SELECTION OF VEHICLE BY USING MULTI ATTRIBUTE UTILITY TECHNIQUE COMBINED WITH LINEAR PROGRAMMING METHOD

Govind Singh Raghuwanshi[1], Dr. Pankaj Agarwal[2], P. L. Verma[3]
[1]"M. Tech. Scholor, Department of Mechanical Engineering, SATI, Vidisha"
[2]"Professor and Head, Department of Mechanical Engineering, SATI, Vidisha"
[3]"Professor, Department of Mechanical Engineering, SATI, Vidisha"

A B S T R A C T

In the study, multi attribute utility system technique is performed with linear programming. It is applied in order to take decision in selecting a best out of selected six vehicle type for the examination and recognize the best kind of vehicle from the analysis. To actualize the decision making procedure by utilizing decision making programming MACBETH. Most complex decisions require the decision maker to make trade-offs between competing value objectives. Multi attribute utility system technique (MAUT), it is used to analyses the preferences of various choices, goods, uncertain conditions, of an agent over bundles of goods either under conditions of certainty about the results of any potential choice, or under conditions of uncertainty. When a person has to take a decision between two or more options. The decision is based on various attributes of the options. MAUT technique works for single dimensional value measure, ranking, works for analyst, for measuring accurate results, scores and weights etc. The complexity stems from the probability nature of the problem, a multitude of quantitative and qualitative factors influencing supplier choices as well as the intrinsic difficulty of making numerous tradeoffs among various factors. One analytical approach often suggested for solving such complex problems is MAUT.

Keyword: MAUT, Linear Programing, Decision Making, MACHBATH

1. INTRODUCTION

In a large portion of the methodologies dependent on the Multi-attribute Utility Theory (MAUT), the loads related with the criteria can appropriately mirror the general significance of the criteria just if the scores aij are from a typical, dimensionless scale. The premise of MAUT is the utilization of utility capacities. Utility capacities can be connected to change the crude execution estimations of the alternatives against different criteria, both truthful (objective, quantitative) and judgmental (abstract, subjective), to a typical, dimensionless scale. In the training, the interims [0,1] or [0,100] are utilized for this reason. Utility capacities assume another significant job: they convert the crude execution esteems with the goal that an increasingly favored presentation acquires a higher utility worth. A genuine model is a measure mirroring the objective of cost minimization. The related utility capacity must bring about higher utility qualities for lower cost esteems.

Nomenclature

VG Very Good
G Good
P Poor
VP Very Poor
A Average
M Moderate

1.1. Multi-criteria decision-making approaches

Multi-Criteria Decision-Making (MCDM) approaches, introduced in the early 1970s, are powerful tools used for evaluating problems and addressing the process of making decisions with multiple criteria. MCDM problems typically are quite complex, but the distinguishing characteristic is the fact that various conflicting criteria and the interactions between them have to be modeled explicitly in order to gain an understanding of the problem or to provide a solution to the problem. MCDM as a multi-disciplinary field of Operations Research (OR), uses mathematical approaches involving the following steps:

1. Structuring decision processes,
2. Defining and selecting alternatives,
3. Determining criteria formulations and weights,
4. Applying value judgments and evaluating the results to make decisions in design or selecting alternatives with respect to multiple conflicting criteria.

In the MCDM, three kinds of problems are distinguished: choice problems, ranking problems and sorting problems.

- In choice problems the objective is to aid the decision maker by the choice of the subset of the “best” solution or alternative. The final output is a choice or selection procedure.
- The objective of ranking problems is to aid decision maker to simplify the “most attractive” actions in to equivalent classes. The ranking consists in ordering a set of solutions. The aim is finding the goodness of all alternatives, which is usually presented as a ranking from the best to the worst. They are completely or partially ordered with respect to the preferences. The final output is the ordering procedure.

In sorting problems we want to know which alternatives belong to each class of a predefined set of ordered classes. Decision makers assign each action to a category. The result is an assignment procedure.

1.2. Linear programming

Linear Programming is a technique for making decisions under certainty i.e.; when all the courses of options available to an organization are known & the objective of the firm along with its constraints are quantified. That course of action is chosen out of all possible alternatives which yield the optimal results. Linear Programming can also be used as a verification and checking mechanism to ascertain the accuracy and the reliability of the decisions which are taken solely on the basis of manager's experience without the aid of a mathematical model.

1.3. MAUT (Multiple Attributes Utility Theory)

As indicated in the previous section, supplier selection is a complex decision-making problem. The complexity stems from the probability nature of the problem, a multitude of quantitative and qualitative factors influencing supplier choices as well as the intrinsic difficulty of making numerous tradeoffs among these factors. One analytical approach often suggested for solving such complex problems is MAUT.

The utility concept in complex decision problems involving multiple attributes and multiple conflicting objectives, and provided a systematically approach of multiple attributes utility analysis (MAUA). MAUA is targeted in solving problems of trading off the achievement of some objectives against other objectives to obtain the maximum overall utility. A decision-maker is assumed to be facing the above-mentioned problem, and he/she has to choose a solution from some solution alternatives. MAUA is used to assess the decision-maker’s preference structure and model it mathematically with a multiple attributes utility function. This multiple attributes utility function is then applied to help the decision maker reach an optimal decision

2. LITERATURE REVIEW

(Lin, Hung and Hu, 2018)Due to thorough quality necessities and high unit costs, the assembling of machines utilized in the aeronautic trade is portrayed by a high passage limit, high hazard and a long restitution period. A decent decision-making model for assessing and choosing providers is imperative for manageable venture improvement. In this manner, this investigation shows another two-arrange model for assessing and choosing providers in the aeronautic trade. In the primary stage, a various levelled structure is worked with five principle and 16 sub-criteria for provider assessment and choice after the changed Delphi technique; in the subsequent stage, the best elective arrangement is chosen following the investigative system process (ANP) strategy. At long last, this examination confirms the practicality of the above model dependent on the buy of high-exactness and surprising expense 3D estimating apparatuses by Aerowin Technology Corporation, which is recorded on the Taiwan Stock Exchange. The outcomes demonstrate that the five criteria in the above model are positioned by their level of significance, as pursues: quality> cost>delivery>marketing>organizational planning.

