

Original Article

A Dual-Method Framework Using SWARA–TOPSIS and SWARA-MACAB for Automotive Dealership Evaluation

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Abstract - With dealerships serving as essential middlemen between manufacturers and consumers, enabling both car sales and after-sales services, the automobile sector is essential to the expansion of the national economy. Dealership performance evaluation is a complex process that involves taking into account a number of qualitative and quantitative elements. 36 possible auto dealership choices are thoroughly evaluated in this study using hybrid Multi-Criteria Decision-Making (MCDM) techniques based on 16 criteria taken from the Balanced Scorecard framework. SWARA–MABAC and SWARA–TOPSIS are two new hybrid models that are presented. When the relative relevance of the criteria is assessed in both models using the Step-wise Weight Assessment Ratio Analysis (SWARA) approach, it is shown that the “LGP” criterion has the highest weight (25%), while the “FP4” criterion has the lowest weight (1.9%). The options are then ranked using the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and the Multi-Attributive Border Approximation area Comparison (MABAC) techniques. Dealership DE3 continuously receives the highest ranking in both models, according to the comparison results, demonstrating the validity of the assessment procedure. In a competitive automobile market, this integrated approach provides decision-makers with a dependable framework for choosing a dealership, allowing for a balanced evaluation of strategic, financial, operational, and customer-oriented considerations.

Keywords - Automotive Dealership Evaluation, Multi-Criteria Decision Making (MCDM), SWARA, TOPSIS, MABAC, Balanced Scorecard, Criteria Weighting, Hybrid Decision-Making Models, Dealership Performance Ranking, Alternative Evaluation.

1. Introduction

A car dealership is a business that sells new or used cars, excluding RVs, but including trucks, motorbikes, and occasionally heavy machinery directly to clients. Dealerships, which serve as bridges between buyers and producers, have a significant influence on a country's economy. India, the world's third-largest car market by sales volume, is a great example. In today's worldwide marketplaces and fierce competition, companies are increasingly considering high-performance dealerships to boost sales and enhance service quality [1]. Assessing dealerships involves a number of financial and non-financial aspects, making it a classic Multi-Criteria Decision-Making (MCDM) dilemma. According to Kumar (2010) [2], MCDM approaches help evaluate complicated, ambiguous situations by combining qualitative and quantitative elements to discover the optimal options among alternatives. Previous research has proved the usefulness of the SWARA technique in determining criterion

weights in a variety of applications. Majeeda and Breesamb (2021) [3] applied SWARA for landfill site selection; Cetin and Icigen (2017) [4] used SWARA and MOORA for employee selection in hospitality; Zolfani and Chatterjee (2019) [5] combined SWARA and BWM to evaluate sustainable building materials; and Stanujkic et al. (2015) [6] employed SWARA to select optimal packaging designs, demonstrating its advantages over AHP and conjoint analysis. There are several instances that demonstrate the use of Multi-Criteria Decision-Making (MCDM) systems in a variety of sectors. Uğur Baç (2020) [7] compared the benefits of smart card systems to traditional ticket payment methods using SWARA and WASPAS. Alimardani et al. (2013) [8] used SWARA and VIKOR to pick suppliers in agile environments based on cost, technology, flexibility, and availability. Ghenai et al. (2020) [9] used extended SWARA and ARAS to evaluate the sustainability of renewable energy systems. Muravev and Mijic (2020) [10] integrated BWM and



MABAC for the selection of providers, tested using MAIRCA and VIKOR models. Other studies have successfully used hybrid MCDM approaches in infrastructure and public services. Sharma et al. (2018) [11] proposed a crude AHP-MABAC model to rank Indian railway stations. Sonara and Kulkarni (2021) [12] used AHP-MABAC to identify efficient solutions for electric cars. Nunić (2018) [13] used FUCOM-MABAC to choose PVC carpentry producers, whereas Vesković et al. (2018) [14] assessed railway management in Bosnia and Herzegovina using a Delphi-SWARA-MABAC model. Chakraborty and Ghosh (2021) [15] analyzed 98 Indian smart cities using DEMATEL for criterion weight and MABAC for ranking. Boonsothonsatit et al. (2024) [16] used AHP and TOPSIS to determine hospital medicine dispensing procedures. Trivedi et al. (2024) [17] used BWM, TOPSIS, and SAW to improve road safety by examining eight criteria and five sub-criteria. Youssef (2020) [18] compared BWM-TOPSIS and AHP for cloud service provider evaluation. Mohammed et al. (2020) [19] evaluated COVID-19 diagnostic models using Entropy-TOPSIS. Wang and Ali (2020) [20] evaluated the security of IoHT-based devices using AHP-TOPSIS. Dwivedi and Sharma (2023) [21] rated 15 electric car companies using Entropy-TOPSIS. Ulkhaq et al. (2018) [22] used AHP-TOPSIS to pick automobiles based on nine parameters.

Although MCDM techniques have found extensive applications in transportation, energy, healthcare, and intelligent infrastructure, few studies have been conducted on their application for assessing automobile dealerships. Most importantly, no study has been conducted to compare two hybrid MCDM models for this purpose. To fill this void, this research advances a hybrid technique combining SWARA-MABAC and SWARA-TOPSIS for assessing automobile dealerships.

2. Proposed Methods

2.1. SWARA Method

STEP 1: In a model with l decision-makers and n criteria, the importance score assigned to criterion j by decision-maker k is denoted as (p_{jk}) , where $j = 1$ to n and $k = 1$ to l . Each decision-maker prioritizes criteria based on their relative importance, usually awarding 5 points to the most important criterion, then 4, 3, 2, and 1 in decreasing order.

