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Using MCDM Methods in automotive industry- A Review

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Abstract

In the automobile sector, choosing the best car necessitates weighing a number of factors, including cost, fuel economy, performance, safety, and environmental impact. In order to solve complicated situations that need the simultaneous evaluation of multiple conflicting aspects, Multi-Criteria Decision Making (MCDM) procedures are essential. Among the various MCDM approaches, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and MOORA are widely recognized for their straightforward structure and reliable outcomes. The application of the TOPSIS approach in the automobile industry to determine the best car alternatives based on several performance parameters is the main topic of this study. The process involves creating a decision matrix, normalizing the data, and identifying ideal and non-ideal reference solutions. Next, options are ranked based on how near they are to the optimal answer. Through objective and quantitative analysis, TOPSIS helps consumers and industry professionals choose the best car by facilitating systematic comparisons between various vehicles and helping decision-makers achieve a balanced evaluation of diverse attributes. Rapid technical breakthroughs, strict environmental restrictions, and changing customer expectations present the automotive sector with increasingly complicated decision-making issues. It is necessary to simultaneously assess several, frequently contradictory factors in order to choose the best vehicle designs, suppliers, materials, powertrain technology, and consumer car options. By offering organized, transparent, and quantitative frameworks for decision-support, Multi-Criteria Decision Making (MCDM) techniques have become powerful analytical tools to tackle these issues. With a focus on popular approaches like TOPSIS, MOORA, AHP, VIKOR, and their hybrid integrations, this review paper provides a thorough overview of the implementation of MCDM techniques in the automotive industry.

Keywords: Automotive industry, MCDM, MOORA, PROMETHEE, TOPSIS

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INTRODUCTION

The automotive industry is today a large and rapidly evolving field that involves the development, production, promotion, and distribution of motor vehicles.

It significantly contributes to economic growth and technological advancement worldwide. In contrast, Multi-Criteria Decision-Making (MCDM) approaches provide systematic frameworks for handling decision problems that require the simultaneous assessment of several, often conflicting, criteria. Here is how these two domains can intersect and complement each other:

AUTOMOBILE INDUSTRY

Key Aspects Include

1. Market Trends
2. Technology
3. Environmental Concerns
4. Customer Preferences
5. Global Supply Chain

Applications of MCDM in the Automobile Industry

1. *Supplier Selection:* The supplier & evaluating selection based on the criteria like cost, quality, delivery performance, and environmental compliance.
2. *Vehicle Design:* Deciding on materials, engine types (electric vs. hybrid vs.ICE), and features.
3. *Market Strategy:* Analyzing consumer preferences, market trends, and regional demands.
4. *Sustainability Practices:* Prioritizing green initiatives and compliance with environmental regulations.
5. *Manufacturing Decisions:* Optimizing production processes and technology investments.

Multi-Criteria Decision-Making (MCDM) Method

MCDM methods are used in various domains, including engineering, business, environmental planning, and supply chain management, to aid in making informed and rational decisions.

Key Features of MCDM Methods

1. *Multiple Criteria:* Decisions involve more than one criterion, which can be quantitative (e.g., cost, efficiency) or qualitative (e.g., aesthetics, user satisfaction).
2. *Conflict of Objectives:* Criteria often have trade-offs; for example, higher quality might mean higher cost.
3. Preference Modeling: MCDM methods incorporate decision-makers' preferences by assigning weights or priorities to different criteria such as safety, cost, fuel efficiency, and environmental impact.
4. Structured Framework: MCDM provides a systematic and transparent framework for evaluating alternatives, such as vehicle designs, materials, or suppliers.

Steps in an MCDM Process

(a). Define the Problem
(b). Establish Criteria
(c). Assign Weights
(d). Evaluate Alternatives
(e). Apply the MCDM Method
(f). Validate and Select

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution):

TOPSIS compares each alternative to an ideal alternative, which has the best score in each criterion. The geometric distance between each option and the optimal option is then determined by the procedure. The option that is closest to the ideal solution and furthest from the negative perfect solution is the one that is selected.

