code

SCM Based Criteria		
C1	Product Availability	The company's ability to provide products when customers need them
C2	Delivery Timeliness	Delivery time as promised
C3	Product/Service Quality	The quality of the product or service received by customers is consistent
C4	Service Flexibility	The company's ability to accommodate orders, returns, complaints, or changes requested by customers
C5	Process Efficiency	The company's ability to provide services efficiently, cost-wise, and in a timely manner.
CRM Based Criteria		
C6	Customer Satisfication	Customer satisfaction with products, services, and experiences
C7	Customer Trust	Customer trust in the company
C8	Customer Engagement	Customer engagement in interactions, reviews, communities, and referrals
C9	Service Recovery	Company ability to resolve complaints and restore customer satisfaction
C10	Loyalty Program & Personalization	Effectiveness of loyalty programs and personalized offers

Table 2 contains alternative strategies for increasing customer loyalty.

Table 2. Alternative Code

Code	Alternatif Strategi
A1	Service Quality Improvement
A2	Inventory System and Product Availability Improvement
A3	Delivery and Tracking Optimization
A4	Faster Complaint and Return Handling
A5	Tiered Loyalty Program
A6	Data-Driven Offer Personalization
A7	Omnichannel Customer Experience
A8	Customer Engagement through Community and Digital Media
A9	Price, Stock, Delivery, and Policy Transparency
A10	Customer Referral and Word-of-Mouth Program

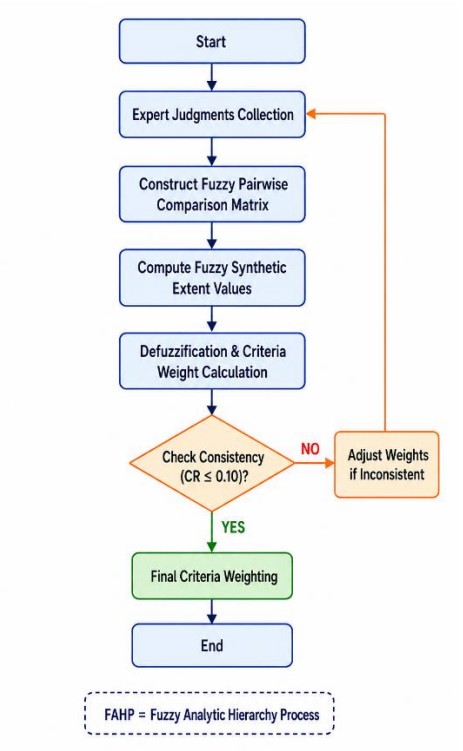

Figure 2. Fuzzy AHP Process for criteria weighting

2.2 TOPSIS

TOPSIS is a Multi-Criteria Decision Analysis method that ranks options by how close they are to the best possible solution and far from the worst. It figures out an overall index using the distances from these solutions, then ranks the alternatives based on that [15]. Figure 3 shows the stages of the TOPSIS method.

A TOPSIS analysis has three main steps [7]:

1. Normalize the decision matrix.
   This step is performed to standardize the ranking of strategies for increasing customer loyalty across various criteria. The normalization method allows all criteria to be measured on the same scale.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad \text{.....(1)}$$

   where :
   - x_{ij} is the original value of the jth criterion for the i-th strategy
   - r_{ij} is the normalized value

2. Determining the ideal solution and the negative-ideal solution.

This step serves to determine the ranking reference point. Each strategic alternative is evaluated based on the ideal solution by defining this reference point. The ideal solution (A+) is calculated using the following formula:

$$A^+ = \{(\max v_{ij})j \in J\}\text{.....(2)}$$

Meanwhile, the negative-ideal solution (A-) is calculated using the equation :

$$A^- = \{(\min v_{ij})j \in J\}\text{.....(3)}$$

3. Calculate the Euclidean distance from each ideal solution and the negative ideal solution.
   The ideal solution distance (D+) is calculated using the equation :

$$D_i^+ = \sqrt{\sum_{j=1}^{n}(r_{ij} - A^+)^2} \text{ .....(4)}$$

And the distance from the negative-ideal solution (D-) is calculated by

$$D_i^- = \sqrt{\sum_{j=1}^{n}(r_{ij} - A^-)^2} \text{ .....(5)}$$

Each alternative is calculated for its relative proximity index (Ci). This determines how close or far an alternative is from the optimal choice.

