

A BENCHMARK MODEL FOR INTERNAL ASSESSMENT OF INDUSTRY USING FUZZY TOPSIS APPROACH

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ABSTRACT

Internal assessment is one of the most important factor of an industry, needs appropriate improvement planning between the departments with development of Benchmark model among them. The proposed study applies Fuzzy Technique for Order Preference by Similarity to Ideal Solution to rank different alternatives. The preliminary results indicate that the proposed model is capable of determining appropriate competition between departments which are Human Resource, Finance, Production, Quality Assurance. To remove the subjectivity, the linguistic data about the attributes is converted into a crisp score by using fuzzy numbers and then the different alternatives are evaluated based on attributes by TOPSIS approach to find the best alternative according to the industry's requirement. Thus the endeavor has been made by the authors to give a simple model for the evaluation of internal assessment of an industry.

KEYWORDS

Benchmarking, MADM, Assessment, Ranking, Industry

1. INTRODUCTION

The essence of benchmarking is the process of identifying the highest standards of excellence for products, services and then make the improvements required to reach those standards, commonly called “best practices”. Benchmarking is recognized as “an essential tool for continuous improvement of quality” (Dattakumar & Jagadeesh 2003). Benchmarking is an important business practice priority and well defined tool for improving the weakness through improvement processes in which a company measures its performance against market leaders, finds how market leaders have achieved their performance levels and prudently uses this knowledge to improve its own performance (Saunders, Mann & Smith 2007). Benchmarking has been introduced by practitioners for improving their corporate competitive advantage. It has also been effectively used to reengineer business improvement programmes rely on effective development, integration and analysis of measurement data.

In the current society, with an increasing trend and complexity of information, the primary focus of industrial enterprises is to have continuous improvement. Since there is a close competition in the manufacturing industries and the market is highly competitive in this industry. Benchmarking is the most popularly adopted by industries to understand how well they are performing relative to their competitors. It is also used to identify what management practices are worthwhile to apply in own firm in order to achieve desired performance goals. Benchmarking has been defined

as the search for industry best practices that lead to superior performance (Camp 1989). In the process of best practice benchmarking, management identifies the best firms in their industry or in another industry where similar processes exist, and compares the results and processes of those studied to one's own results and processes. In this way, they learn how well the targets perform and more importantly the business processes that explain why these firms are successful.

In this study addition to industry analysis, it is trying to design a model for its department using Multi Criteria Decision Making method and fuzzy approach. This study is intended not only to increase competitiveness by providing the above model, but also to state that where departments lies for standardization. Since industries contains intangibility, inseparability and heterogeneity it makes people more difficult to measure quality. Since the evaluation is resulted from evaluator's view of linguistic variables, it must be conducted in an uncertainty, fuzzy environment. In order to overcome the issue, fuzzy set theory will be used into the measurement of performance. Fuzzy set theory aids in measuring the ambiguity of concepts that are associated with human being's subjective judgment. Nowadays, the fuzzy set theory has been applied to many fields of management science, like decision making (Chen, & Tzeng, 2007; Huang, Chiang, 2008; Liu & Lai, 2009) however, it is scarcely used in the field of service quality.

We propose a novel two-dimensional approach that determines the deferrable strategy with the most value by maximizing the real option values while minimizing the risks associated with each alternative strategy. Also, there is a need for an effective tool in identifying and prioritizing relevant criteria to develop a systematic quality measurement process. The approach should also develop consensus decision making because MADM is a practical tool for selection and ranking of a number of alternatives and its applications are numerous. The high flexibility of this concept is able to accommodate further extension to make better choices in various situations. It is not uncommon for certain groups to constantly make complex decisions within organizations. However for using any MADM technique it is usually assumed that the decision information is provided in advance by a group of team. TOPSIS has been deemed one of the major decision making techniques within the manufacturing and service area. In addition the concept of TOPSIS has also been connected to multi-objective decision making and group decision making. The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a multi-criteria decision analysis method which was originally developed by Hwang & loon in 1981 with further developments by Yoon in 1987 and Hwang, Lai and Liu in 1993. TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. It is a method of compensatory aggregation that compares a set of alternatives by identifying weights for each criterion, normalizing scores for each criterion and calculating the geometric distance between each alternative and the ideal alternative which is the best score in each criterion. An assumption of TOPSIS is that the criteria are monotonically increasing or decreasing. Normalization is usually required as the parameters or criteria are often of incongruous dimensions in multi-criteria problems.. To simplify the decision making activities, it is suggested an integrated group TOPSIS procedure for solving real-world problems, with the goal of making effective decisions.

