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Comparative Analysis of Fuzzy Tahani and Fuzzy Tsukamoto Methods in a Decision Support System for Employee Promotion

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ABSTRACT

Employee promotion requires a structured evaluation when several criteria contain gradual or linguistic boundaries. This study compares Fuzzy Tahani and Fuzzy Tsukamoto in a decision support model for employee-promotion recommendations. To ensure a controlled comparison, both methods use the same five criteria, domains, and membership functions. Because the source report does not contain official employee-assessment scores, the computational mechanism is verified using five anonymized test alternatives rather than actual personnel decisions. Fuzzy Tahani combines membership degrees through a fuzzy query and produces a fire-strength score, whereas Fuzzy Tsukamoto activates IF-THEN rules with monotonic consequents and produces a crisp value through weighted defuzzification. The test data produce the same ranking for both methods: A2, A5, A1, A3, and A4, yielding a Spearman rank correlation of 1.00. Despite identical rankings, the output behavior differs: Tahani is highly sensitive to the weakest mandatory condition under the MIN operator, while Tsukamoto aggregates contributions from multiple active rules. The results indicate methodological consistency on the test data but must be validated with official institutional data before operational use.

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INTRODUCTION

Employee promotion is a human-resource decision involving career development, organizational responsibility, and authority allocation. Decision Support Systems (DSS) help structure assessments and improve consistency when promotion depends on multiple criteria with overlapping linguistic categories (Wanto et al., 2020; Berutu et al., 2021).

Fuzzy logic, introduced by Zadeh (1965), represents uncertainty through membership degrees between 0 and 1. It has been applied to employee selection, performance evaluation, promotion, and other multicriteria decisions (Kusumadewi & Purnomo, 2010; Utama, 2021; Rahmawati et al., 2021).

Fuzzy Tahani evaluates alternatives through fuzzy database queries, whereas Fuzzy Tsukamoto uses IF–THEN rules and weighted aggregation to generate crisp outputs. Both methods have been applied to various selection and evaluation problems (Sianturi et al., 2020; Satria & Sibarani, 2020; Dewi et al., 2021; Hutahaean & Hutagalung, 2022).

Previous promotion studies have also employed SMART, SAW, AHP, and TOPSIS. However, direct comparisons between Tahani and Tsukamoto using identical datasets, criteria, and membership functions remain limited. This study addresses that gap by comparing their rankings, output characteristics, transparency, and implementation complexity using five anonymized alternatives. Because official employee-assessment records are unavailable, the results serve only to verify the comparative mechanisms and require validation with institutional data before practical implementation.

METHODS

Research Design and Test Data

The study uses an applied quantitative-comparative design. The decision context is employee promotion at Universitas Budi Darma. Five anonymized alternatives (A1-A5) are evaluated on five criteria: performance (C1), discipline (C2), responsibility (C3), length of service (C4), and competence (C5). These values are test data for algorithm verification because the source report does not contain official employee scores.

Table 1. Test Alternatives and Criterion Values

Alt.	C1	C2	C3	C4 (Years)	C5

A1	82	85	80	6	78
A2	88	90	86	8	85
A3	76	80	82	10	79
A4	90	75	84	5	88
A5	84	88	78	7	82

Membership Functions

The same membership functions are applied to both methods so that differences in output arise from the decision mechanism rather than from different fuzzy definitions. For criteria C1-C3 and C5, the test model uses Moderate = triangular (60, 75, 90) and High = right-shoulder with transition 75-90. For C4, Moderate = triangular (2, 6, 10) and Long = right-shoulder with transition 4-10 years. These parameters are verification settings, not official personnel standards. Membership functions should be validated by the authorized unit before deployment.

Table 2. Membership-Function Parameters

Criteria	Set	Parameters	Function
C1-C3, C5	Moderate	60, 75, 90	Triangular
C1-C3, C5	High	75, 90, 100	Right shoulder
C4	Moderate	2, 6, 10	Triangular
C4	Long	4, 10, 20	Right shoulder

Fuzzy Tahani Procedure

The Tahani model stores crisp values, calculates membership degrees, formulates a fuzzy query, and ranks alternatives by fire strength. The query used in the test is: Performance High AND Discipline High AND (Responsibility Moderate OR High) AND (Competence Moderate OR High) AND (Length of Service Moderate OR Long). For AND conditions, the MIN operator is used; therefore, the final fire strength equals the weakest required membership among the query components. This behavior makes the model transparent but also creates a bottleneck effect when one mandatory criterion has a low degree (Sianturi et al., 2020; Setiawan, 2020).

Fuzzy Tsukamoto Procedure

The Tsukamoto model uses five input criteria with two linguistic states, producing 2^5 = 32 possible rule combinations. Each rule obtains an alpha-predicate from the minimum antecedent membership. The consequent is monotonic and generates a crisp z value for the rule. The final score is calculated as Z = sum(alpha_i z_i) / sum(alpha_i). In the verification model, a rule is categorized as Eligible when at least four conditions are High/Long, or when three conditions are High and length of service is Long. This rule base is a test configuration and must be validated by the institution before real use (Tsukamoto, 1979; Kusumadewi & Purnomo, 2010).