(Shanmuganathan et al., 2018)depicts the assessment of the Multi Attribute Utility Theory(MAUT), one of the Multi Criteria Decision Making(MCDM) procedures. It was presented by Fishburn (1965,1970), Keeney(1969,1971,1973), and Raiffa(1969) who proposed a decision making strategy intended for going for broke. This paper likewise clarifies how the hypotheses, ideas and thoughts of MAUT help a person in rational decision making, how an individual is effectively ready to comprehend the fundamental ideas of the above said strategy, how the information are measured, how far it is compelling in making decisions for taking care of an issue in the continuous circumstance, other than talking about how the judgment and uncertainties can be considered in the Multi Criteria Decision Making Method(MCDM). This strategy handles the issue of making a decision in various coherent and significant habits. For a situation study , it was exhibited how the strategy could be utilized in making a decision under vulnerability. Likewise in this paper is delineated how a decision turns out to be great when the decision maker is a software engineering instructor who picks his PC for his own work and how it encourages him in his own life. We can infer that MCDM strategies do think about vulnerability.

(Feylizadeh and Bagherpour, 2018)Earned Value Management (EVM) has been widely utilized in the writing for examining the timetable and cost execution lists. Be that as it may, the impacts of hazard factors on the undertaking achievement have been recently disregarded in the venture the executives ordinary setting. In this paper, an efficient task control and observing framework is created by consolidating the EVM essential standards, hazard analysis, and utility hypothesis for improving the exhibition of assembling frameworks. Weight esteems relating to the timetable execution file (SPI), the cost exhibition file (CPI), and the hazard execution record (RPI) are determined dependent on master decisions utilizing Z-number and Analytic Hierarchy Process (Z-AHP). At long last, a Multi-Attribute Utility Theory (MAUT) and Multi-Objective Linear Programming (MOLP) under fluffy condition are used to show the relevance of the proposed methodology. Affectability analysis showed the hazard execution is the most delicate when contrasted and the timetable and the cost list. The methodology given in this paper can be additionally utilized by the two academicians and supervisors in overwhelming serious assembling frameworks..

(Zhang et al., 2017)study considers a design problem in the supply chain network of an assembly manufacturing enterprise with economies of scale and environmental concerns. The study aims to obtain a rational trade-off between environmental influence and total cost. A mixed-integer nonlinear programming model is developed to determine the optimal location and size of regional distribution centres (RDCs) and the investment of environmental facilities considering the effects of economies of scale and CO_2 emission taxes. Numerical examples are provided to illustrate the applications of the proposed model. Moreover, comparative analysis of the related key parameters is conducted (i.e., carbon emission tax, logistics demand of customers, and economies of scale ofRDC), to explore the corresponding effects on the network design of a green supply chain. Moreover, the proposed model is applied in an actual case—network design of a supply chain of an electric meter company in China. Findings show that (i) the optimal location ofRDCs is affected by the demand of customers and the level of economies of scale and that (ii) the introduction ofCO_2 emission taxes will change the structure of a supply chain network, which will decrease CO_2 emissions per unit shipment.

(Tosun, 2017)said that the technology selection has a very crucial role to any company aiming for competitive advantage in the globalized world. In a competitive environment, firms try to meet customer demand and their increasing quality expectations, at the same time finding ways to decrease costs using factors such as flexibility, quality and innovativeness. Technology selection and evaluation problem have many criteria (both subjective and objective factors) that conflict with each other. To overcome this problem multi criteria decision making methods are developed. In this study MACBETH method is used to select and evaluate technology alternatives. Decision makers' opinions are evaluated to rank the alternatives.

(El Sawalhi and El Agha, 2017)appropriate procurement method is becoming an increasingly important issue due to complex decision making that clients are facing early in the lifecycle of construction projects. The aim of this paper is to improve the procurement system in the construction industry by developing a model using the multi-attribute utility theory (MAUT) as a decision support system for the selection of an appropriate procurement method for construction projects in the Gaza Strip. Factors that influence the selection of an appropriate method for construction projects in the Gaza Strip are identified and the results indicate that the most significant six factors influencing the selection of procurement methods in the Gaza Strip construction projects are price competition, degree of project complexity, Time constraints of the project, project size, client financial capability and client experience in procurement methods. The study concludes that there is no variety of procurement methods used in the Gaza Strip construction industry, as a traditional procurement method is preferred. This is because most professionals in the Gaza Strip are not familiar or experienced with alternative procurement methods.

(Sadaoui and Shil, 2016)study proposes a multi-round, first-score, semi-sealed multi-attribute reverse auction system. A fundamental concern in multi- attribute auctions is acquiring a useful description of the buyers' individuated requirements: hard constraints and qualitative preferences. To consider real requirements, we express dependencies among attributes. Indeed, our system enables buyers eliciting conditional constraints as well as conditional preferences. However, determining the winner with diverse criteria may be very time consuming. Therefore, it is more useful for our auction to process quantitative data. A challenge here is to satisfy buyers with more facilities, and at the same time keep the auctions efficient. To meet this challenge, our system maps the qualitative preferences into a multi-criteria decision rule.