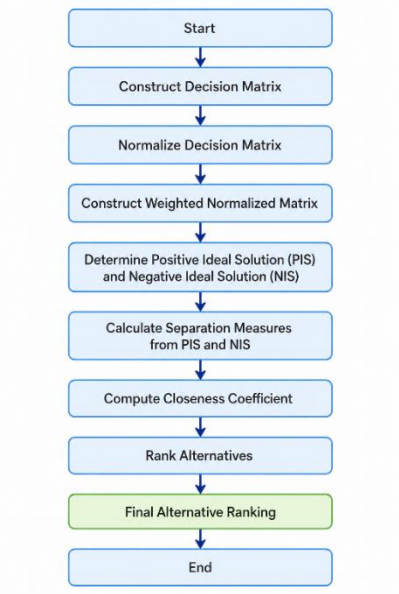

Figure 3. TOPSIS process for ranking

III. RESULTS AND DISCUSSION

This section presents the results of data processing and a discussion related to strategic priorities for increasing customer loyalty to a product/service. The method used is Fuzzy AHP-TOPSIS.

a. Fuzzy AHP

The stage begins by creating a paired matrix of the criteria. In this paired matrix, the weight of each criterion is based on expert opinion. Table 3. This is a linguistic scale for weighting the criteria.

Table 3. Linguistic Scale of Criteria Weight

Lingusitic Variable	Triangular Fuzzy Number (l,m,u)
Equal Importance	(1,1,1)
Moderately	(1,2,3)
More Important	(2,3,4)
Very More Important	(3,4,5)
Extremely	(4,5,6)

1. Using Table 3, the expert comparison matrix will be changed using linguistic variables and then converted into a Triangular Fuzzy Number.
2. The next step is to calculate the criteria synthesis scores. Then, the relative weights of each criterion are calculated. The relative weights of the criteria are still in the form of fuzzy numbers.

Table 4. Relatif Weight of Criteria

	C1				C10		
	l	m	u		l	m	u
C1	1	1	1	…	1,913	2,125	2,338
C2	1,283	1,412	1,569	…	2,7	3	3,3
C3	1,497	1,647	1,83	…	3,15	3,5	3,85
C4	0,374	0,412	0,458	…	0,788	0,875	0,963
C5	0,642	0,706	0,784	…	1,35	1,5	1,65
C6	1,925	2,118	2,353	…	4,05	4,5	4,95
C7	1,711	1,882	2,092	…	3,6	4	4,4
C8	0,856	0,941	1,046	…	1,8	2	2,2
C9	1,07	1,176	1,307	…	2,25	2,5	2,75
C10	0,428	0,471	0,523	…	1	1	1

3. Defuzzification was performed on the TFN fuzzy weights to obtain crisp values using the centroid method. The defuzzification results are shown in Table 5.

Table 5. Defuzzifikasi Weight of Criteria

	C1	C2	C3		C8	C9	C10
C1	1,000	0,708	0,607	…	1,063	0,850	2,125
C2	1,421	1,000	0,857	…	1,500	1,200	3,000
C3	1,658	1,175	1,000	…	1,750	1,400	3,500
C4	0,415	0,294	0,252	…	0,438	0,350	0,875
C5	0,711	0,503	0,431	…	0,750	0,600	1,500
C6	2,132	1,510	1,294	…	2,250	1,800	4,500
C7	1,895	1,342	1,151	…	2,000	1,600	4,000
C8	0,948	0,671	0,575	…	1,000	0,800	2,000
C9	1,184	0,839	0,719	…	1,258	1,000	2,500
C10	0,474	0,336	0,288	…	0,503	0,403	1,000

4. The defuzzification results in Table 4 were normalized to obtain the final criteria weights. The final criteria weights are shown in Table 6.