An endeavor has been made in this paper to evaluate the performance of various departments in the industry by using Fuzzy TOPSIS process, so that managers can choose the right decision for improvement with confidence. TOPSIS is the best established technique and used by many researchers to model the decision making processes. It is the technique, which evaluates the alternatives with the ideal solution, the alternative which is closest to the positive ideal solution and farthest from the negative ideal solution, will be the best choice. To convert the linguistic

data of intangible factors into crisp score the 11 point scale has been used. The results of this research paper convert the subjective decision making process into objective. It becomes easier for managers to compare the different departments on the basis of objective values. This will improve a lot of planning and strategies which becomes more effective for the industry.

2. LITERATURE REVIEW

Benchmarking evaluation has been targeted by many researchers. Sambasivarao et al. (1997) developed a decision support system for evaluation of advanced manufacturing system. Kengpol et al. (2001) applied analytical hierarchy process to select advanced technology by incorporating quantitative (objective) and qualitative (subjective) factors. Yurdakul (2004) also utilized a combination of analytical hierarchy process and goal programming for evaluation of computer-integrated manufacturing technologies. The model used analytical hierarchy process to determine attributes weights in goal programming. The main problem of these methods is that they are based on accurate measurement and crisp evaluation. But, in our routine life, most of the time attribute involves linguistic terms which need to be converted into crisp scores. Perego et al. (1998) presented reviews on the application of FMADM theory to the evaluation of manufacturing system. Proposed FMADM techniques belong to three categories: (1) fuzzy goal methodology, (2) fuzzy linguistic methods, and (3) fuzzy hierarchical models. G.R. Jahanshahloo et al. (2006) extend the method to decision-making problems and among multi-criteria models in making complex decisions and multiple attribute models for the most preferable choice. Mohamed F. and Ei-Santawy et al. (2012) select and rank consulting firms by suggesting new multi-criteria decision making approach for financial aspects to be optimized. Carlsson and Fullér (2003) introduced a (heuristic) real option rule in a fuzzy setting, where the present values of expected cash flows and expected costs are estimated by trapezoidal fuzzy numbers. Chen et al. (2007) developed a comprehensive but simple methodology to evaluate IT investment in a nuclear power station based on fuzzy risk analysis and real option approach. Frode (2007) used the conceptual real option framework of Dixit and Pindyck (1994) to estimate the value of investment opportunities in the Norwegian hydropower industry. Villani (2008) combined two successful theories, namely real options and game theory, to value the investment opportunity and the value of flexibility as a real option while analyzing the competition with game theory. Collan et al. (2009) presented a new method for real option valuation using fuzzy numbers. Their method considered the dynamic nature of the profitability assessment, that is, the assessment changes when information changes. As cash flows taking place in the future come closer, information changes and uncertainty is reduced. Chrysafis and Papadopoulos (2009) presented an application of a new method of constructing fuzzy estimators for the parameters of a given probability distribution function using statistical data. Wang and Hwang (2007) developed a fuzzy research and development portfolio selection model to hedge against the environmental uncertainties. They applied fuzzy set theory to model uncertain and flexible project information.

Mansour Momeni et al. (2011) evaluate different maintenance strategies for different equipment in MCDM problem by imprecise judgment of decision makers using TOPSIS for the evaluation of same. Jihong Pang et al. (2011) presents a systematic decision support approach to solve the optimization design problems of product quality based on quality function deployment (QFD) and TOPSIS. Iraj Alavi et al. (2011) fuzzy AHP and fuzzy TOPSIS methods are proposed for Plant species selection, where the ratings of various alternative under various subjective criteria and the weights of all criteria are represented by fuzzy numbers. Yahia Zare Mehrjerdi (2013) introduce a multi attribute decision making model for radio frequency identification system consisting of four main criteria and five alternatives, and second to develop and solve the proposed fuzzy