(Chandraveer Singh Rathore, 2016)Supplier's Selection is one among the foremost essential activities of supply chain management. Supplier's Selection could be an advanced activity involving qualitative and quantitative multi-criteria. A trade-off between these tangible and intangible factors is essential in choosing the most effective Supplier.This paper explains the various methodsfor supplier selection and the use of AHP in selecting the most effective suppliers. The complete procedure of AHP is explained in this paper with some examples. The complete model development for the supplier selection is shown. The importance of AHP process in supplier selection is stressed. The use of MATLAB Software is shown to calculate the priority vector and thus find the solution of Example AHP Problem.

(Yildiz and Yayla, 2015)Considering more than one criterion (and even the sub-criteria of these criteria) during supplier selection makes the selection uncertain. Conventional methods cannot generate a realistic solution to the problem. Using MCDM methods considerably simplifies solving the problem, and enables decision-makers to make better decisions. In this study, a literature review was performed on MCDM methods used between 2001 and 2014 for the supplier selection problem. MCDM methods used in supplier selection are categorized into three main methods, and a summary table of the reviewed studies is presented.

(Dhouib, 2014)environmental problems and its recycling alternatives have been a major issue nowadays because of their complex combination of very different materials, which include several rubbers, carbon blacks, steel cord and other organic and inorganic minor components. The most important problem in the scrap tire recycling program is the type of product recovery option because there are few specific data available. Multi-criteria decision analysis (MCDA) was used to assess options in reverse logistics for waste tire. MCDA is a widely used decision methodology that considers conflicting systems of criteria. However, many real-world decision problems involve ambiguity and imprecise information. In this study, the analysis has been undertaken using an extended version of MACBETH methodology to take into account the imprecise and linguistic assessments provided by a decision-maker by integrating the 2-tuple model dealing with non-homogeneous information data. The proposed fuzzy MACBETH method has been applied to a real case related to the automobile tire waste to elucidate its details.

(Karande and Chakraborty, 2013)Supplier selection is always found to be a complex decision-making problem in manufacturing environment. The presence of several independent and conflicting evaluation criteria, either qualitative or quantitative, makes the supplier selection problem a candidate to be solved by multi-criteria decision-making (MCDM) methods. Even several MCDM methods have already been proposed for solving the supplier selection problems, the need for an efficient method that can deal with qualitative judgments related to supplier selection still persists. In this paper, the applicability and usefulness of measuring attractiveness by a categorical-based evaluation technique (MACBETH) is demonstrated to act as a decision support tool while solving two real time supplier selection problems having qualitative performance measures. The ability of MACBETH method to quantify the qualitative performance measures helps to provide a numerical judgment scale for ranking the alternative suppliers and selecting the best one.

(Hanlon et al., 2012)examined the association between parameters of the decision-making processes that are described in the Multi-Attribute Utility (MAU) model and actual food choices (fruit and vegetable consumption) among undergraduate students. Four hundred and six undergraduates from a large, public university in Southern California completed a pencil-and-paper questionnaire for the parameters of MAU, which consist of the perceived value, perceived likelihood, and momentary salience for each anticipated consequence of eating a healthy diet. Fruit and vegetable intake was collected daily using an online food intake log. Linear regression analysis revealed that MAU total scores were a significant predictor of fruit plus vegetable consumption (p = .000). T-test results indicated that high fruit plus vegetable eaters and low fruit plus vegetable eaters were significantly different from each other on individual parameter scores of the MAU model (range, p = .032 to p = .000). Conclusions: This study suggest that the MAU model may predict eating behaviors and provides support for further investigation; the MAU framework may help identify the factors that have greatest influence college students' nutrition decision making processes, and can aid in the development of interventions that address target consequences that have high utility scores in the target population.

3. OBJECTIVE

The objectives of this work are:

- To select six vehicle type for the examination and recognize the best kind of vehicle from the analysis.
- To figure consequence of each sort of vehicle case dependent on parameters, for example, cost, speed, control, sitting limit and administration star.
- To actualize the decision making procedure by utilizing decision making programming MACBETH.

4. METHODOLOGY

The flow of work is shown in figure 1. The first step is data collection which represent the all the data where collect by previous research. The result is compare on the basis of cost.

Setting capacity, engine torque, maximum speed and mileage is shown in flow diagram.