STEP 2: Individual ratings from all decision makers are averaged using the geometric mean, as seen below. The symbol $\bar{p}_j$ indicates the combined relative relevance score for each criterion.

STEP 3: The factors are listed in order of relevance, from highest to lowest, according to their relative importance ratings. The relative relevance of criterion j in contrast to criterion $j-1$ is then calculated, starting with the second criterion. This is denoted as s_j .

$$\bar{p}_j = \left(\prod_{k=1}^l p_{jk} \right)^{1/l}, \forall_j \quad (1)$$

$$S_j = \bar{p}_{j-1} - \bar{p}_j, j = 2, \dots, n \quad (2)$$

STEP 4: The coefficient values (c_j) for all criteria are determined using the following equation.

$$C_j = \begin{cases} 1, j = 1 \\ S_j + 1, j = 2, \dots, n \end{cases} \quad (3)$$

STEP 5: The following equation is used to calculate the corrected weights (s'_j) for all criteria:

$$S'_j = \begin{cases} 1, j = 1 \\ \frac{s'_{j-1}}{C_j}, j = 2, \dots, n \end{cases} \quad (4)$$

STEP 6: The final weights (w_j) for all criteria are determined using the equation presented below.

$$w_j = \frac{s'_j}{\sum_{j=1}^n s'_j}, j = 1, 2, \dots, n \quad (5)$$

2.2. MABAC

Pamucar and Cirovic proposed the MABAC technique in 2015. It estimates the distance between an option and the border approximation region. Alternatives are evaluated based on their distance differences.

STEP 1: Establishment of the initial decision matrix

$$X = \begin{matrix} & C_1 & C_2 & \dots & C_n \\ \begin{matrix} A_1 \\ A_2 \\ \dots \\ A_m \end{matrix} & \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \end{matrix}$$

A decision matrix consists of an $m \times n$ matrix where m represents the number of alternatives, n represents the number of criteria, and x_{ij} represents the preference score of alternative A_i in relation to criteria C_j .

STEP 2: The normalization matrix is attained by normalizing the elements of the decision matrix as per the following equations.

$$N = \begin{matrix} & C_1 & C_2 & \dots & C_n \\ \begin{matrix} A_1 \\ A_2 \\ \dots \\ A_m \end{matrix} & \begin{bmatrix} n_{11} & n_{12} & \dots & n_{1n} \\ n_{21} & n_{22} & & n_{2n} \\ \dots & \dots & \dots & \dots \\ n_{m1} & n_{m2} & \dots & n_{mn} \end{bmatrix} \end{matrix}$$

Normalized matrix elements were determined by following the equations for the beneficial criteria.

$$n_{ij} = \frac{r_{ij} - \min r_{ij}}{\max r_{ij} - \min r_{ij}} \quad (8)$$

For non-beneficial criteria:

$$n_{ij} = \frac{\max r_{ij} - r_{ij}}{\max r_{ij} - \min r_{ij}} \quad (9)$$

STEP 3: Construction of the weight matrix using the equation

$$v_{ij} = w_{ij}(n_{ij} + 1) \quad (10)$$

The normalized matrix elements are represented by X, while the criterion's weight coefficients are denoted by W.

$$V = \begin{bmatrix} v_{11} & v_{12} & \dots & v_{1n} \\ v_{21} & v_{22} & \dots & v_{2n} \\ \dots & \dots & \dots & \dots \\ v_{m1} & v_{m2} & \dots & v_{mn} \end{bmatrix} = \begin{bmatrix} w_{1.}(n_{11} + 1) & w_{2.}(n_{12} + 1) & \dots & w_{n.}(n_{1n} + 1) \\ w_{1.}(n_{21} + 1) & w_{2.}(n_{22} + 1) & \dots & w_{n.}(n_{2n} + 1) \\ \dots & \dots & \dots & \dots \\ w_{1.}(n_{m1} + 1) & w_{2.}(n_{m2} + 1) & \dots & w_{n.}(n_{mn} + 1) \end{bmatrix} \quad (11)$$

STEP 4: For each criterion, the boundary approximation area was calculated using the specified Equation (8).

$$g_{ij} = \left(\prod_{i=1}^m v_{ij} \right)^{1/m} \quad (12)$$

v_{ij} and m represents the weight matrix elements and the number of alternatives, respectively.

The border approximation area matrix is generated using the values of g_i , and the matrix is generated in the $n \times 1$ format.

(The number n reflects the total number of criteria that are being used to select the alternatives that are being presented)

$$G = \begin{bmatrix} C_1 & C_2 & \dots & C_1 \\ g_1 & g_2 & \dots & g_n \end{bmatrix} \quad (13)$$

STEP 5: Computation of the distance between the alternative and board approximation zones for the matrix elements. The distance between alternatives and the boundary approximation area (q) is defined as the difference between the elements of the weight matrix (V) and the elements of the bordering approximation areas (G).

$$Q = \begin{bmatrix} q_{11} & q_{12} & \dots & q_{1n} \\ q_{21} & q_{22} & \dots & q_{2n} \\ \dots & \dots & \dots & \dots \\ q_{m1} & q_{m2} & \dots & q_{mn} \end{bmatrix} \quad (14)$$

The variables n , m , v_{ij} , and q_{ij} represent the criteria, alternatives, weighted matrix (V), and adjacent approximate areas for criterion C_i , respectively.

