

# Application of Fuzzy Models in the Evaluation of Business Excellence – A Multi-organisation Research

Tintu B. Devaraj<sup>1</sup>, Dr. Satish K.P.<sup>2</sup>  
<sup>1,2</sup>Government Engineering College, Thrissur Kerala, India

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**Abstract:-** This paper describes an application of the fuzzy set theory to real problems. The problems we are studying here refer to concepts, policies, strategies and techniques of business excellence models used in industrial enterprises and also service companies. This paper focuses on the organisational evaluation process applied in the institutions in order to verify if the quality of their processes, products, services and general resources (mainly human resources) are reaching better levels. The paper utilizes comprehensive parameters and criteria from various Quality Awards such as National Brazilian Quality Awards, Malcolm Baldrige Quality Awards, Tata Business Excellence Model, and Deming's Prize as a reference. A questionnaire is prepared based on these criteria. The obtained results show the theoretical and practical adjustment of fuzzy sets to the general quality evaluation model under study. Proper Suggestions are provided for improving the effectiveness of the organization. Reliability and Validity of the questionnaire is also checked to improve the consistency of the research.

**Keywords:-** Fuzzy Set Theory, Business Excellence Models, Quality Evaluation Process, Reliability, Validity.

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## I. INTRODUCTION

It has been easy to list reasons that justify the need and opportunity to develop, in a permanent way, the quality evaluation. The quality is evaluated because it is a subject of high relevance for the organization survival. The quality importance requires a careful accompanying of its production process. Large number of variables which interferes in quality development requires a permanent analysis of the process, mainly because there are new elements appearing in the scenery. These arguments justify the need of evaluating the Quality Management, i. e., the business process which makes the evaluation feasible.

The business excellence evaluation is a process having wide objectives, involving the organization and its action in the environment. In order to reach this objective, specific indicators are always used. These indicators include sectors, areas, processes, functions, activities, and finally, individual and group contributions. The evaluation starts from parameters applied to the parts that compose the organization; after, it is utilized aggregation methods that, finally, determine a global parameter, which evaluates the whole organization. It can be observed that the methodology starts in the parts and finishes in the whole, with individual parameters being aggregate gradually. The determination of evaluation parameters has critical importance in the whole evaluation process. The final aggregation determines the global result.

## II. STRUCTURE OF THE BUSINESS EXCELLENCE EVALUATION PROCESS

The paper utilizes comprehensive parameters and criteria from various Business Excellence models and Quality Award models such as National Brazilian Quality Awards, Malcolm Baldrige Quality Awards, Tata Business Excellence Model, and Deming Prize as a reference. Here seven Criteria are taken for evaluating the Business Excellence or TQM as many organisations call it. It involves (i) Leadership (ii) Information and Analysis (iii) Strategy and Planning (iv) Development and Management of Human Resources (v) Quality Management Process (vi) Results Obtained Related to Quality and Operation (vii) Focus on the Client and its Satisfaction.

A questionnaire is prepared based on these seven criteria. The approach of the organization towards these criteria is assessed based on the choice given in the questionnaire. Since this paper focus on the fuzzy model that compare the effectiveness of TQM, and doesn't involves any ranking or awarding, sampling is not required. Any Top level manager who is concerned with the quality of product and operation can answer the questionnaire. The Criteria are as follows: (1) Leadership: it involves (1.1) High direction leadership; (1.2) Management for the quality; (1.3) Public responsibility and the relations of the enterprise with the social community (2) Information and analysis: it involves (2.1) Range and data and information management about quality and performance (2.2) Comparisons with the concurrence and also with excellence References (2.3) Analysis and use of data (3) Strategic planning and Quality: it involves (3.1) Strategic planning process of quality and performance of the enterprise (3.2) Plans for Quality and performance improvement (4) Development and management of human resources: it involves (4.1) planning and management of human resources (4.2) employees involvement (4.3) employees education and training (4.4) performance of the employees and recognizing them (4.5) employees welfare and satisfaction (5) Quality Management processes: it involves (5.1) project and introduction of products and services in the market (5.2) processes management -production and provision of products and Services processes (5.3) processes management -business and support (to clients) services (5.4) suppliers quality (5.5) quality evaluation process (6) Results obtained related to the quality and operations: it involves obtained results (6.1) related to the quality of the products and services (6.2) related to the enterprise operations (6.3) related to the business and the support (to clients) services (6.4) related to the quality of the suppliers' products and services (7) Focus on the client and the satisfaction: it involves (7.1) clients' expectation: present and future (7.2) clients relationship management (7.3) compromise with clients (7.4)

determination of the clients' satisfaction (7.5) results related to the clients' satisfaction (7.6) comparison of the clients' satisfaction.