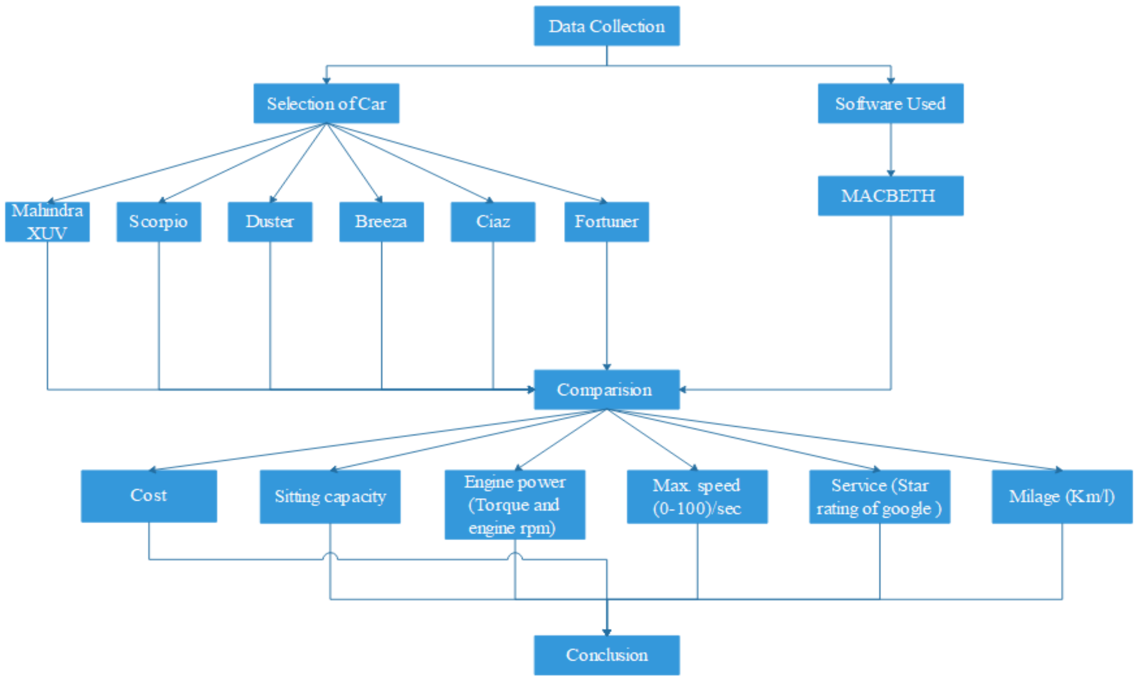


Fig. 1 - Flow of work

The whole process of decision making has been showed in Figure 2 from defining the problem as a goal, defining alternatives and developing criteria, selecting indicators and assigning weights, constructing an evaluation matrix, as it mentioned before, applying the appropriate method to evaluate alternatives, and finally, selecting alternatives according to the kinds of problems. Then, the selected alternatives can be implemented and evaluated in the particular application.

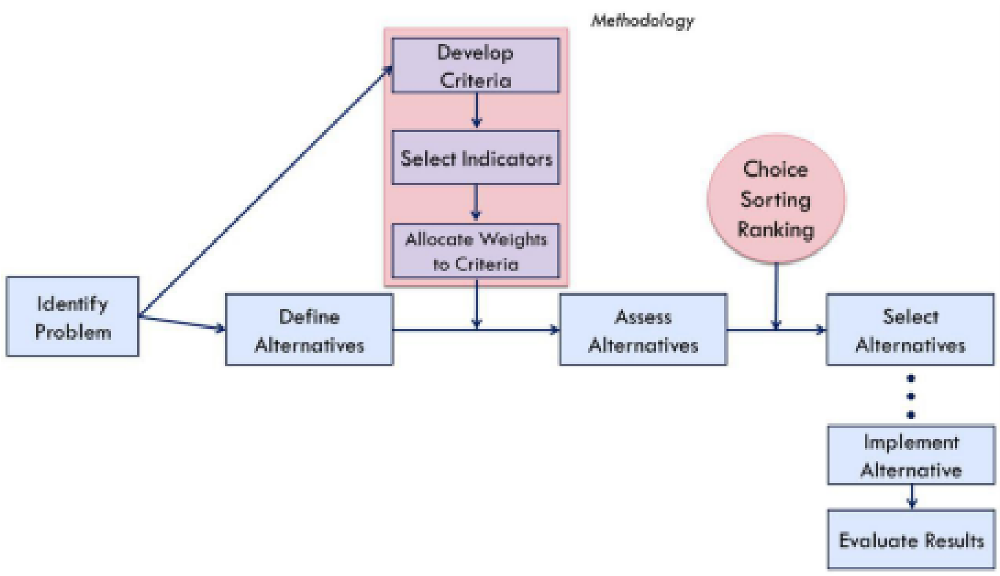


Fig. 2 - The Decision-Making Process

- First select the 6 automobile is selected and comparison of parameters such as price, sitting capacity, power, fuel type, maximum speed, comfortable etc.

- Give individually rating all the selected parameter this rating is the range of 0-100.
- Calculate individual score and weight by using software.

1.1. Selection of Car

Six cars are selected Mahindra XUV, Scorpio, Duster, VitaraBreeza, Ciaz and Fortuner. And compare this model in six criteria Cost, sitting capacity, Engine power, Maximum speed, Service and mileage. The model of car and comparison criterial are describe in table 1

Table 1 - Car model and there specification

Car Model	**Cost**	**Sitting capacity**	**Engine power (Torque and engine rpm)**	**Max. speed (0-100)/sec**	**Service (Star rating of google)**	**Milage (Km/l)**
Mahindra XUV	2274560	7	155@ 3750	11	4	12
Scorpio	1556000	8	140@ 3750	12.62	4	15.4
Duster	1375000	5	102@ 5850	11.8	2	19.87
Breeza	1255713	5	89@ 4000	13.3	4	24.3
Ciaz	1176000	5	89@ 4000	12.1	4	28.09
Fortuner	2959000	7	174@ 3400	13	4.5	14.24

1.2. Software Used

MACBETH (Measuring Attractiveness by a Categorical Based Evaluation Technique) is an interactive approach that requires only qualitative judgments about differences to help a decision maker or a decision-advising group quantifies the relative attractiveness of options. It employs an initial, interactive, questioning procedure that compares two elements at a time, requesting only a qualitative preference judgment.

As judgments are entered into the software, it automatically verifies their consistency. A numerical scale is generated that is entirely consistent with all the decision maker‘s judgments. Through a similar process weights are generated for criteria.