$$Q = V - G = \begin{bmatrix} v_{11} & v_{12} & \dots & v_{1n} \\ v_{21} & v_{22} & \dots & v_{2n} \\ \dots & \dots & \dots & \dots \\ v_{m1} & v_{m2} & \dots & v_{mn} \end{bmatrix} - \begin{bmatrix} g_1 & g_2 & \dots & g_n \\ g_1 & g_2 & \dots & g_n \\ \dots & \dots & \dots & \dots \\ g_1 & g_2 & \dots & g_n \end{bmatrix} \quad (15)$$

$$Q = \begin{bmatrix} v_{11} - g_1 & v_{12} - g_2 & \dots & v_{1n} - g_n \\ v_{21} - g_1 & v_{22} - g_2 & \dots & v_{2n} - g_n \\ \dots & \dots & \dots & \dots \\ v_{m1} - g_1 & v_{m2} - g_2 & \dots & v_{mn} - g_n \end{bmatrix} \quad (16)$$

Alternative A_i can be deployed in one of three locations: Lower Border Approximation Area (G-), Upper Border Approximation Area, or Border Approximation Area (G). The top approximation zone (G) represents the ideal choice (A^+), whereas the lower approximation area (G-) represents the anti-ideal alternative (A). Alternative A_i must have as many components from the upper approximate region as possible in order to be picked as the best option among the collection.

STEP 6: The sum of the distances between the alternative and the board approximation area is determined by using Equation (6). The alternative ranks are assigned based on the ascending order of these values

$$S_i = \sum_{j=1}^n q_{ij}, j = 1, 2, \dots, n, \quad i = 1, 2, \dots, m \quad (17)$$

2.3. TOPSIS

It is a commonly used technique for making decisions using multiple attributes. The alternatives are ranked based on their proximity to the ideal alternative, determined by calculating the distance between each alternative and the ideal and worst alternatives.

STEP 1: Formation of the Decision Matrix:

An $m \times n$ matrix, where m is the number of alternatives and n is the number of criteria, is called a decision matrix.

$$X = \begin{bmatrix} x_{11} & \dots & x_{1n} \\ \dots & \dots & \dots \\ x_{m1} & \dots & x_{mn} \end{bmatrix} \quad (18)$$

For each criterion c_j , the value of alternative a_i 's preference score is represented by x_{ij} .

STEP 2: Equation (6) produces a normalised matrix derived from the decision matrix.

$$y_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \quad (19)$$

Where: $i = 1, 2, \dots, m$ and $j = 1, 2, \dots, n$.

Y_{ij} represents the normalized score of alternative a_i in relation to criterion c_j .

STEP 3: W_j is represented as the criteria C_j weight. The weights were computed using the SWARA method.

STEP 4: The weighted normalized matrix is calculated using Equation (9):

$$d_{ij} = w_{ij} y_{ij} \quad (20)$$

The normalised weighted score of a_i with respect to criterion c_j is represented by d_{ij} .

STEP 5: The positive ideal solution o_i^+ and the negative ideal solution o_i^- are computed by using Equations (6) and (7).

Beneficial criteria are represented by Equations (10) and (11).

$$o_j^+ = \max\{d_{1j}, d_{2j}, \dots, d_{mj}\} \quad (21)$$

$$o_j^- = \min\{d_{1j}, d_{2j}, \dots, d_{mj}\} \quad (22)$$

For non-beneficial criteria, Equations (12) and (13) are applicable:

$$o_j^+ = \min\{d_{1j}, d_{2j}, \dots, d_{mj}\} \quad (23)$$

$$o_j^- = \max\{d_{1j}, d_{2j}, \dots, d_{mj}\} \quad (24)$$

In addition, the vector of positive ideal solutions s^+ is calculated in accordance with Equation (14).

$$o^+ = [o_1^+ \ o_2^+ \ \dots \ o_n^+] \quad (25)$$

Additionally, the vector of the negative ideal solution s^- is determined in accordance with Equation (15):

$$o^- = [o_1^- \ o_2^- \ \dots \ o_n^-] \quad (26)$$

STEP 6: Applying Equations (6) and (7), obtain the Euclidean distance from the positive and negative ideal solutions to each alternative.

$$e_i^+ = \sqrt{\sum_{j=1}^n (d_{ij} - o_j^+)^2} \quad (27)$$

$$e_i^- = \sqrt{\sum_{j=1}^n (d_{ij} - o_j^-)^2} \quad (28)$$

e_j^+ and e_j^- are represented by the Euclidean distance of alternative a_i from the positive ideal solution o^+ and the negative ideal solution o^- .

STEP 7: Equation (18) is used to calculate the closeness coefficient q_i .

$$q_i = \frac{e_i^-}{e_i^+ + e_i^-} \quad (29)$$

STEP 8: Alternatives are ranked according to q_i value. Highest q_i value alternative signifies the ranked alternative.