Table 6. Weight of Criteria

Criteria	Weight	Eigen Value
C1	0,085	10,000
C2	0,120	10,007
C3	0,140	10,013
C4	0,035	10,020
C5	0,060	10,027
C6	0,180	10,034
C7	0,160	10,040
C8	0,080	10,047
C9	0,100	10,054
C10	0,040	10,061
Eigen Max		10,030

Based on the calculation results, the CR value is 0.002 <0.1. This is in accordance with the requirement, namely CR <0.1. This indicates that the data used is consistent.

b. TOPSIS

At this stage, alternative strategic weighting methods are used to increase customer loyalty using the TOPSIS method. The steps in the TOPSIS method are as follows [16]:

1. Weighting Alternative Strategies
   This stage is used to determine the decision matrix. This matrix correlates the 10 criteria and 10 alternative strategies, as shown in Table 1. The decision matrix is shown in Table 7.

Table 7. Alternative Strtegy vs Weight of Criteria

	C1	C2	C3		C7	C8	C9	C10
A1	2	3	5	…	4	3	4	2
A2	5	3	3	…	4	2	2	1
A3	3	5	3	…	5	2	3	1
A4	2	3	4	…	5	3	5	2
A5	1	1	2	…	3	4	2	5
A6	1	1	2	…	4	5	2	5
A7	3	4	4	…	4	4	3	4
A8	1	1	2	…	4	5	2	4
A9	4	4	3	…	5	3	4	2
A10	1	1	2	…	4	5	2	4

2. Decision Matrix Normalization
   The weighting results in the pairwise comparisons in Table 7 will be normalized. Normalization is carried out using equation (1). Table 8 is the result of normalization in Table 7.

Table 8. Normalized Decision Matrix

	C1	C2	C3		C8	C9	C10
A1	0,237	0,320	0,500	…	0,252	0,410	0,189
A2	0,593	0,320	0,300	…	0,168	0,205	0,094
A3	0,356	0,533	0,300	…	0,168	0,308	0,094
A4	0,237	0,320	0,400	…	0,252	0,513	0,189
A5	0,119	0,107	0,200	…	0,336	0,205	0,472
A6	0,119	0,107	0,200	…	0,420	0,205	0,472
A7	0,356	0,426	0,400	…	0,336	0,308	0,378
A8	0,119	0,107	0,200	…	0,420	0,205	0,378
A9	0,475	0,426	0,300	…	0,252	0,410	0,189
A10	0,119	0,107	0,200	…	0,420	0,205	0,378

3. Weighted Normalization Matrix
   After obtaining the normalization matrix, calculations are performed to determine the weighted normalization values. Table 8 shows the multiplication of the criterion weights obtained in the previous calculation multiplied by the weights of the available alternatives.

Table 8. Matrix of Weighted Normalized

	C1	C2	C3		C8	C9	C10
	0,085	**0,120**	**0,140**		**0,020**	**0,041**	**0,008**
A1	0,020	0,038	0,070	…	0,013	0,021	0,004
A2	0,050	0,038	0,042	…	0,013	0,031	0,004
A3	0,030	0,064	0,042	…	0,020	0,051	0,008
A4	0,020	0,038	0,056	…	0,027	0,021	0,019
A5	0,010	0,013	0,028	…	0,034	0,021	0,019
A6	0,010	0,013	0,028	…	0,027	0,031	0,015
A7	0,030	0,051	0,056	…	0,034	0,021	0,015
A8	0,010	0,013	0,028	…	0,020	0,041	0,008
A9	0,040	0,051	0,042	…	0,034	0,021	0,015
A10	0,010	0,013	0,028	…	0,020	0,041	0,008

4. Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS)
   Using equations (2) and (3), the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS) can be calculated for each criterion. PIS is the best value for each criterion. NIS indicates the worst value for each criterion. Table 9 shows the PIS and NIS for each criterion.

Table 9. PIS and NIS

	C1	C2	C3		C8	C9	C10
PIS	0,050	0,064	0,070	…	0,034	0,051	0,019
NIS	0,010	0,013	0,028	…	0,013	0,021	0,004

5. Distance between PIS and NIS
   The next step is to calculate the distance between alternative strategies and PIS and NIS using equations (4) and (5).