TOPSIS problem. By extension of TOPSIS method, an algorithm to determine the most preferable choice among all possible choices, when data is interval, is presented. K. Shahroudi et.al., (2012) present an integrated model and a supporting approach for effective supplier selection decisions and determined optimum order allocation. Therefore, an integrated approach of ANP-TOPSIS is proposed in choosing the best supplier and defined the optimum quantities order among selected supplier by using a mathematical model. Joshua Ignatius et. al., (2012) provides a novel integration and an unbiased method in reaching a transparent decision making outcome for the funding allocation of projects. The differences in implementation between the AHP-fuzzy-TOPSIS and other similar applications are discussed. F.Hosseinzadeh Lotfi et. al., (2007) extend the TOPSIS method for decision-making problems with Fuzzy data. By this extension of TOPSIS method, an algorithm for determining the most preferable choice among all possible choices in the case of fuzzy data is presented. Karsak et al., (2001) proposed an FMADM procedure for evaluating advanced manufacturing system investments. This approach applied fuzzy discounted cash flow analysis and decision-makers linguistic assessments to the economic criterion and strategic criteria respectively. Then mean operators are used to aggregate the triangular fuzzy numbers used in their algorithm. However, the non-financial terms are not considered in their method. These methods seem to be too complex. Therefore, the objective of this study is to measure performance by using Fuzzy TOPSIS, which further improves the evaluation process. Maysam Ashrafzadeh et.al.,(2012) present a multi-criteria decision making approach for warehouse location selection under fuzzy environment. Under many situations, the values of the qualitative criteria are often imprecisely defined for the decision-makers. In this paper, we present a multi-criteria decision making approach for selecting departments under partial information. To overcome this difficulty, fuzzy multi-criteria decision-making methods are proposed. From the literature as shown in table no.1, the following dimensions are taken, which are further used as attributes for our different alternatives departments of industry.

Table 1. Dimensions of departments

Dimensions	Criterion	Definitions
Tangibles	Building layout	Aesthetic, being convenient of the Industry
	Equipment	The availability of machinery in the production system achieving to Rate
Responsiveness	Timeliness	Ability to provide operations and promised production & quality on time
	Completeness	The availability of all kind of services perfectness at time
	Willingness	Helping employees willingly & completing requirements
Reliability	Accuracy	Accuracy, consistency given information regarding dimensions, production rate etc
	Expertise	Authority of staff providing reliability to specialized
	Image	Creating good vision to staff and maintain it
	Security	Protection of every type of system data
Assurance	Salary/rewards	Favorable payment at time & regard with money
	Courtesy	Courtesy of personnel and their ability to inspire trust and confidence
	Compensation	To give guaranty to the employees in case of a problem

Empathy	Caring	Individualized service attention & understanding needs of employees
	Manner	The attitude of personnel in the department setting
	Communication	Transfer of information between personnel and employees, the degree of interaction level of two-way communication
Professionalism	Skill	Competence and performance of staff
	Experience	The accumulation comes into existence step by step
	Innovation	Developing the personnel and hospital services, by trainings, using new technologies

3. METHODOLOGY

The proposed model will be followed as figure1 for solution of the problem in this paper. The framework consists of several steps which are consisting of definitions, conversions, modeling and analyzing phases.

Firstly, definition phase consist of introduction of Benchmarking where definition given by different authors are viewed and the behavior of paper is also viewed. Through literature, we are able to be identified the attributes in form of success factors which is quite helpful for preparation of questionnaires and general introduction of TOPSIS approach with FUZZY technique.

In second phase, questionnaire sent to departments where data is obtained in scale of 100 and measured by linguistic data about attributes converted to crisp score by using fuzzy numbers. Third phase included modeling of MADM approach i.e.TOPSIS, where data from fuzzy scale are used and further these will be solved by the steps of TOPSIS approach. Next phase is analyzing, which gives output resultant of the solution that make comparison between departments. This will give ranking of alternatives and conclusion for the study.