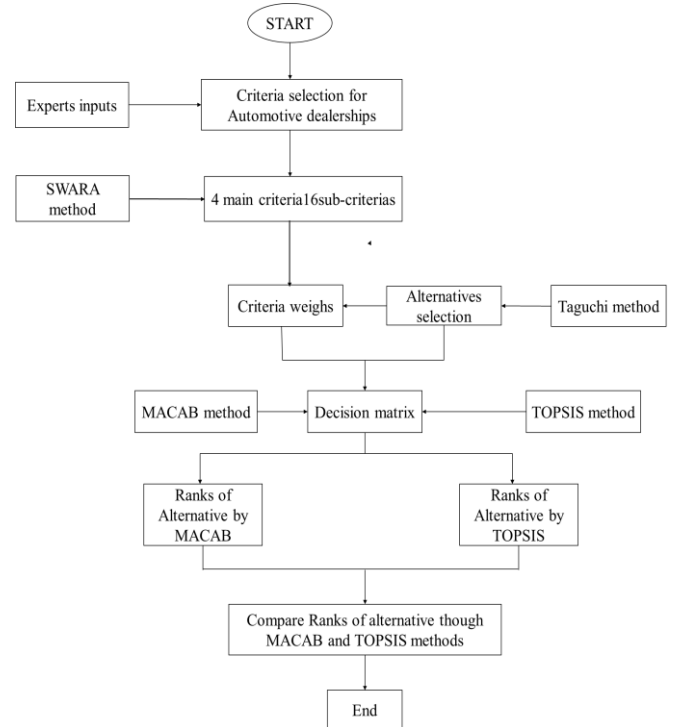


Fig. 1 Methodology of hybrid methods

3. Proposed Methodology

This study uses the SWARA technique, MABAC, and TOPSIS to evaluate and rank car stores in a four-phase procedure. The first part is selecting assessment criteria based on insights from professionals with over ten years of experience in the automobile dealership industry. This selection is guided by the Balanced Scorecard system, which includes four major perspectives: financial, customer, internal processes, and learning and growth. Each viewpoint has four sub-criteria, for four major criteria and sixteen sub-criteria, as outlined below.

3.1. Financial Perspective

- FP1 Revenue growth from vehicle sales: Resulting from effective sales processes and customer service.
- FP2 Profit margin on service and parts: Indicates efficiency and the perceived value customers find in the dealership's services.
- FP3 Cost control and reduction measures: Investments in efficient processes could potentially enhance customer service if savings are reinvested in customer service.
- FP4 Inventory turnover rate: Reflects how well the inventory matches customer demand.

3.2. Customer Perspective

- CP1 Customer satisfaction scores from sales and service: Direct measurement of customers' feelings about the service they received.
- CP2 Number of repeat customers or referrals: Indicators of customer satisfaction and the quality of the customer service provided.
- CP3 Customer loyalty or retention rates: Directly tied to the consistent quality of customer service experienced.
- CP4 Time taken to resolve customer complaints or issues: Shows responsiveness and effectiveness in addressing customer concerns.

3.3. Internal Processes Perspective

- IPP1 Time taken to service a vehicle: Represents the speed and efficiency of service, which directly impacts customer waiting times.
- IPP2 Inventory management efficiency: Ensuring parts and vehicles are available when customers need them, preventing service delays.
- IPP3 Rate of service errors or reworks: Reflects the consistency of the service quality.
- IPP4 Efficiency of the sales process, e.g., time to close a sale: Demonstrates streamlining of the customer's buying experience.

3.4. Learning & Growth Perspective

- LGP1 Employee training and development programs: Prepare employees to deliver excellent customer service.
- LGP2 Employee satisfaction and turnover rates: Happy employees often deliver better customer service, and turnover can be a result of or affect customer service.
- LGP3 Number of new skills or certifications acquired by staff: Reflects the ongoing professional development geared towards improving customer service.
- LGP4 Ability to adapt to new automotive trends, e.g., electric vehicles or autonomous driving: Shows the dealership's commitment to meeting evolving customer needs.

3.4.1. Second Phase

36 empirical alternatives were generated using the Taguchi L36 Design of Experiments method to evaluate and rank automotive dealerships. These alternatives form the

decision matrix, incorporating 16 prioritized evaluation criteria. The resulting matrix, shown below, serves as the basis for further analysis.

3.4.2. Third Phase

The SWARA technique was used to find the weights of the main criteria and sub-criteria that should be considered during the evaluation process of automotive dealerships.

3.4.3. Fourth Phase

The ranks of automotive dealerships were estimated by applying the MABAC and TOPSIS methods. The ranks of automotive dealerships obtained from the MABAC and TOPSIS methods are compared.

4. Results and Discussions

4.1. Estimation of Weights through SWARA

The SWARA approach is used to determine the weights of four primary criteria and sixteen sub-criteria. Seven experts ranked the criteria in Step 1 (Table 1), and geometric mean values were calculated using Equation (1). The criteria were then rated according to their relative relevance. Equations (2)-(5) were used to calculate comparative importance, coefficients, adjusted values, and final weights, which were then reported in Table 2. Figure 2 depicts the weighting of the important criteria. Learning and Growth Perspective (LGP) was the most impactful, with 46.2%, followed by Internal Process Perspective (IPP) at 33.8%, Customer Perspective (CP) at 14.5%, and Financial Perspective (FP) at 5.5%. Sub-criteria weights were also obtained using the SWARA approach and are shown in Figure 1. The horizontal axis represents the sub-criteria, while the vertical axis represents their respective weights (0.0 to 0.6). Out of the 16 sub-criteria, FP1 had the relative weight (56%), while FP4 received the lowest. Figure 3 shows the global sub-criterion weights, which include both main and sub-criterion weights. Global weights range from 0.00 to 0.25. The most essential sub-criterion was GP2, followed by GP4, then IPP3, IPP1, and CP1. Moderate weights were assigned to GP1, CP3, IPP4, and FP1. Six more sub-criteria had modest worldwide weights and had less of an influence on dealership rankings.