### III. RELIABILITY TEST

In scientific research, accuracy in measurement is of great importance. Scientific research normally measures physical attributes which can easily be assigned a precise value. Many times numerical assessments of the mental attributes of human beings are accepted as readily as numerical assessments of their physical attributes. The magnitude of the imprecision is much greater in the measurement of mental attributes than in that of physical attributes. This fact makes it very important that the researcher in the social sciences and humanities determine the reliability of the data gathering instrument to be used.

The reliability of a research instrument concerns the extent to which the instrument yields the same results on repeated trials. Although unreliability is always present to a certain extent, there will generally be a good deal of consistency in the results of a quality instrument gathered at different times. The tendency toward consistency found in repeated measurements is referred to as reliability. Here internal consistency method is used to test the reliability of the questionnaire. Cronbach's Alpha provides a measure of the internal consistency of a test or scale; it is expressed as a number between 0 and 1. A value above 0.7 indicate high reliability of the data gathering instrument and a value below 0.7 indicates imprecision of the data gathering instrument. Statistical Software Mini Tab is used for testing the reliability.

Cronbach's Alpha = 0.8886

**Table I:** Cronbach's Values for 28 Questionnaire

Omitted Variable	Total Mean	Total StDev	Total Corr	Cronbach's Alpha
Q1	16.3	2.289	0.87188	0.87525
Q2	16.244	2.351	0.63413	0.88071
Q3	16.319	2.33	0.60557	0.88135
Q4	16.325	2.396	0.34526	0.88711
Q5	16.459	2.372	0.635	0.88069
Q6	16.25	2.288	0.8396	0.876
Q7	16.309	2.392	0.33158	0.8874
Q8	16.364	2.347	0.68771	0.8795
Q9	16.335	2.381	0.61433	0.88116
Q10	16.36	2.373	0.38115	0.88633
Q11	16.369	2.327	0.65301	0.88028
Q12	16.334	2.373	0.60244	0.88142
Q13	16.344	2.425	0.23332	0.88951
Q14	16.304	2.4	0.29193	0.88826
Q15	16.334	2.386	0.59692	0.88155
Q16	16.349	2.443	0.04018	0.89358
Q17	16.354	2.35	0.51404	0.8834
Q18	16.344	2.365	0.45451	0.88472
Q19	16.309	2.412	0.32339	0.88758
Q20	16.37	2.373	0.45938	0.88461
Q21	16.289	2.344	0.54289	0.88276
Q22	16.264	2.368	0.46526	0.88448
Q23	16.34	2.39	0.39803	0.88596
Q24	16.29	2.365	0.50905	0.88351
Q25	16.349	2.483	0.15221	0.89752
Q26	16.329	2.37	0.35571	0.88688
Q27	16.369	2.396	0.31164	0.88783
Q28	16.454	2.457	0.03066	0.89505

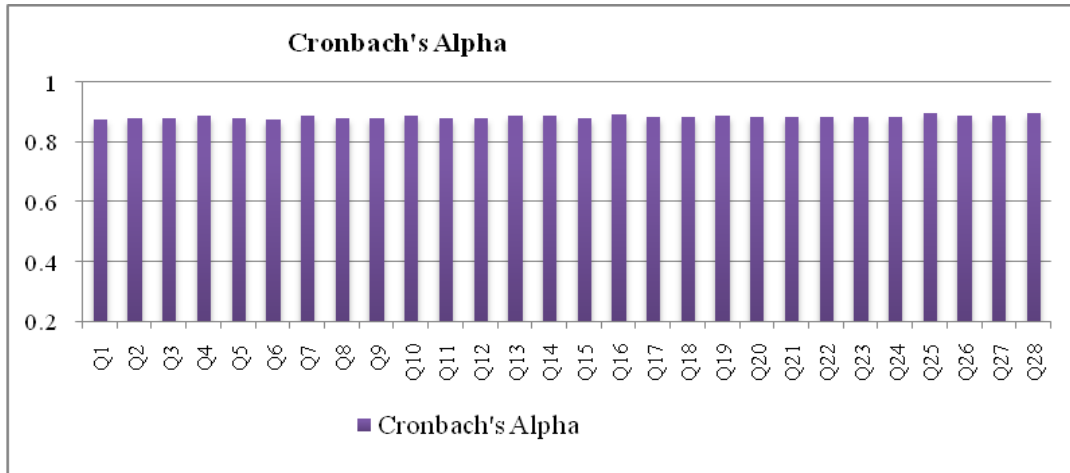


Fig 1: Cronbach's Alpha Value of Questionnaires

**IV. FUZZY MODEL FOR EVALUATION**

In this model the described seven criteria and twenty eight items are utilized. Each item includes four references to be considered in the questionnaire. These references have got a value called Percentage Grade denoted by the letter 'y'. Its values ranges from 25 to 95 (percentage). Therefore, the evaluation provides to the Organization, a posture according to many specific situations. Once defined the percentage to each item, this percentage grade is multiplied by the Weightage given to each Criteria. It must be noted two evaluation activities: At first the alternative is selected and it is given a grade to it. After that, considering its weight, it is obtained the "weighted grade". The weighted grade is denoted by 't'. The maximum evaluation value just can be obtained if the maximum weights to the 7 areas are attributed.