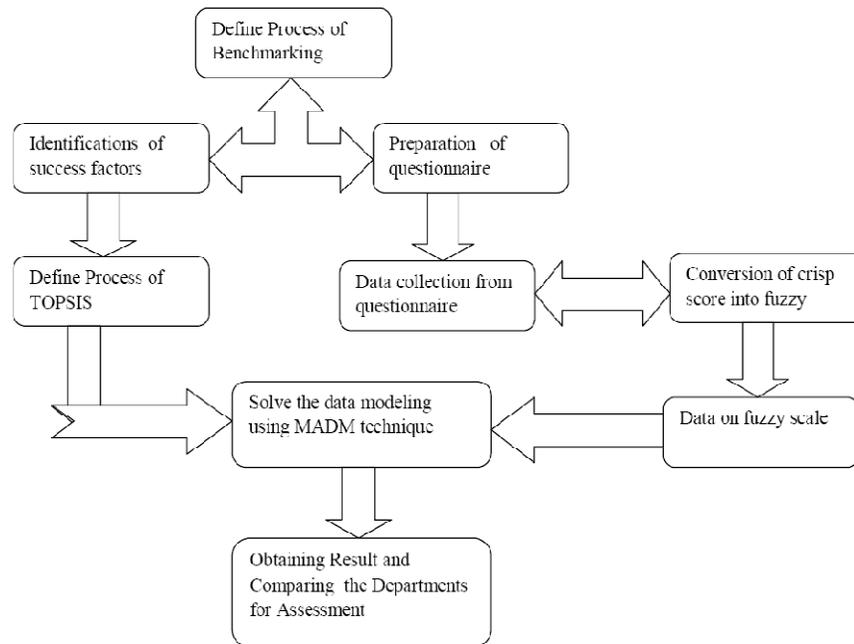


Figure1. Proposed Benchmark model

A brief discussion of Fuzzy Numbers and TOPSIS approach in a fuzzy environment is done in the following sections.

3.1 FUZZY Numbers

For converting linguistic terms used for describing intangible factors into crisp score, the evaluation experts use different scales as available in the literature. In this paper, an 11 point fuzzy scale suggested by Chen & Hwang (1992) has been adopted for measuring performance System. The scale is shown in Table 2.

Table 2 Conversion of Fuzzy Numbers into Crisp Score

Linguistic Terms	Fuzzy Numbers	Crisp Score
Exceptionally low	M1	0.045
Extremely low	M2	0.135
Very low	M3	0.255
Low	M4	0.335
Below normal	M5	0.410
Normal	M6	0.500
Above normal	M7	0.590
High	M8	0.665
Very High	M9	0.745
Extremely High	M10	0.865
Exceptionally High	M11	0.955

3.2 TOPSIS

This method was proposed by Hwang & Yoon (1981) and used to determine the best alternative based on the compromise solution. The compromise solution can be termed as the solution with the smallest Euclidean distance from the positive ideal solution and the farthest distance from the negative ideal solution. The positive ideal solution is regarded as the solution, when all the attributes reach its maximum value, and the negative ideal solution is termed as the solution, when all its attributes reach the minimum level. Therefore, TOPSIS method not only gives the solution closest to the optimal, but farthest from the inferior. The step by step procedure to calculate the best alternative by using TOPSIS method is as described:

Step 1: Building of decision matrix

The first step is to define the problem in terms of alternatives and attributes. This information is expressed in the form of decision matrix, as follows:

A_1, A_2, \dots, A_m represent the set of alternatives; a_1, a_2, \dots, a_n represent the set of attributes; x_{ij} represents the values of attributes j for alternative i .

$$A = \begin{matrix} \text{Alternatives} & a_1 & a_2 & \cdots & a_n \\ A_1 & x_{11} & x_{12} & \cdots & x_{1n} \\ A_2 & x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ A_m & x_{m1} & x_{m2} & \cdots & x_{mn} \end{matrix}$$

Step 2: Formation of normalized matrix

The next step is to form the normalized matrix from the decision matrix, 'A'. Normalization is done to bring the values, in a particular range and moreover, to make them dimensionless. The elements of the normalization matrix, 'B' are calculated as:

$$n_{ij} = \frac{x_{ij}}{\sum_{i=1}^m x_{ij}^2}$$

Where, x_{ij} are the elements of the decision matrix, 'A'.