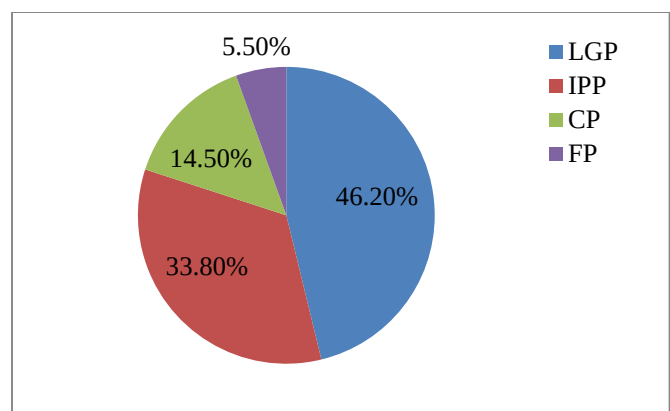


Fig. 2 Main criteria s weights percentages

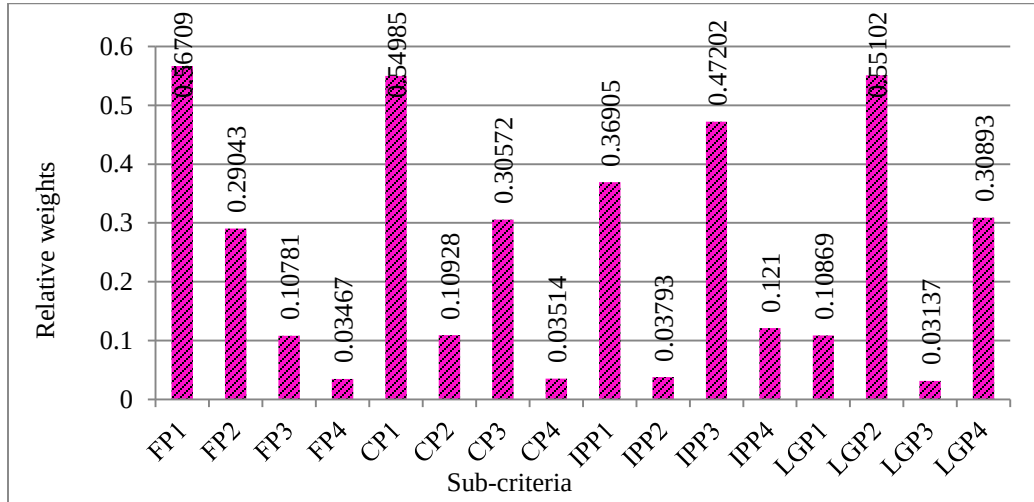


Fig. 3 Sub Criteria v/s Relative weights

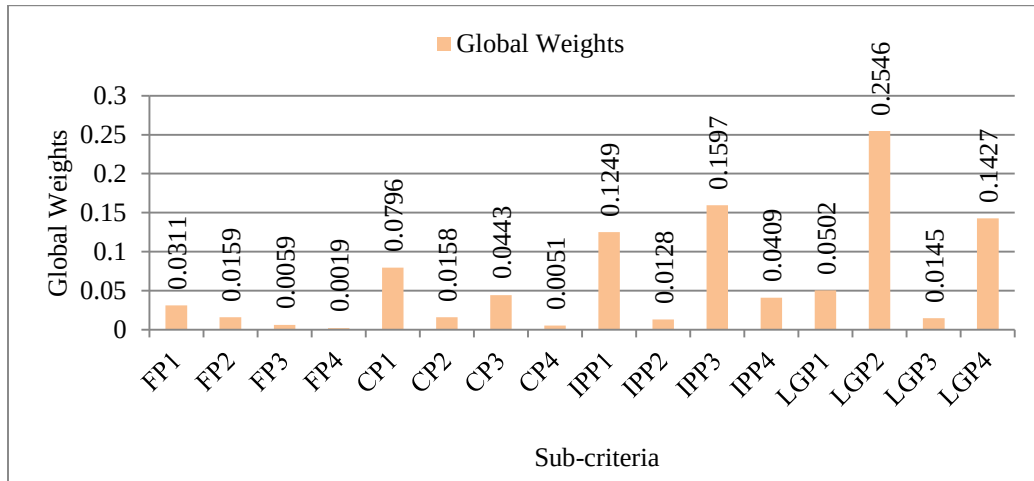


Fig. 4 Sub-Criteria v/s Global weights

Table 1. Ratings of the experts on the main criteria

Main Criteria								
	DM1	DM2	DM3	DM4	DM5	DM6	DM7	GM
CP	1	2	2	2	2	4	1	1.811447
FP	3	1	1	1	1	3	2	1.511209
IPP	4	3	3	4	3	1	3	2.783927
LGP	2	4	4	3	4	2	4	3.14922

Table 2. Merged importance and final weights

Main Criteria					
	Merged Relative Importance Score	Comparative Importance	Coefficient Value	Corrected Weight Value	Final weight Value
LGP	3.14922		1	1	0.461997
IPP	2.783927	0.365293121	1.365293121	0.732443	0.338386
CP	1.811447	0.972479763	2.337772884	0.313308	0.144747
FP	1.511209	0.300237938	2.638010822	0.118767	0.05487
				2.164519	