1.3. Software working step

1. A tree was then created in the MACBETH decision support system

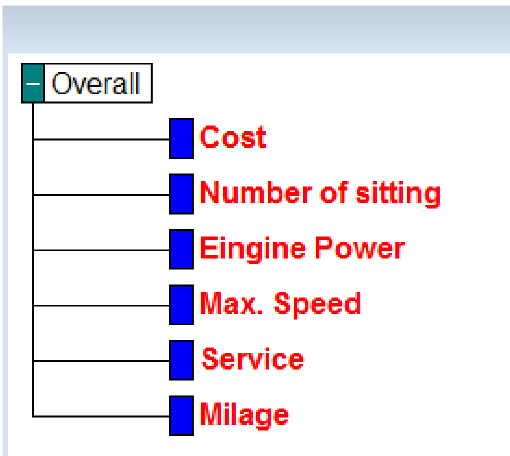


Fig. 3 -MACBETH value tree for supplier selection problem

2. The next step was to create a value scale for each of the criteria.

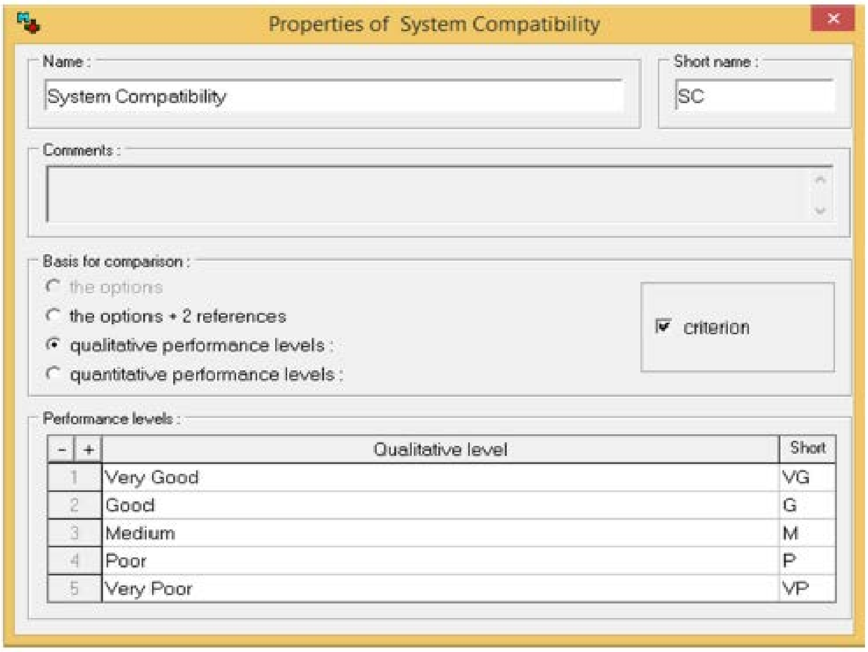


Fig. 4 -Performance levels of 'System Compatibility' criterion

3. The identified differences of attractiveness for performance levels. In MACBETH, decision maker can also give the interval values like weak- moderate or strong-very strong.

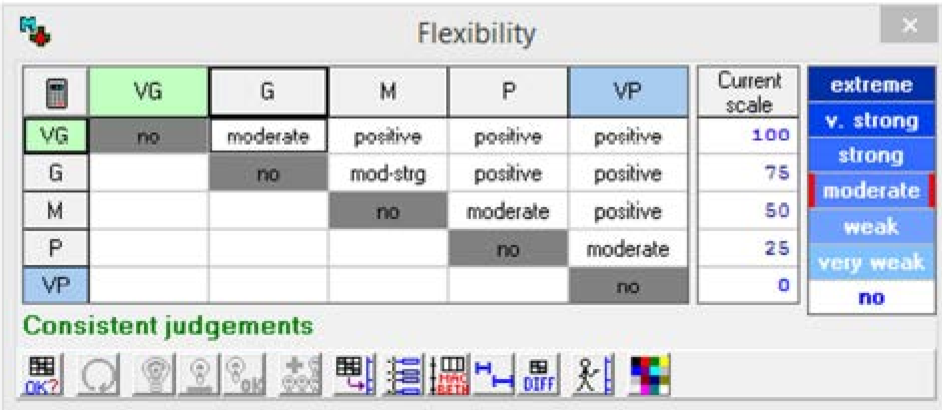
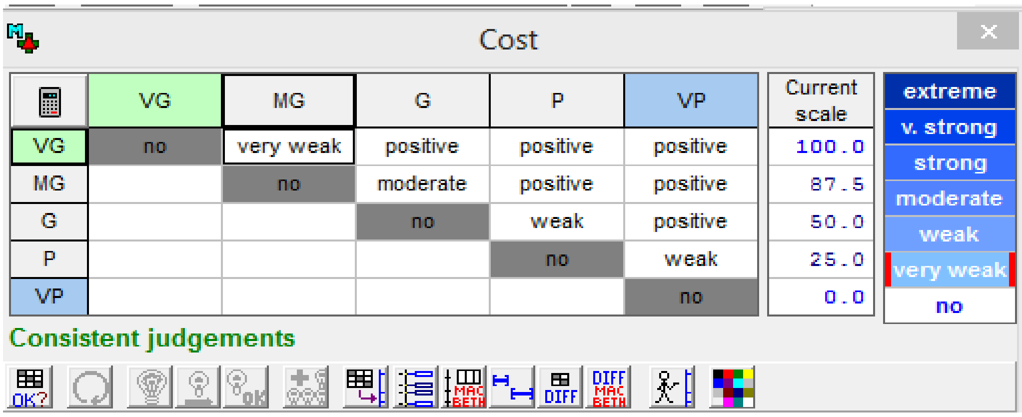


Fig. 5 -Comparison of performance levels for 'Flexibility' criterion.