Table 10. Alternative Distances to PIS and NIS

	D+	D-
A1	0,047	0,058
A2	0,058	0,053
A3	0,049	0,064
A4	0,046	0,058
A5	0,088	0,021
A6	0,086	0,029
A7	0,038	0,059
A8	0,086	0,026
A9	0,041	0,062
A10	0,087	0,026

6. Closeness Coefficient
   Determining the best alternative using the TOPSIS method involves looking at the proximity of the positive ideal solution and the negative ideal solution that have been obtained. The equation for calculating the final TOPSIS value is:

$$CC_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad \ldots\ldots\ldots\ldots\ldots (6)$$

   By using equation (6), the Closeness Coefficient of each alternative to the ideal solution can be calculated and can be seen in Table 11.

Table 11. Closeness Coefficient

	Closeness Coefficient
A1	0,555
A2	0,476
A3	0,564
A4	0,560
A5	0,194
A6	0,251
A7	0,611
A8	0,233
A9	0,601
A10	0,231

7. Rank alternative strategies
   The final step in this method is to rank the Closeness Coefficient values from highest to lowest. Table 12 shows the ranking of alternative strategies for increasing customer loyalty based on the closeness coefficient values obtained.

Table 12. TOPSIS Ranking of Customer Loyalty Strategy

Ranking	Alternatif Stategi	Cleseness Coefficient
1	A7	0,611
2	A9	0,601
3	A3	0,564
4	A4	0,560
5	A1	0,555
6	A2	0,476
7	A6	0,251
8	A8	0,233
9	A10	0,231
10	A5	0,194

Based on the calculations carried out by the TOPSIS method, the ranking of alternative strategies for increasing customer loyalty is based on the value of the closeness coefficient. The stages to obtain this value are by compiling a decision matrix, normalization, calculating a weighted normalization matrix, calculating the value of the positive ideal solution and negative ideal solution, the distance to the value of the positive ideal solution and negative ideal solution and ending with a calculation to obtain the value of relative closeness.

Table 12 shows that alternative A7, Omnichannel Customer Experience, has a closeness coefficient of 0.611. This is the highest value obtained from the calculation, making Omnichannel Customer Experience the first priority strategy alternative. Next in the ranking is Price, Stock, Delivery, and Policy Transparency, which has a closeness coefficient of 0.601. This strategy alternative shows that increasing customer trust also requires transparency from the seller. Delivery and Tracking Optimization ranks third in terms of closeness coefficient value with a value of 0.564. This indicates that delivery accuracy and clear tracking are also important factors in building and increasing customer loyalty.

IV. CONCLUSION

The Multi-Criteria Decision Analysis framework can be used to find strategic priorities in increasing customer loyalty through the integration of Supply Chain Management and Customer Relationship Management perspectives.

The Fuzzy AHP method is used to determine the criteria weights. The criteria weights are the result of expert assessments that contain uncertainty. The TOPSIS method is used to obtain a ranking of proposed alternative strategies based on their proximity to the positive ideal solution and negative ideal solution values.

The comparison criteria matrix in the Fuzzy AHP calculation results has a Consistency Ratio of 0.002, which is smaller than the acceptable limit of 0.1. The CR value of 0.002 indicates that the selection of the comparison criteria matrix values is consistent.

Meanwhile, the TOPSIS calculation results show that the Omnichannel Customer Experience strategy has a score of 0.611, which is the highest score. This indicates that this strategy should be a priority in increasing customer loyalty. Second place, with a closeness coefficient of 0.601, is Price, Stock, Delivery, and Policy Transparency. Third place is Delivery and Tracking Optimization, which has a closeness coefficient of 0.564. These three alternative strategies indicate that increasing customer loyalty requires good coordination between Supply Chain Management and Customer Relationship Management.

REFERENCES

[1] I. Brusch, B. Schwarz, and R. Schmitt, "David versus goliath-service quality factors for niche providers in online retailing," *Journal of Retailing and Consumer Services*, vol. 50, pp. 266-276, 2019, doi: https://doi.org/10.1016/j.jretconser.2019.05.008.

[2] M. U. H. Uzir, I. Jerin, H. Al Halbusi, A. B. A. Hamid, and A. S. A. Latiff, "Does quality stimulate customer satisfaction where perceived value mediates and the usage of social media moderates?," *Heliyon*, vol. 6, no. 12, 2020, doi: https://doi.org/10.1016/j.heliyon.2020.e05710.