Table. 3 Decision matrix

ADE s	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
DE s	LGP1	LGP2	LGP3	LGP4	IPP1	IPP2	IPP3	IPP4	Cp1	Cp2	Cp3	Cp4	Fp1	Fp2	Fp3	Fp4
DE1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DE2	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
DE3	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3
DE4	1	1	1	1	1	1	1	1	2	2	2	2	3	3	3	3
DE5	1	1	1	1	2	2	2	2	3	3	3	3	1	1	1	1
DE6	1	1	1	1	3	3	3	3	1	1	1	1	2	2	2	2
DE7	1	1	2	2	1	1	2	3	1	2	3	3	1	2	2	3
DE8	1	1	2	2	2	2	3	1	2	3	1	1	2	3	3	1
DE9	1	1	2	2	3	3	1	2	3	1	2	2	3	1	1	2
DE10	1	2	1	2	1	1	3	2	1	3	2	3	2	1	3	2
DE11	1	2	1	2	2	2	1	3	2	1	3	1	3	2	1	3
DE12	1	2	1	2	3	3	2	1	3	2	1	2	1	3	2	1
DE13	1	2	2	1	1	2	3	1	3	2	1	3	3	2	1	2
DE14	1	2	2	1	2	3	1	2	1	3	2	1	1	3	2	3
DE15	1	2	2	1	3	1	2	3	2	1	3	2	2	1	3	1
DE16	1	2	2	2	1	2	3	2	1	1	3	2	3	3	2	1
DE17	1	2	2	2	2	3	1	3	2	2	1	3	1	1	3	2
DE18	1	2	2	2	3	1	2	1	3	3	2	1	2	2	1	3
DE19	2	1	2	2	1	2	1	3	3	3	1	2	2	1	2	3
DE20	2	1	2	2	2	3	2	1	1	1	2	3	3	2	3	1
DE21	2	1	2	2	3	1	3	2	2	2	3	1	1	3	1	2
DE22	2	1	2	1	1	2	2	3	3	1	2	1	1	3	3	2
DE23	2	1	2	1	2	3	3	1	1	2	3	2	2	1	1	3
DE24	2	1	2	1	3	1	1	2	2	3	1	3	3	2	2	1
DE25	2	1	1	2	1	3	2	1	2	3	3	1	3	1	2	2
DE26	2	1	1	2	2	1	3	2	3	1	1	2	1	2	3	3
DE27	2	1	1	2	3	2	1	3	1	2	2	3	2	3	1	1
DE28	2	2	2	1	1	3	2	2	2	1	1	3	2	3	1	3
DE29	2	2	2	1	2	1	3	3	3	2	2	1	3	1	2	1
DE30	2	2	2	1	3	2	1	1	1	3	3	2	1	2	3	2
DE31	2	2	1	2	1	3	3	3	2	3	2	2	1	2	1	1
DE32	2	2	1	2	2	1	1	1	3	1	3	3	2	3	2	2
DE33	2	2	1	2	3	2	2	2	1	2	1	1	3	1	3	3
DE34	2	2	1	1	1	3	1	2	3	2	3	1	2	2	3	1
DE35	2	2	1	1	2	1	2	3	1	3	1	2	3	3	1	2
DE36	2	2	1	1	3	2	3	1	2	1	2	3	1	1	2	3

Table 4. Macab final ranks

DEs	Si	Rank	DEs	Si	Rank
DE1	-0.4021	36	DE19	0.0484	22
DE2	0.0056	25	DE20	0.0008	26
DE3	0.4133	1	DE21	0.0571	19
DE4	0.1181	10	DE22	0.0648	18
DE5	-0.1696	33	DE23	0.1547	7
DE6	0.0683	17	DE24	-0.1746	34
DE7	0.1606	6	DE25	0.048	23
DE8	-0.0033	27	DE26	0.2454	3