Comparison and Verification

Because Tahani and Tsukamoto produce different numerical scales, raw output magnitudes are not compared directly. The primary comparison uses ranking order and rank differences. Rank consistency is summarized using Spearman rank correlation: rho = 1 - [6 sum(d_i^2)]/[n(n^2 - 1)], where d_i is the rank difference for alternative i and n is the number of alternatives. Functional verification also checks membership calculations, Tahani fire strength, Tsukamoto defuzzification, and ranking consistency. Black-box testing principles are used to verify that the software functions respond correctly to input-output scenarios (Pressman & Maxim, 2020).

RESULTS AND DISCUSSION

Fuzzy Tahani Results

For A2, the query memberships are 0.867, 1.000, 0.733, 0.667, and 0.667. Applying the MIN operator gives a fire strength of 0.667. This is the highest Tahani score among the five alternatives. A4 obtains a fire strength of 0.000 because its discipline value is 75, which has zero membership in the High set under the

specified right-shoulder function. Thus, even though A4 has strong values on performance and competence, one mandatory zero-membership condition suppresses the entire conjunctive query.

Table 3. Fuzzy Tahani Results

Alt.	muC1	muC2	muC3	muC4	muC5	Fire	Rank
A1	0.467	0.667	0.667	1.000	0.800	0.467	3
A2	0.867	1.000	0.733	0.667	0.667	0.667	1
A3	0.067	0.333	0.533	1.000	0.733	0.067	4
A4	1.000	0.000	0.600	0.750	0.867	0.000	5
A5	0.600	0.867	0.800	0.750	0.533	0.533	2

Fuzzy Tsukamoto Results

The Tsukamoto model evaluates the active rules for each alternative and aggregates their crisp consequences. A2 activates 16 rules in the test configuration and obtains Z = 57.697, the highest score. A4 still receives Z = 38.929 despite its weak discipline membership because the final score is formed from the contributions of multiple activated rules rather than from a single overall minimum. This illustrates a structural distinction between the two methods: Tsukamoto can preserve information from partial rule activation even when one criterion is weak.

Table 4. Fuzzy Tsukamoto Results

Alt.	Sum(alpha*z)	Sum(alpha)	Z	Rank	Active Rules
A1	403.200	8.867	45.474	3	32
A2	228.867	3.967	57.697	1	16
A3	144.000	3.267	44.082	4	16
A4	72.667	1.867	38.929	5	8
A5	355.000	7.300	48.630	2	32

Ranking Comparison

Both methods produce the same ranking: A2 > A5 > A1 > A3 > A4. Consequently, every rank difference is zero and Spearman rho equals 1.00. This result demonstrates perfect rank agreement for the five verification alternatives. It should not be generalized as evidence that the two methods will always produce identical rankings, because the sample is small and the functions and rules were configured specifically for this test. A different criterion distribution, membership boundary, or rule base can change the relative order.

Table 5. Rank Agreement between the Two Methods

Alt.	Tahani Rank	Tsukamoto Rank	Delta Rank
A1	3	3	0
A2	1	1	0
A3	4	4	0
A4	5	5	0
A5	2	2	0

Comparative Interpretation

Both methods produce identical rankings but use different reasoning. Fuzzy Tahani applies query-based screening, where the weakest mandatory criterion determines the final membership. Thus, A4's high performance and competence cannot compensate for zero membership in High discipline. Fuzzy Tsukamoto uses rule-based inference and weighted aggregation, allowing trade-offs among criteria. However, its complexity increases with the number of criteria, requiring 32 rule combinations for five binary criteria and 64 for six.

Tahani is simpler for database filtering and linguistic queries, while Tsukamoto provides a continuous score through explicit rules. Therefore, Tahani is more suitable for strict requirements, whereas Tsukamoto is preferable when graded, rule-based evaluation is needed. These findings align with previous studies on fuzzy decision-making and other multicriteria methods, emphasizing that method selection should reflect

organizational policies, decision logic, and uncertainty rather than algorithm popularity alone (Sianturi et al., 2020; Satria & Sibarani, 2020; Dewi et al., 2021; Hutahaean & Hutagalung, 2022; Sundari et al., 2022; Widoproyo & Devi, 2022; Supiandi et al., 2022).

CONCLUSION

The controlled verification shows that Fuzzy Tahani and Fuzzy Tsukamoto can both generate promotion-recommendation rankings from the same five criteria and membership definitions. On the five anonymized test alternatives, both methods produce the identical order A2 > A5 > A1 > A3 > A4, with Spearman rank correlation equal to 1.00. The important difference lies in the decision mechanism rather than the observed ranking. Tahani is compact and highly sensitive to the weakest mandatory condition in a fuzzy query, whereas Tsukamoto aggregates the outputs of multiple active rules and provides a crisp score. Therefore, neither method should be declared universally superior from this verification alone. Operational selection should follow the organization's promotion policy, tolerance for compensation among criteria, need for rule-based explanation, and maintenance capacity. Validation with official employee data and authorized policy rules is required before the model is used to support real promotion decisions.

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