Advantages of TOPSIS

1. Simultaneously takes into account the finest and worst options.
2. Simple to comprehend and intuitive.
3. Effectively manages numerous criteria and big datasets.
4. Both helpful and non-beneficial criteria can be included.

Disadvantages of TOPSIS

1. Requires exact weights for the criteria, which could lead to subjectivity.
2. The normalization technique and weights have an impact on the outcomes.
3. Assumes linear preferences, which could not always be the case.

MOORA (Multi-Objective Optimization on the Basis of Ratio Analysis)

The Since its introduction by Brauers and Zavadskas in 2006, MOORA has been well-known for its ease of use, adaptability, and efficiency in assessing options based on a variety of factors.

Key Features

When judgments must be made while taking into account competing factors including cost, quality, and performance, the MOORA technique is employed.

It is a ratio-based method that converts difficult decision-making issues into more straightforward mathematical representations for assessment and comparison.

The method focuses on normalizing decision data to eliminate the influence of different measurement units among criteria, ensuring that each criterion contributes equally to the evaluation process. It distinguishes between:

- *Beneficial criteria:* Factors to be maximized (e.g., profit, efficiency).
- *Non-beneficial criteria:* Factors to be minimized (e.g., cost, waste).

The alternatives are ranked based on their aggregated performance scores, allowing decision-makers to choose the most optimal option.

Importance of the MOORA Method

1. *Simplicity:* It is computationally straightforward and easy to implement.
2. *Flexibility:* Can tackle both quantitative and qualitative data.
3. *Versatility:* Applicable to various fields like engineering, finance, management, healthcare, and environmental studies.
2. *Accuracy:* Provides a clear and reliable ranking of alternatives based on objective analysis.

The MOORA method is particularly useful in real-world problems where decision-makers must balance competing objectives to arrive at the best possible solution.

AHP (Analytic Hierarchy Process)

It is used to solve complex problems involving multiple criteria by breaking them down into a hierarchy and assigning priorities to each element. The AHP is widely recognized for its ability to combine qualitative and quantitative data to derive a consistent and logical decision.

Key Features

Hierarchy-Based: Structures the decision problem into levels, typically comprising:

- The goal (overall objective).
- Criteria (factors affecting the decision).
- Sub-criteria (optional, more specific factors).

Alternatives (options to be evaluated).

Pairwise Comparisons: Evaluates elements pair by pair to determine their relative importance using a scale (e.g., Saaty's 1-9 scale).

Consistency Check: Verifies the consistency of judgments to ensure reliability in decision-making.

Here, we are apply for the literature review for the uses of automobile sector using MCDM method.

LITERATURE REVIEW

From the literature review, we observed that the works has been done basically AHP, PROMETHEE & GRE methods, by the help of MCDM methods. We observe least work around TOPSIS, MOORA like this method. So we used only for TOPSIS method. Following are the papers based on MCDM used in the automotive industry (Table 1).