2. RESULT

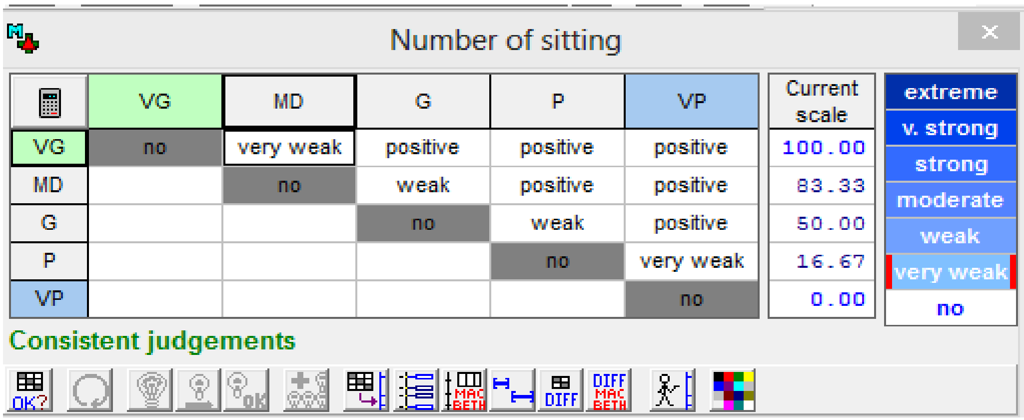
Seven ordinal performance levels, arranged in descending order of importance as 'very good' (VG), 'good' (G), 'medium good' (MG), 'fair' (F), 'medium poor' (MP), 'poor' (P) and very poor' (VP). In this example, the average of the decision maker's opinions is considered as the performance of an alternative with respect to a criterion. At first, the decision criteria and their performance levels are entered into M-MACBETH software according to descending order of their attractiveness. For beneficial criteria, VG being the most attractive performance level is selected as the upper performance level, while VP being the least attractive level is chosen as the lower



Cost

	VG	MG	G	P	VP	Current scale
VG	no	very weak	positive	positive	positive	100.0
MG		no	moderate	positive	positive	87.5
G			no	weak	positive	50.0
P				no	weak	25.0
VP					no	0.0

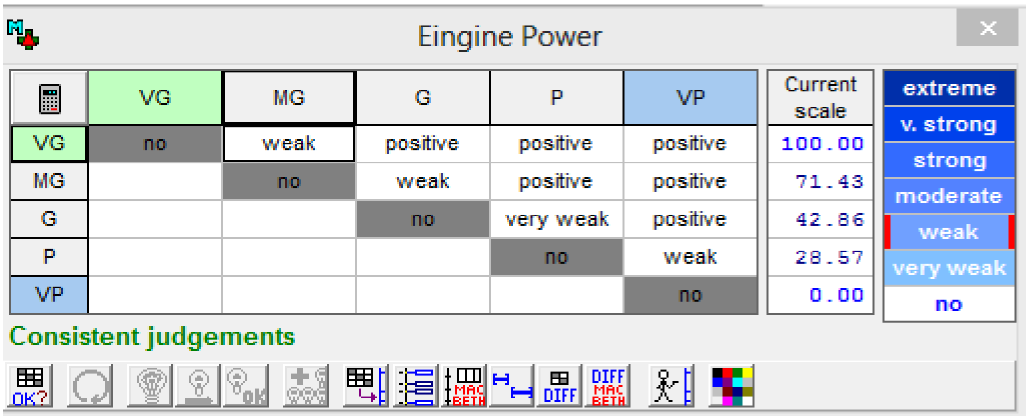
Fig. 6 -Comparison of performance levels for ‘cost criterion



Number of sitting

	VG	MD	G	P	VP	Current scale
VG	no	very weak	positive	positive	positive	100.00
MD		no	weak	positive	positive	83.33
G			no	weak	positive	50.00
P				no	very weak	16.67
VP					no	0.00

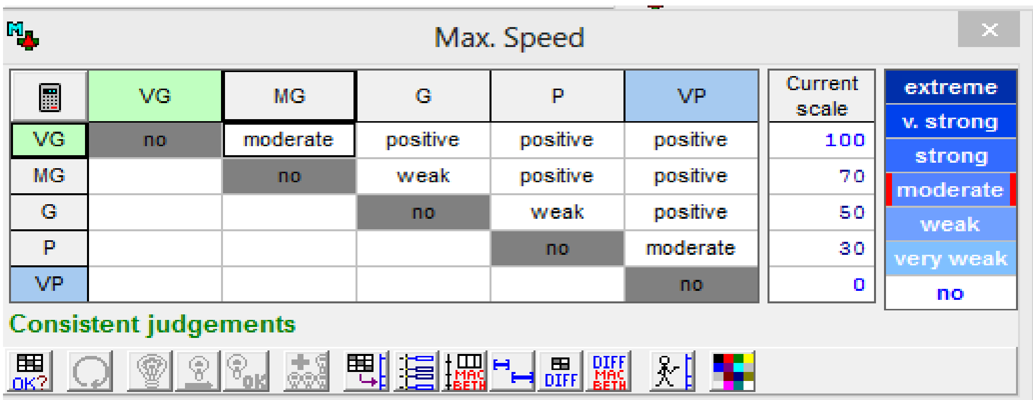
Fig. 6 -Comparison of performance levels for ‘No. of sitting criterion



Eingine Power

	VG	MG	G	P	VP	Current scale
VG	no	weak	positive	positive	positive	100.00
MG		no	weak	positive	positive	71.43
G			no	very weak	positive	42.86
P				no	weak	28.57
VP					no	0.00