The variable t is associated to 8 basic membership functions according to the classification described by the variable y. The Table II describes these functions. The membership functions are determined based on the response of the top level management towards an item, i.e. based on the references they prefer.

- (a).  $0.1 < y \leq 0.25$ : A systematic approach was evident at the beginning. The approach is still in the early stage of deployment in most areas.
- (b).  $0.25 < y \leq 0.45$ : An effective systematic approach was evident at the beginning. The approach was not in good progress later on. Most of the areas are still in the early stage of deployment.
- (c).  $0.45 < y \leq 0.65$ : An effective systematic approach is evident throughout. Prior importance is given to the customer. The approach is well deployed although deployment may vary in some area.
- (d).  $0.9 < y < 1$ : An effective systematic approach is evident throughout. Primary importance is given to the customer. The approach is fully deployed without significant weakness or gaps in any areas.

Table II: 't' Intervals and Respective Membership Function (mf)

Variation of 't'	Choices	Percentage Grade: 'y' (%)	f	Membership function: U/A(t)
$0 \leq t \leq 1$	A	25	f1	$f(t) = t^2$
$0 \leq t \leq 1$	B	45	f2	$f(t) = t^{3/2}$
$0 \leq t \leq 1$	C	65	f3	$f(t) = t^{1/2}$
$0 \leq t \leq 1$	D	95	f4	$f(t) = t^{1/3}$

The twenty eight parameters can be classified as compensatory and non compensatory parameters. (a) Noncompensatory parameters: 1.2.; 2.2.; 3.1.; 3.2.; 4.5.;5.3.; 5.4.; 5.5.; 6.3.; 6.4.; 7.3.; 7.4; (b) Compensatory parameters (the rest) according to the Table III.

**Table III:** Compensatory Items

The parameter	Is compensated by	Justification given by the constraints
1.1	1.3	The social sense stresses the organizational towards the quality adopting
2.1	2.3	The large information analysis demands data from the company
4.1	4.4	The planning must include evaluation and recognizing mechanisms
4.2	4.3	The human resources involvement requires and activates education and training mechanisms
5.1	5.2	The key processes must be defined from the market requirements
6.1	6.2	The same above: Process results must be measured by results in terms of market
7.1	7.2	Well knowing the market, the organization can determine how to attend it
7.5	7.6	Satisfaction indicators can be organized by confronting values

The parameters aggregation is necessary to provide the organization evaluation as a whole and even compare it to other organizations. In the fuzzy set environment, this aggregation can be represented by intersection operators to fuzzy sets defined by parameters which compose the evaluation. The membership functions are aggregated using the formulas:

$$U1/A(t) = \min \{ U1.2/A(t) ; U1.1/A(t) + U1.3/A(t) - (U1.1/A(t)*U1.3/A(t)) \}$$

$$U2/A(t) = \min \{ U2.2/A(t) ; U2.1/A(t) + U2.3/A(t) - (U2.1/A(t)*U2.3/A(t)) \}$$

$$U3/A(t) = \min \{ U3.1/A(t) ; U3.2/A(t) \}$$

$$U4/A(t) = \min \{ U4.5/A(t); U4.2/A(t)+U4.3/A(t) - (U4.2/A(t)*U4.3/A(t)); U4.1/A(t) + U4.4/A(t) - (U4.1/A(t)*U4.4/A(t)) \}$$

$$U5/A(t) = \min \{ U5.3/A(t) ; U5.4/A(t) ; U5.5/A(t) ; U5.1/A(t) + U5.2/A(t) - (U5.1/A(t)*U5.2/A(t)) \}$$

$$U6/A(t) = \min \{ U6.3/A(t); U6.4/A(t); U6.1/A(t)+ U6.2/A(t)-(U6.1/A(t)*U6.2/A(t)) \}$$

$$U7/A(t) = \min \{ U7.3/A(t) ; U7.4/A(t) ; U7.1/A(t) + U7.2/A(t) - (U7.1/A(t)*U7.2/A(t)); U7.5/A(t) + U7.6/A(t) - (U7.5/A(t)*U7.6/A(t)) \}$$