S.N.	Paper Title	Name of the Journal(s)	MCDM Methods	Publication Year
1	A hybrid MCDM approach for evaluating an automobile purchase model	International Journal of Information and Decision Science	PROMETHEE; GRE	2013 [1]
2	Using analytic hierarchy process (AHP) to improve human performance: an application of multiple criteria decision making problem	Journal of Intelligent Manufacturing,	AHP	2004 [2]
3	Facility location selection using PROMETHEE II method	International Conference on Industrial Engineering and Operations Management	PROMETHEE	2010 [3]
4	PROMETHEE: a comprehensive literature review on methodologies and applications	European Journal of Operational Research	PROMETHEE	2010 [4]
5	The lean improvement of the chemical emissions of motor vehicles based on preference ranking: a PROMETHEE uncertainty analysis	Omega International Journal of Management Science	PROMETHEE	2008 [5]
6	Performance evaluation of international airports in the region of East Asia	Proceedings of Eastern Asia Society for Transportation Studies	AHP	2003 [6]
7	A survey and optimization-based evaluation of development strategies for the air cargo industry	International Journal of Production Economics	TOPSIS	2007 [7]
8	Evaluating attack helicopters by AHP based on linguistic variable weight	European Journal of Operational Research	AHP	1999 [8]
9	Decision making in equipment selection: an integrated approach with AHP and PROMETHEE	Journal of Intelligent Manufacturing	AHP; PROMETHEE	2008 [9]
10	Multi-criteria analysis of alternative-fuel buses for public transportation	Energy Policy	AHP; TOPSIS	2005 [10]
11	A Closer Look at Drawbacks of Minimizing Weighted Sums of Objectives for Pareto Set Generation in Multi-Criteria Optimization Problems	Structural Optimization	WSM	1997 [11]
12	Interactive selection model for vendor selection process: an analytical hierarchy process approach	International Journal of Production Research	AHP	2003 [12]
13	An AHP-multi criteria suitability evaluation of technological diversification in the automotive industry	International Journal of Production Research	AHP	2012 [13]
14	Industrial competitiveness analysis: Using the analytic hierarchy process	The Journal of High Technology Management Research	AHP	2006 [14]
15	An AHP based prioritization model for risk evaluation factors in the automotive industry	International Journal of the Analytic Hierarchy Process	AHP	2018 [15]
16	Using MCDM Technique-TOPSIS for Selecting Small Passenger Car	Pal Arch's Journal of archaeology	TOPSIS	2020 [16]

17	Combining the AHP and TOPSIS to Evaluate Car Selection	Association for Computing Machinery	AHP; TOPSIS	2020 [17]
18	An analytic hierarchy process approach with a novel framework for luxury car selection	8th International Management Conference	AHP	2012 [18]
19	Application of Fuzzy TOPSIS Algorithm for Selecting Best Family Car	International Conference on Decision Aid Sciences and Application	FUZZY TOPSIS	2020 '[19]
20	Investigating car purchasing decision-making process using Multi-Objective Optimization Ratio Analysis based Analytical Hierarchy Process Model	Journal of Contemporary Issues in Business and Government	AHP	2021 [20]
21	Development of a new hybrid multi criteria decision-making method for a car selection scenario	FACTA UNIVERSITATIS	AHP	2020 '[21]
22	Assessment and Comparison of Various MCDM Approaches in the Selection of Manufacturing Process	Advances in Materials Science and Engineering	AHP	2020 [22]
23	SELECTION OF CAR USING FUZZY AHP AND FUZZY TOPSIS METHOD BY MCDM APPROACH	International Research Journal of Engineering and Technology (IRJET)	FUZZY AHP	2023 [23]
24	A state-of the-art survey of TOPSIS applications	*Expert System Appications*	TOPSIS	2012 [24]
25	Multi-attribute optimization of EDM process parameters for machining of SiC and B_4C particle reinforced Al 6061 metal matrix composite adopting TOPSIS method	*International Journal of Advanced. Technology & Engineering*	TOPSIS	2021 [25]

Table 1. Literature review table.

CONCLUSION

This review highlights the significant role that Multi-Criteria Decision Making (MCDM) methods play in addressing complex decision-making challenges within the automotive industry like automobile sectors. From material selection and supplier evaluation to vehicle design optimization and technology adoption, MCDM tools offer a structured framework for balancing multiple conflicting criteria. Methods like AHP, TOPSIS, VIKOR, and PROMETHEE have been widely applied, each demonstrating strengths depending on the context and data requirements. The integration of MCDM with modern tools such as fuzzy logic, machine learning, and sustainability metrics is becoming increasingly relevant as the industry moves toward smarter, greener, and more cost-efficient solutions. Overall, the application of MCDM techniques contributes to enhanced transparency, rationality, and objectivity in strategic and operational decisions in the automotive sector.

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