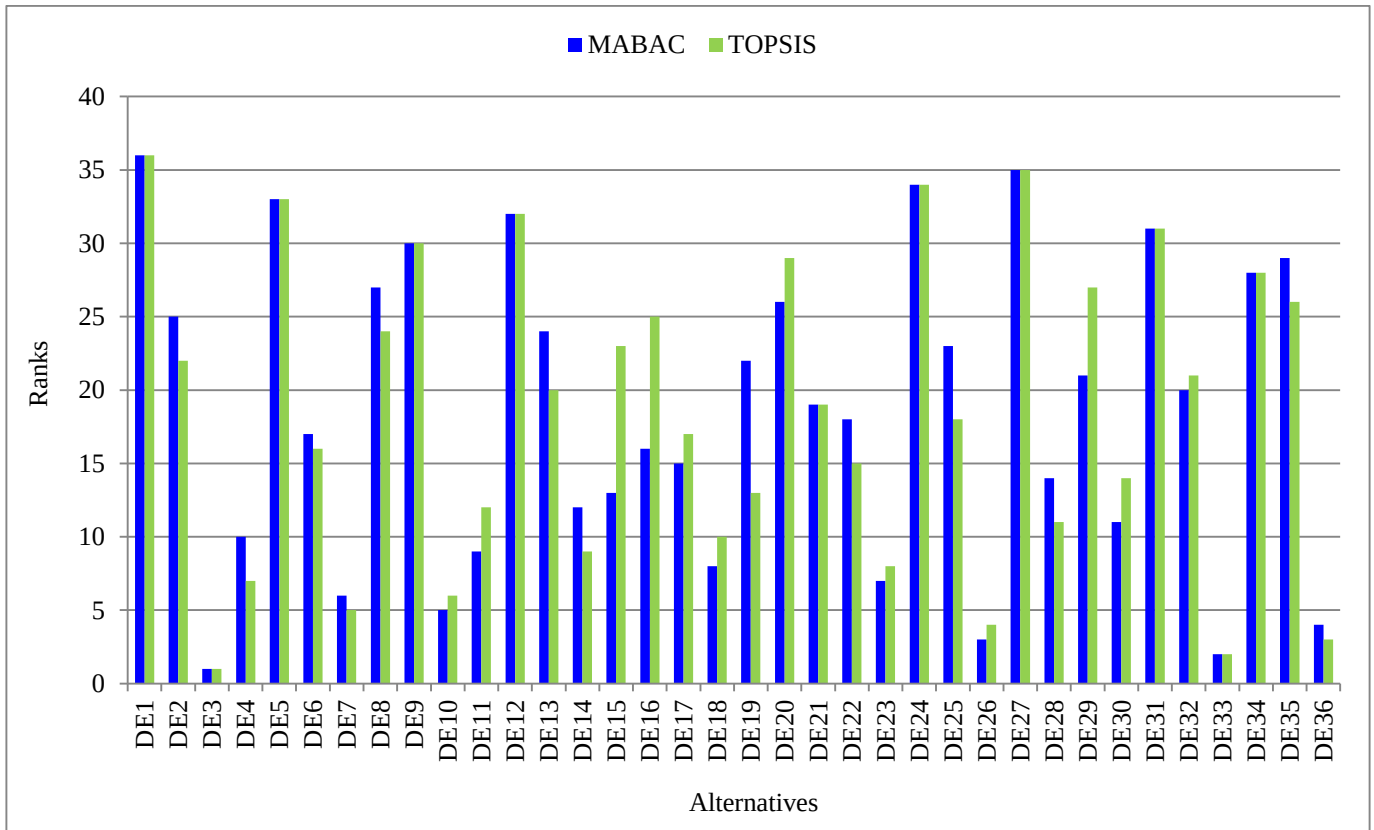
DE9	-0.0598	30	DE27	-0.2063	35
DE10	0.2057	5	DE28	0.0767	14
DE11	0.1332	9	DE29	0.0495	21
DE12	-0.0734	32	DE30	0.1061	11
DE13	0.0235	24	DE31	-0.0678	31
DE14	0.1031	12	DE32	0.0546	20
DE15	0.0968	13	DE33	0.2877	2
DE16	0.0694	16	DE34	-0.0258	28
DE17	0.0697	15	DE35	-0.057	29
DE18	0.1457	8	DE36	0.2272	4

Table 5. Decision matrix

ADE s	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
DE s	LGP1	LGP2	LGP3	LGP4	IPP1	IPP2	IPP3	IPP4	Cp1	Cp2	Cp3	Cp4	Fp1	Fp2	Fp3	Fp4
DE1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
DE2	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2
DE3	1	1	1	1	3	3	3	3	3	3	3	3	3	3	3	3
DE4	1	1	1	1	1	1	1	1	2	2	2	2	3	3	3	3
DE5	1	1	1	1	2	2	2	2	3	3	3	3	1	1	1	1
DE6	1	1	1	1	3	3	3	3	1	1	1	1	2	2	2	2
DE7	1	1	2	2	1	1	2	3	1	2	3	3	1	2	2	3
DE8	1	1	2	2	2	2	3	1	2	3	1	1	2	3	3	1
DE9	1	1	2	2	3	3	1	2	3	1	2	2	3	1	1	2
DE10	1	2	1	2	1	1	3	2	1	3	2	3	2	1	3	2
DE11	1	2	1	2	2	2	1	3	2	1	3	1	3	2	1	3
DE12	1	2	1	2	3	3	2	1	3	2	1	2	1	3	2	1
DE13	1	2	2	1	1	2	3	1	3	2	1	3	3	2	1	2
DE14	1	2	2	1	2	3	1	2	1	3	2	1	1	3	2	3
DE15	1	2	2	1	3	1	2	3	2	1	3	2	2	1	3	1
DE16	1	2	2	2	1	2	3	2	1	1	3	2	3	3	2	1
DE17	1	2	2	2	2	3	1	3	2	2	1	3	1	1	3	2
DE18	1	2	2	2	3	1	2	1	3	3	2	1	2	2	1	3
DE19	2	1	2	2	1	2	1	3	3	3	1	2	2	1	2	3
DE20	2	1	2	2	2	3	2	1	1	1	2	3	3	2	3	1
DE21	2	1	2	2	3	1	3	2	2	2	3	1	1	3	1	2
DE22	2	1	2	1	1	2	2	3	3	1	2	1	1	3	3	2
DE23	2	1	2	1	2	3	3	1	1	2	3	2	2	1	1	3
DE24	2	1	2	1	3	1	1	2	2	3	1	3	3	2	2	1
DE25	2	1	1	2	1	3	2	1	2	3	3	1	3	1	2	2
DE26	2	1	1	2	2	1	3	2	3	1	1	2	1	2	3	3
DE27	2	1	1	2	3	2	1	3	1	2	2	3	2	3	1	1
DE28	2	2	2	1	1	3	2	2	2	1	1	3	2	3	1	3
DE29	2	2	2	1	2	1	3	3	3	2	2	1	3	1	2	1
DE30	2	2	2	1	3	2	1	1	1	3	3	2	1	2	3	2
DE31	2	2	1	2	1	3	3	3	2	3	2	2	1	2	1	1
DE32	2	2	1	2	2	1	1	1	3	1	3	3	2	3	2	2
DE33	2	2	1	2	3	2	2	2	1	2	1	1	3	1	3	3
DE34	2	2	1	1	1	3	1	2	3	2	3	1	2	2	3	1
DE35	2	2	1	1	2	1	2	3	1	3	1	2	3	3	1	2
DE36	2	2	1	1	3	2	3	1	2	1	2	3	1	1	2	3

