Analysis and optimization of automobiles using TOPSIS method (A case study)

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Abstract

The global automobile scenario is undergoing a major innovative metamorphosis at a rate of never experienced before. All automobile industries have their brands to face the global marketing challenges to secure the role of the leader in this state of economic revolution. Therefore it has become essential for all the industries to focus on catering the needs of the corporate world.

Our paper identifies the technical properties requirements of the automobiles and discusses about the estimation methods. We have used TOPSIS method (Technique of Order Preference and similarity to the Ideal Solution) to optimize the automobiles based on the source data and suggested the best one which satisfies the current requirements of consumers.

Keywords : Automobile, optimization, TOPSIS method.

I. Introduction

A. History of Automobile Industry:In the year 1769, a French engineer by the name of Nicolas J. Cugnot invented the first automobile to run on roads. This automobile, in fact, was a self-powered, three-wheeled, military tractor that made the use of a steam engine. However, Thomas Davenport of the U.S.A. and Scotsman Robert Davidson were amongst the first to invent more applicable automobiles, making use of non-rechargeable electric batteries. Jean Joseph Étienne Lenoir was the first to invent an internal combustion engine that ran on petroleum and attached it to a three-wheeled carriage, and successfully traversed a distance of fifty miles in 1863.

B .Automobile Industry in India:The first car ran on India's roads in 1897. Till the 1930s, cars were imported directly. Embryonic automotive industry emerged in India in the 1940s. Following the independence, in 1947, the Government of India and the private sector launched efforts to create an automotive component manufacturing industry to supply to the automobile industry.

Objectives

- § Increased asset utilization
- § Improve opting method of vehicles according to the technical issues
- § To improve the overall efficiency and performance.
- § To satisfy the customers according to their requirements.

II. Growth of Automobile Industry in India

The Automotive industry in the Republic of India is one of the largest in the world. Following economic liberalization in India in 1991, the Indian automotive industry has demonstrated sustained growth as a result of increased competitiveness and relaxed restrictions. It is the world's second largest manufacturer of motorcycles, with annual sales exceeding 8.5 million in 2009. India's passenger car and commercial vehicle manufacturing industry is the seventh largest in the world, with an annual production of more than 2.6 million units in 2009. In 2009, India emerged as Asia's fourth largest exporter of passenger cars, behind Japan, South Korea and Thailand. As of 2009, India is home to 40 million passenger vehicles and more than 1.5 million cars were sold in India in 2009 (an increase of 26%), making the country the second fastest growing automobile market in the world.

Optimizatin of Automobiles

Automobiles industry is one of the fast growing sectors. More than 60% of the people are engaged with automobiles globally. There are approximately 600 million passenger cars worldwide (roughly one car per eleven people). The numbers are increasing rapidly, especially in China and India.

Complex innovations were made by the existence of the automobile; on the other hand their growth made the automobile more of a necessity. The relationship was tightly intertwined. Therefore it is became essential to perform optimization in automobile field also, as this field is made up of many types of brands with different qualities and quantities.

Optimization is the process of choosing the permissible actions that result in the best outcome. In this paper, We used TOPSIS method to perform the optimization.

A.Types of Brand

The brands we have considered for our study are TATA, TOYOTA, MAHINDRA, HYUNDAI, FORD, MARUTI, VOLKSWAGON, SKODA, HONDA and NISSAN. Brands of automobiles are chosen based on frequency of availability of those models on road.

Iv. Nature of Study

We are going to take in account the popular 10 seated cars in India (as mentioned above) and compare them with their specifications (specified above). We have done

the optimization of automobiles based on some technical parameters such as Turning radius, Fuel efficiency, Cost, torque, power, mass equipped, maximum speed, Fuel tank capacity, Acceleration and Wheel base. These parameters will affect customer satisfactions at maximum.

V. Case Study

A. Data

The specifications of various cars have been collected from their respective company website and shown below

B. Methodology

The major tool used for the study is: Topsis method. This is used to rate the cars based on their reception among people.

Multicriteria decision making (MCDM) may be considered as a complex and dynamic process including one managerial level and one engineering level (Duckstein and Opricovic, 1980). The managerial level defines the goals, and chooses the final "optimal" alternative. The multicriteria nature of decisions is emphasized at this managerial level, at which public officials called "decision makers" have the power to accept or reject the solution proposed by the engineering level. These decision makers, who provide the preference structure, are "off line" from the optimization procedure done at the engineering level. Very often, the preference structure is based on political rather than only technical criteria. In such cases, a system analyst can aid the decision making process by making a comprehensive analysis and by listing the important properties of noninferior and/or compromise solutions (Yu, 1973). The engineering level of the MCDM process defines alternatives and points out the consequences of choosing any one of them from the standpoint of various criteria. This level also performs the multicriteria ranking of alternatives.