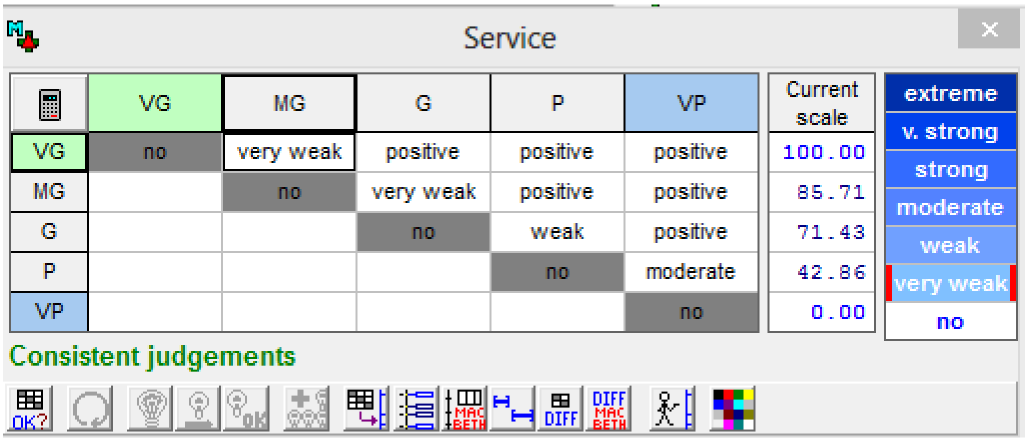
Fig. 7 -Comparison of performance levels for ‘Engine power’ criterion



Max. Speed

	VG	MG	G	P	VP	Current scale
VG	no	moderate	positive	positive	positive	100
MG		no	weak	positive	positive	70
G			no	weak	positive	50
P				no	moderate	30
VP					no	0

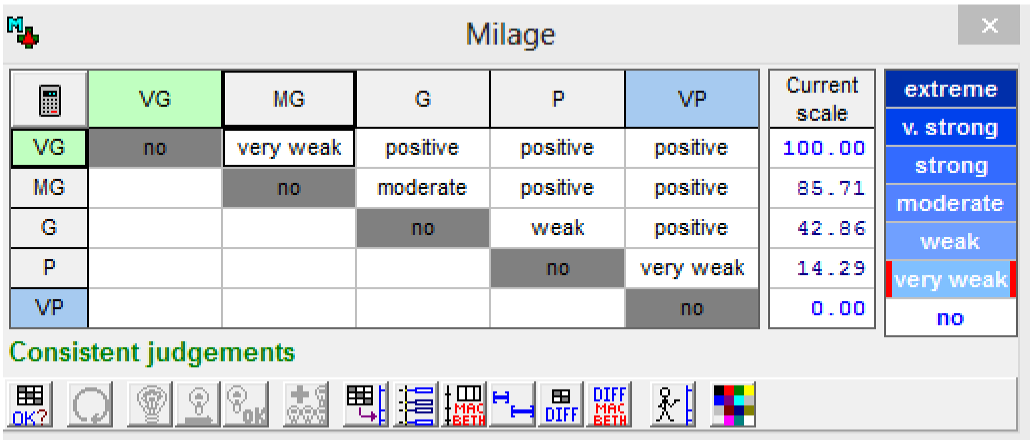
Fig. 8 -Comparison of performance levels for ‘Max. Speed’ criterion



Service

	VG	MG	G	P	VP	Current scale
VG	no	very weak	positive	positive	positive	100.00
MG		no	very weak	positive	positive	85.71
G			no	weak	positive	71.43
P				no	moderate	42.86
VP					no	0.00

Fig. 9 -Comparison of performance levels for ‘Service’ criterion



Milage

	VG	MG	G	P	VP	Current scale
VG	no	very weak	positive	positive	positive	100.00
MG		no	moderate	positive	positive	85.71
G			no	weak	positive	42.86
P				no	very weak	14.29
VP					no	0.00

Fig. 10 -Comparison of performance levels for ‘mileage’ criterion

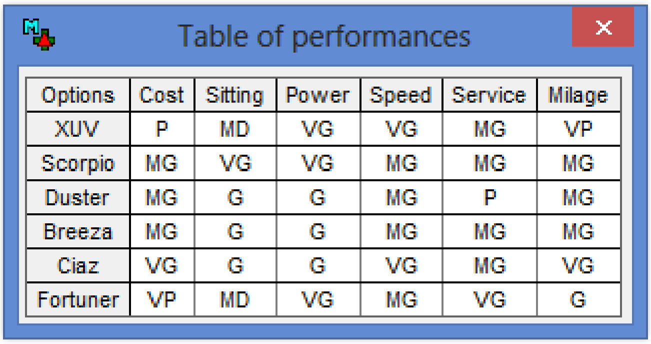
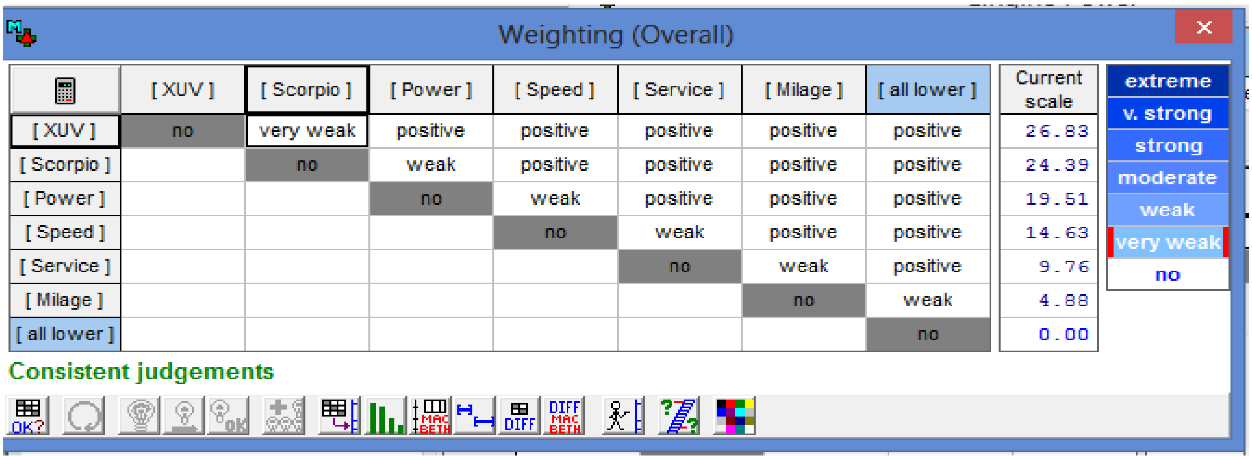