Table 6. Closeness coefficient and ranks of the alternative

DE s	Si+	Si-	Ci	Rank	DE s	Si+	Si-	Ci	Rank
DE1	0.055926	0	0	36	DE19	0.032186	0.041944	0.565818	13
DE2	0.030456	0.027081	0.470678	22	DE20	0.043813	0.029325	0.400957	29
DE3	0.013934	0.054163	0.795385	1	DE21	0.035091	0.033321	0.487063	19
DE4	0.028425	0.047312	0.624688	7	DE22	0.029164	0.034429	0.5414	15
DE5	0.05035	0.017496	0.257875	33	DE23	0.02928	0.047054	0.616423	8
DE6	0.030106	0.033504	0.526711	16	DE24	0.050348	0.016559	0.247493	34
DE7	0.023763	0.044905	0.653948	5	DE25	0.030417	0.029695	0.493996	18
DE8	0.043884	0.033809	0.435161	24	DE26	0.019999	0.051797	0.72145	4
DE9	0.041201	0.02385	0.366635	30	DE27	0.053547	0.012622	0.190751	35
DE10	0.022689	0.041609	0.647131	6	DE28	0.031259	0.043246	0.580444	11
DE11	0.033447	0.044421	0.570469	12	DE29	0.042164	0.030673	0.42112	27
DE12	0.045169	0.023201	0.33934	32	DE30	0.031113	0.037182	0.544434	14
DE13	0.03532	0.033255	0.484943	20	DE31	0.047956	0.027319	0.362921	31
DE14	0.027802	0.043979	0.612682	9	DE32	0.032852	0.03033	0.480043	21
DE15	0.041275	0.033946	0.451288	23	DE33	0.017131	0.050771	0.747711	2
DE16	0.042071	0.032204	0.433577	25	DE34	0.046174	0.030993	0.401633	28
DE17	0.032949	0.035179	0.516369	17	DE35	0.036238	0.027705	0.433272	26
DE18	0.028507	0.044426	0.609135	10	DE36	0.016827	0.049598	0.746677	3


Fig. 5 Alternatives v/s Ranks

4.2. Application of MABAC

The MABAC approach was used to determine the best automobile dealership option. Using the Taguchi L36 technique, a decision matrix with 36 possibilities and 16 criteria was created (Table 3). The matrix was normalized using Equations (8) and (9), and the weighted matrix was computed using Equation (10), with weights obtained via the SWARA approach. The border approximation area matrix (GI) was then computed using Equation (12). The distance (Q) between each alternative and the boundary approximation region was calculated using Equation (15) and is displayed in Table 6. The final ranks of the options, determined using Equation (17), are shown in Table 4.

4.3. TOPSIS

The TOPSIS approach was used to rank the 36 options provided by the Taguchi method using 16 assessment criteria. Equation (4) was used to normalize the decision matrix, and Equation (20) yielded the weighted normalized matrix. Equation (21) was used to calculate positive and negative ideal solutions based on the weighted matrix. Equations (27) and (28) were used to compute the Euclidean distances between these perfect solutions. The closeness coefficients, which indicate the relative ranking of each choice, were calculated using Equation (29). The findings, reported in Table 6, reveal that the option with the highest proximity coefficient is selected first.

4.4. Comparison

Figure 5 shows the rankings of 36 car dealership options using the SWARA-MABAC and SWARA-TOPSIS algorithms. Both approaches consistently rank DE3 as the best choice. DE1 ranks lowest in SWARA-MABAC, as it does in SWARA-TOPSIS. SWARA-MABAC's top five possibilities are DE3, DE33, DE26, DE36, and DE10, whereas SWARA-TOPSIS produces a similar top five: DE3, DE33, DE36, DE26, and DE10. The lowest five possibilities are the same for both methods: DE12, DE5, DE24, DE27, and DE1.

5. Conclusion

The study provides a comprehensive hybrid Multi-Criteria Decision-Making (MCDM) approach by combining SWARA, TOPSIS, and MABAC to evaluate 36 automobile dealership choices using 16 criteria derived from the four Balanced Scorecard dimensions. SWARA was effectively utilized to scientifically define weights for four major and 16 secondary criteria, which were then merged into TOPSIS and MABAC for overall ranking. According to consumer preferences, the most significant sub-criteria for dealership selection were LGP3, IPP3, LGP4, IPP1, and CP1. The criteria CP3, LGP1, IPP4, FP1, and FP2 showed a substantial effect, whereas the rest had little significance. These findings emphasize the need to align dealership strategy with customer-driven goals. Using the SWARA-MABAC technique, the top five dealerships were DE3, DE33, DE26, DE36, and DE10. The SWARA-TOPSIS technique also identified the top performers as DE3, DE33, DE36, DE26, and DE7. The concordance between the two techniques confirms the hybrid framework's trustworthiness. In general, high-performing dealerships in both techniques are DE3, DE33, DE36, DE26, DE7, DE10, and DE23, whereas bad performers were DE1, DE24, DE5, DE12, DE31, and DE9. This extensive investigation stresses the effectiveness of hybrid MCDM approaches in the automobile sector and enables data-driven decision-making to improve dealership performance and customer satisfaction levels.

Ethical Approval

This work does not contain any studies with human participants or animals performed by any of the authors.

Data Availability

The data that support the findings of this study are available in this article.

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