[3] A. Japutra, A. F. Utami, S. Molinillo, and I. A. Ekaputra, "Influence of customer application experience and value in use on loyalty toward retailers," *Journal of Retailing and Consumer Services*, vol. 59, p. 102390, 2021, doi: https://doi.org/10.1016/j.jretconser.2020.102390.

[4] A. Cardoso *et al.*, "Trust and loyalty in building the brand relationship with the customer: Empirical analysis in a retail chain in northern Brazil," *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 8, no. 3, p. 109, 2022, doi: https://doi.org/10.3390/joitmc8030109.

[5] M.-W. Li, H.-Y. Teng, and C.-Y. Chen, "Unlocking the customer engagement-brand loyalty relationship in tourism social media: The roles of brand attachment and customer trust," *Journal of Hospitality and Tourism Management*, vol. 44, pp. 184-192, 2020.

[6] A. K. Othman, L. F. A. Hassan, M. A. M. Ibrahim, M. S. Saripin, N. S. A. Sapuan, and Z. N. Roslan, "Factors that influence customer loyalty in using e-commerce," *Journal of Islamic Management Studies*, vol. 2, no. 2, pp. 43-58, 2020.

[7] W. Cheng, M. Hu, and C. Wu, "Enhancing green building decision-making with a hybrid fuzzy AHP-TOPSIS model for material selection," *Applied Water Science*, vol. 15, no. 6, p. 129, 2025, doi: https://doi.org/10.1007/s13201-025-02481-7.

[8] B. G. Demircan and K. Yetilmezsoy, "A hybrid fuzzy AHP-TOPSIS approach for implementation of smart sustainable waste management

strategies," *Sustainability*, vol. 15, no. 8, p. 6526, 2023, doi: https://doi.org/10.3390/su15086526.

[9] D.-C. Liu, J.-F. Ding, G.-S. Liang, and K.-D. Ye, "Use of the fuzzy AHP-TOPSIS method to select the most attractive container port," *Journal of Marine Science and Technology*, vol. 28, no. 2, p. 3, 2020, doi: https://doi.org/10.6119/JMST.202004_28(2).0003.

[10] M. Sequeira, A. Adlemo, and P. Hilletofth, "A hybrid fuzzy-AHP-TOPSIS model for evaluation of manufacturing relocation decisions," *Operations Management Research*, vol. 16, no. 1, pp. 164-191, 2023, doi: https://doi.org/10.1007/s12063-022-00284-6.

[11] S. Piya, A. Shamsuzzoha, M. Azizuddin, N. Al-Hinai, and B. Erdebilli, "Integrated fuzzy AHP-TOPSIS method to analyze green management practice in hospitality industry in the sultanate of Oman," *Sustainability*, vol. 14, no. 3, p. 1118, 2022, doi: https://doi.org/10.3390/su14031118.

[12] Q. H. Do, "Evaluating lecturer performance in Vietnam: An application of fuzzy AHP and fuzzy TOPSIS methods," *Heliyon*, vol. 10, no. 11, 2024, doi: https://doi.org/10.1016/j.heliyon.2024.e30772.

[13] R. Aliyev, H. Temizkan, and R. Aliyev, "Fuzzy analytic hierarchy process-based multi-criteria decision making for universities ranking," *Symmetry*, vol. 12, no. 8, p. 1351, 2020, doi: https://doi.org/10.3390/sym12081351.

[14] T. B. Chandrawati, A. A. P. Ratna, and R. F. Sari, "Path selection using fuzzy weight aggregated sum product assessment," *International Journal of Computers communications & control*, vol. 15, no. 5, 2020, doi: https://doi.org/10.15837/ijccc.2020.5.3978.

[15] S. Chakraborty, "TOPSIS and Modified TOPSIS: A comparative analysis," *Decision analytics journal*, vol. 2, p. 100021, 2022, doi: https://doi.org/10.1016/j.dajour.2021.100021.

[16] V. Pandey, Komal, and H. Dincer, "A review on TOPSIS method and its extensions for different applications with recent development: V. Pandey et al," *Soft Computing*, vol. 27, no. 23, pp. 18011-18039, 2023.