Table of performances

Options	Cost	Sitting	Power	Speed	Service	Milage
XUV	P	MD	VG	VG	MG	VP
Scorpio	MG	VG	VG	MG	MG	MG
Duster	MG	G	G	MG	P	MG
Breeza	MG	G	G	MG	MG	MG
Ciaz	VG	G	G	VG	MG	VG
Fortuner	VP	MD	VG	MG	VG	G

Fig. 11 -Table of performance of problem 2



Weighting (Overall)

	[XUV]	[Scorpio]	[Power]	[Speed]	[Service]	[Milage]	[all lower]	Current scale
[XUV]	no	very weak	positive	positive	positive	positive	positive	26.83
[Scorpio]		no	weak	positive	positive	positive	positive	24.39
[Power]			no	weak	positive	positive	positive	19.51
[Speed]				no	weak	positive	positive	14.63
[Service]					no	weak	positive	9.76
[Milage]						no	weak	4.88
[all lower]							no	0.00

Fig. 12 -MACBETH weighing judgments for supplier selection problem

Table of scores

Options	Overall	Cost	Sitting	Power	Speed	Service	Milage
XUV	69.54	25.00	83.33	100.00	100.00	85.71	0.00
Scorpio	90.17	87.50	100.00	100.00	70.00	85.71	85.71
Duster	62.64	87.50	50.00	42.86	70.00	42.86	85.71
Breeza	66.82	87.50	50.00	42.86	70.00	85.71	85.71
Ciaz	75.26	100.00	50.00	42.86	100.00	85.71	100.00
Fortuner	61.93	0.00	83.33	100.00	70.00	100.00	42.86
[all upper]	100.00	100.00	100.00	100.00	100.00	100.00	100.00
[all lower]	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Weights :		0.2683	0.2439	0.1951	0.1463	0.0976	0.0488

Fig. 13 - Table of score of problem

After performing analysis it is seen that the maximum overall score is 90.17 which is Scorpio and it is best choice. The predicted performance of cars in increasing order is Scorpio >Ciaz> XUV >Breeza> Duster > Fortuner.

3. CONCLUSION

In this paper, MACBETH method, belonging to the class of MAUT techniques, is applied for solving supplier selection problems. Its applicability is illustrated with real time examples and the obtained results are compared. It is noted that the pair-wisecomparison of performance between the alternatives and two selected reference levels help to produceaccurate results in MACBETH method. The support of M-MACBETH software also improves theusefulness of this method in solving complex decision-making problems having performance of thealternatives expressed in ordinal scale. Sensitivity analysis is also performed to visualize the effects ofchanging criteria weights on the final rankings of the alternative suppliers.

REFERENCES

[1] C. T. Lin, K. P. Hung, and S. H. Hu, “A decision-making model for evaluating and selecting suppliers for the sustainable operation and development of enterprises in the aerospace industry,” Sustain., vol. 10, no. 3, 2018.

[2] M. Shanmuganathan, K. Kajendran, A. N. Sasikumar, and M. Mahendran, “Multi Attribute Utility Theory – An Over View,” Int. J. Sci. Eng. Res., vol. 9, no. 3, pp. 698–706, 2018.

[3] M. R. Feylizadeh and M. Bagherpour, “Manufacturing performance measurement using fuzzy multi-attribute utility theory and Z-number,” Trans. Famena, vol. 42, no. 1, pp. 37–49, 2018.

[4] D. Zhang, F. Zou, S. Li, and L. Zhou, “Green supply chain network design with economies of scale and environmental concerns,” J. Adv. Transp., vol. 2017, 2017.

[5] Ö. Tosun, “Using Macbeth Method for Technology Selection in Production Environment,” Am. J. Data Min. Knowl. Discov., vol. 2, no. 1, pp. 37–41, 2017.

[6] N. I. El Sawalhi and O. El Agha, “Multi-attribute utility theory for selecting an appropriate procurement method in the construction projects,” J. Constr. Dev. Ctries., vol. 22, no. 1, pp. 75–96, 2017.

[7] S. Sadaoui and S. K. Shil, “A multi-attribute auction mechanism based on conditional constraints and conditional qualitative preferences,” J. Theor. Appl. Electron. Commer. Res., vol. 11, no. 1, pp. 1–25, 2016.

[8] S. A. Chandraveer Singh Rathore, “International journal of engineering sciences & research technology supplier selection process in supply chain management,” Int. J. Eng. Sci. Res. Technol., vol. 5, no. 9, pp. 24–29, 2016.

[9] A. Yildiz and A. Y. Yayla, “Multi-Criteria Decision-Making Methods for Supplier Selection: a Literature Review,” South African J. Ind. Eng., vol. 26, no. 2, p. 158, 2015.

[10] D. Dhouib, “An extension of MACBETH method for a fuzzy environment to analyze alternatives in reverse logistics for automobile tire wastes,” Omega, vol. 42, no. 1, pp. 25–32, 2014.

[11] P. Karande and S. Chakraborty, “Using MACBETH method for supplier selection in manufacturing environment,” Int. J. Ind. Eng. Comput., vol. 4, no. 2, pp. 259–272, 2013.

[12] A. S. Hanlon, J. W. Weiss, S. Mcmahan, and E. Cheng, “Using the Multi-Attribute Utility Model to Better Understand Fruit and Vegetable Intake among College Students,” Californian J. Health Promot., vol. 10, no. 10, pp. 40–56, 2012.