Step 3: Formation of relative importance matrix, 'C'

Experts or practitioners are asked to do pairwise comparison among the attributes. Based upon that a relative importance matrix 'C' is formed, which is n X n matrix. This matrix has elements c_{ij} representing the relative importance of the i th attribute over the j th. The diagonal elements of this matrix will be '1'. The symmetric terms of the matrix will be reciprocal of each other.

Step 4: Calculation of weight vector

Eigenvector method is used to calculate the weight vector, as it allows some inconsistencies arising because of human behavior in building relative importance matrix 'C'. The other approaches can also be applied to find the weights like AHP, ANP, Standard Deviation Method, Entropy Method etc. To find the weight vector by using eigenvector method, the following equation is used:

$$Cx = \lambda x$$

where, λ is the eigenvalue of C and x is the corresponding eigenvector

The weight vector is calculated as follows:

- 1) Find x_{\max} , eigenvector, corresponding to the maximum eigenvalue λ_{\max}
- 2) Find the sum of the elements of x_{\max} as:

$$\delta = \sum_{i=1}^n (x_i)_{\max}$$

- 3) Finally, the weight vector is calculated as follows:

$$w = \frac{(x_{\max})}{\delta} \text{ such that } \sum_{i=1}^n w_i = 1$$

Step 5: Formation of weighted normalized matrix

The matrix, which combines the relative weights and normalized specification of the alternatives, is weighted normalized matrix, 'E'.

Step 6: Ranking of alternatives

The weighted normalized matrix 'E' is used to find the positive and negative ideal solutions. The Euclidean distance from the positive and negative ideal solution is calculated as:

The Euclidean distance from the positive ideal solution is given as:

$$S_i^+ = \sqrt{\sum_{j=1}^m (e_i^+ - e_{ij})^2}; i = 1, 2, 3, \dots, n$$

The Euclidean distance from the negative ideal solution is given as:

$$S_i^- = \sqrt{\sum_{j=1}^m (e_{ij} - e_i^-)^2}; i = 1, 2, 3, \dots, n$$

Relative closeness (K^*) of the Euclidean distance from the positive ideal solution is given as

$$K^* = \frac{S_i^-}{S_i^- + S_i^+}$$

To select the fuzzy based measurement the performance of departments, a hypothetical example consisting of four alternatives with 6 attributes have been considered, this is shown in the Table 3

Table 3 Data for Measuring Performance

Alternatives	AS	EA	RA	PO	RP	TG
A	38	63	40	EH	EH	H
B	31	62	31	EH	EH	VH
C	50	42	29	VH	VH	EH
D	64	50	52	H	VH	AN

Where, AS= Assurance, EA= Empathy, RA= Reliability, PO=Professionalism, RP=Responsiveness, TG= Tangibles, EH=Extremely High, H=High, VH=Very High, AN=Above Normal, N=Normal

Based upon Table 2, all the values of Table 3, have been converted on the 11 point scale. Linguistic terms are directly derived from the Table 2, like the values of Professionalism, Responsiveness and Reliability. The values of the other attributes have also converted on the Fuzzy scale by using following Equation

$$y-y_1 = \frac{y_2-y_1}{(x_2-x_1)} (x-x_1)$$

Where, ‘y’ represents the Fuzzy values of Table 2.

‘x’ represents the objective values of attributes (RO,RP and TG) of Table 3.

Table 4 Data on ‘11’ Point Fuzzy Scale

Alternatives	AS	EA	RA	PO	RP	TG
A	0.222	0.558	0.403	0.865	0.865	0.665
B	0.045	0.533	0.110	0.865	0.865	0.745
C	0.526	0.045	0.045	0.745	0.745	0.865
D	0.880	0.233	0.793	0.665	0.745	0.590

The alternative with the highest relative closeness will be the best choice. In this paper the authors selected the four different departments (A- Human Resources, B- Production, C- Quality Assurance, D- Finance) of a industry in India for applying the TOPSIS approach for priority wise ranking of above departments.

After that develop and distribute the Performa to the different people of Top, Middle and Lower level management of different department of industry for giving the points out of 100. A brief discussion of Fuzzy Numbers and TOPSIS approach in a fuzzy environment is done in the following sections.