The main steps of multicriteria decision making are the following:

(a) Establishing system evaluation criteria that relate system capabilities to goals;

(b) Developing alternative systems for attaining the goals (generating alternatives);

(c) Evaluating alternatives in terms of criteria (the values of the criterion functions);

(d) Applying a normative multicriteria analysis method;

Cars/properties	Tor	Pov	Mass equ	Max. spe	Mi	Tank cap	Wheel bas	Turni rad	Accelera tion(time to atta	Cos
Tata-Nano	47.3	14.85	620	105	23.6	15	2.230	4	13	**1.234**
Toyota-Innova [G]	131.3	42	915	170	12	45	2.750	4.9	12	8.484
Hyundai-i10	82.5	25.9	996	143	19.2	35	2.380	4.74	15.3	3.5
Mahin-dra Scorpio	222.3	69.8	2,610	156	14	60	2.80	5.6	15.6	8.94
Ford-Figo(1.2 Duratec Petrol LXI)	136	42.7	104	160	15.5	45	2.489	4.9	16.2	3.819
Maruti-Swift(Vdi)	169	53	1050	155	20	43	2.430	4.7	13.75	6.87
Volkswagon-Polo	191	60	1075	183.8	15.5	45	2.456	4.97	10.7	6.93
Skoda-Fabia	137	43	1565	206	16	45	2.465	4.9	14.8	6.67
Honda-Jazz	176	55.3	960	165	14.1	42	2.50	4.9	11.2	7.0
Nissan-Micra	107	33.6	675	158	23.08	41	2.300	4.65	14.2	3.98

(e) Accepting one alternative as "optimal" (preferred);

(g) If the final solution is not accepted, gather new information and go into the next iteration of multicriteria optimization.

Several approaches for MCDM exist. Some of the MCDM listed below.

- Weighted score method
- TOPSIS method
- Analytic Hierarchy Process (AHP)
- Goal programming
- Compromise ranking method (VIKOR)
- Simple Additive Weighting method

The TOPSIS method is one of the best multi-criteria decision making method. The TOPSIS method has two main advantages:

(i) Its mathematical simplicity and

(ii) Very large flexibility in the definition of the choice set.

When solving real-life problems, or representing real world phenomena, linguistic variable usually appears to be an important output of the process. It selects among the alternatives that is the closest to the ideal solution and farthest from negative ideal solution.

Topsis method has the following steps

STEPS INVOLVED IN TOPSIS:

Step 1: Calculate the weights of the evaluation criteria. To find the relative normalized weight of each criterion, first of all, the geometric mean of ith row in the pair-wise comparison matrix is calculated by:

$$GMi = \sqrt[n]{\left(\prod_{j=1} X_{ij}\right)} \quad i=1,2,\ldots m \qquad \ldots..(1)$$

Then, geometric means of the rows in the comparison matrix are normalized as:

$$Wi = GMi / \Sigma_{i=1} GMii = 1,2,\ldots.m \qquad \ldots..(2)$$

Step 2: Construct the normalized decision matrix. This step converts the various attribute dimensions into non dimensional attributes. An element rij of the normalized decision matrix R is calculated as follows:

$$r_{ij} = x_{ij} / \sqrt{\left(\sum_{i=1} x^2_{ij}\right)} \quad \text{for } j = 1, \ldots, n; \qquad \ldots..(3)$$

Step 3: Calculate the weighted normalized decision matrix (V). The weighted normalized value vij is calculated as:

$$v_{ij} = w_j r_{ij} \qquad \ldots..(4)$$

Step 4: Identify the positive ideal solution and negative ideal solution.

$$A^* = \{v_1^*, \ldots, v_n^*\}, \qquad \ldots..(5)$$

Where

$$v_j^* = \{\max_i (v_{ij}) \text{ if } j \in J ; \min_i (v_{ij}) \text{ if } j \in J' \} \ldots..(6)$$

Negative ideal solution.

$$A' = \{v_1', \ldots, v_n'\}, \qquad \ldots..(7)$$

where

$$v_{ii}' = \{\min (v_{ij}) \text{ if } j \in J ; \max (v_{ij}) \text{ if } j \in J' \} \ldots..(8)$$

Step 5: Calculate the separation measure. In this step the concept of the n-dimensional Euclidean distance is used to measure the separation distances of each alternative to the ideal solution and negative-ideal solution. The corresponding formulas are

The separation from the ideal alternative is:

$$S_i^* = \sum_j [(v_j^* - v_{ij})^2]^{1/2} \qquad i = 1, \ldots, m \ \ldots..(9)$$

Similarly, the separation from the negative ideal alternative is:

$$S_i' = \sum_j [(v_j' - v_{ij})^2]^{1/2} \qquad i = 1, \ldots, m \ \ldots.(10)$$

Step 6: Calculate the relative closeness to the ideal solution. The relative closeness of the alternative Ai with respect to A* is defines as:

$$C_i^* = S_i' / (S_i^* + S_i') \ , \ 0 \ C_i^* \ 1 \ldots.(11)$$

Select the option with C_i^* closest to 1.

Step 7: Rank the preference order. Choose an alternative with maximum C_i^* or rank alternatives according to C_i^* in descending order.

C. Calculation

The calculation is done using TOPSIS method on the collected data.

Calculate the relative closeness to the ideal solution. The relative closeness of the alternative Ai with respect to A* is defines as:

VI. FINDINGS

Thus on comparing the ranks of each car in the above table, the maximum value is found to be 0..936758 which correspo

VII. CONCLUSION

Based on our case study on the collected data, we come to know the present competitive situation in the Automobile Industry in India. Also we come to know that customers expect more and that expectation grows based on their needs day to day. So we conclude that in order to hold their place in the global competitive scenario various new strategies must be adopted by the companies apart from modernizing their products. nds to TATA Nano. So our case study using TOPSIS method on the collected data reveals that Tata Nano is the best economical and adoptable car at present.

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PRODUCT NAME	CI* VALUE	RANK
Tata- Nano	0.936758	2
Toyota-Innova [G]	0.813677	4
Hyundai- i10	0.765895	6
Mahin-dra Scorpio	0.000132	10
Ford-Figo(1.2 Duratec Petrol LXI	0.99996	1
Maruti-Swift(Vdi)	0.731137	7
Volkswagon-Polo	0.714263	8
Skoda-Fabia	0.338546	9
Honda- Jazz	0.787941	5
Nissan- Micra	0.91981	3

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