To find the relative importance among the attributes, a group of experts were consulted. The relative importance matrix 'R' is shown table 5 below.

Table 5 Relative Matrix

$$R = \begin{bmatrix} 1 & 0.6 & 0.2 & 0.3 & 0.66 & 0.55 \\ 0.4 & 1 & 0.4 & 0.4 & 0.6 & 0.5 \\ 0.8 & 0.6 & 1 & 0.5 & 0.7 & 0.75 \\ 0.7 & 0.6 & 0.5 & 1 & 0.35 & 0.8 \end{bmatrix}$$

As a next step, maximum Eigen value of the relative importance matrix has been calculated, which is shown below table 6.

Table 6 Eigen value relative importance matrix

$$(R-J_{\max i}) = \begin{bmatrix} -2.358 & 0.6 & 0.2 & 0.3 & 0.66 & 0.55 \\ 0.4 & -2.358 & 0.4 & 0.4 & 0.6 & 0.5 \\ 0.8 & 0.6 & -2.358 & 0.5 & 0.7 & 0.75 \\ 0.7 & 0.6 & 0.5 & -2.358 & 0.35 & 0.8 \end{bmatrix}$$

In the next step, weights of each attribute are calculated from the knowledge of maximum Eigen value calculated in the previous step and value of weights are $w_1=0.15133$; $w_2=0.15871$; $w_3=0.21678$; $w_4=0.2159$.

In the following step, weight matrix 'E' is calculated by using Table 7.

Table no.7 Weighted Matrix

$$E = \begin{bmatrix} 0.034 & 0.089 & 0.087 & 0.187 & 0.104 & 0.091 \\ 0.007 & 0.085 & 0.024 & 0.187 & 0.104 & 0.102 \\ 0.08 & 0.007 & 0.01 & 0.161 & 0.09 & 0.118 \\ 0.133 & 0.037 & 0.172 & 0.144 & 0.09 & 0.081 \end{bmatrix}$$

This weighted matrix 'E' is all-inclusive matrix, which takes care of the attribute values and their relative importance. The weighted attributes for performance measurement can be obtained as

$E_{\max} =$	0.133	0.089	0.172	0.187	0.104	0.118
$E_{\min} =$	0.007	0.007	0.01	0.144	0.09	0.081

$S_i^+ =$	0.18	0.24	0.25	0.13
$S_i^- =$	0.15	0.12	0.11	0.21

Relative closeness to the ideal solution and ranking of departments based upon performance by using Fuzzy TOPSIS approach. The comparative evaluation by using other technique is beyond the scope of this paper due to its extended length. However, results as obtained from alternative

reliable and robust technique for the same input criteria have also been shown in Table 8 for comparison.

Table 8 Relative Closeness to Ideal Solution and Ranking

S.No.	K_i	Ranking based on current approach
1	0.46	2
2	0.34	3
3	0.30	4
4	0.62	1

Table 9. Ranking of departments

Value	0,62	0.46	0.34	0.30
Ranking	1	2	3	4
Department	D (Finance)	A (HR)	B (Production)	C (QA)

4. CONCLUSION

This paper presents ranking procedure based on performance measurement by using Fuzzy TOPSIS approach. It finds the relative importance among the selected attributes without which inter alternatives comparison is not possible. It presents the subjective decision making problem in terms of merit value, which can be used to evaluate the internal assessment of the company in order for development competitiveness between departments. The proposed technique, takes into account the subjective and objective attributes based on their crisp and linguistic features. This paper will provide ideal benchmark solution using elimination search procedures based on TOPSIS Approach. It finds the relative importance among the selected departments without which inter attribute comparison is not possible. It presents the subjective decision making problem in terms of merit value, which can be used to evaluate the priorities-wise ranking of the internal departments of the XYZ company. The present approach is quite helpful in developing solution strategies to complex manufacturing system behaviors in an easy manner in comparison to other similar techniques as available in the literature. The proposed method can be used as benchmarking for other departments as well as other industries. In future studies, other multi-criteria methods should also be considered for evaluating the performance in service industries also.

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