General Aggregation Function:

$$U/A(t) = \min \{ U1/A(t) ; U2/A(t) + U3/A(t) - (U2/A(t)*U3/A(t)); U4/A(t) ; U5/A(t) + U6/A(t) - (U5/A(t)*U6/A(t)); U7/A(t) \}$$

## V. APPLICATION OF FUZZY MODEL

Twenty companies are taken for the evaluation of TQM. The effectiveness of TQM implemented in two companies are compared using this fuzzy model at a time and identifies the weakest areas. ISO Certified companies are chosen for evaluation. The model gives us two types of evaluation-Internal evaluation and External evaluation. Internal evaluation point out the critical areas of the individual company under study and External evaluation point out the critical area of one company when compared to the other company under comparison. A company and its competitor are taken for comparison. They are (1) Pigment Manufacturers (2) Mineral Industries (3) Fertilizer Manufacturers (4) Metallic Minerals Manufacturers (5) Software Organization (6) Tyre Manufacturers (7) Cement Manufacturers (8) Metallurgical Industries (9) Chemical Industries (10) Healthcare Industries. The fuzzy evaluation model for the twenty companies is derived from the above mentioned Fuzzy model. The evaluation model for the Pigment Manufacturer is as follows:

**Table IV:** Fuzzy model for Company A & Company B

Item	Company A	Company B
1	0.9312,0.9823	0.7433,0.4172
2	0.6982,0.9678	0.1961,0.7574
3	0.6982,0.6982,	0.1961,0.6982
4	0.7433,0.8040, 0.9341	0.7433,0.8040, 0.8040
5	0.9491,0.9491, 0.9491,0.9880	0.7649,0.7649, 0.7649,0.9447
6	0.9126,0.9126, 0.9756	0.7211,0.7211, 0.3853
7	0.9830,0.9830, 0.9624,0.8183	0.8062,0.0625, 0.5127,0.5127
General	Minimum: 0.9312,0.6982, 0.6982,0.7433, 0.9491, 0.9126, 0.8183 Compensatory Aggregation 0.9312,0.9089, 0.7433,0.9956, 0.8183	Minimum: 0.4172,0.1961, 0.1961,0.7433, 0.7649,0.3853, 0.0625 Compensatory Aggregation 0.4172,0.3537, 0.7433,0.8555, 0.0625

**A. Internal Evaluation**

Critical Value for Company A is 0.7433

Critical Item for Company A is U4/A (t)

I.e. Development and management of Human Resources. In this criterion the company has got the minimum value for Employee welfare and satisfaction.

Critical Value for Company B is 0.0625

Critical Item for Company B is U7/A (t)

I.e. focus on the clients. In this criterion the company has got the minimum value for Client Relationship Management and Compromise with the client

**B. External Evaluation.**

Values of Company B below the critical value of Company A are:

(1) 0.4172

U1/A(t) i.e. Leadership. It includes High Direction Leadership and Public Responsibility and the Relation of the Enterprise with Social Community.

(2) 0.3537

U2/A(t) i.e. Information and Analysis. It includes Comparisons with the Concurrence and Also With Excellence References.U3/A(t) Strategic Planning and Quality. It includes Strategic planning process of quality and performance of the Enterprise.

**VI. MODEL APPLICATION RESULTS**

The Fuzzy Model is evaluated for the remaining companies. The results obtained are:

**1. Mineral Industries**

*A Internal Evaluation*

Critical Value for Company A is 0.2711

Critical Item for Company A is U4/A (t)

I.e. Development and management of Human Resources. In this criterion the company has got the minimum value for Employee Involvement and Employee Education and training

Critical Value for Company B is 0.0886

Critical Item for Company B is U5/A (t) & U6/A (t)

I.e. Quality Management Process. In this criterion the company has got the minimum value for Supplier Quality and Quality Evaluation Process  
Results related to the Quality and Operations. In this criterion the company has got the minimum value for Results related to the business and support service

*B. External Evaluation.*

Values of Company B below the critical value of Company A is:

(1) 0.2366

U4/A (t) Development and Management of Human Resources. It includes Employee Welfare and Satisfaction

**2. Fertilizer Manufacturers**

*A. Internal Evaluation*

Critical Value for Company A is 0.0692

Critical Item for Company A is U2/A (t) & U3/A (t)

I.e. Information and Analysis. In this criterion the company has got the minimum value for Comparison with the Concurrence and also with Excellence References

Strategic Planning and Quality. In this criterion the company has got the minimum value for Strategic Planning Process of Quality and Performance of the Enterprise and Plans for Quality and Performance Improvement

Critical Value for Company B is 0.0692

Critical Item for Company B is U2/A (t) & U3/A (t)

I.e. Information and Analysis. In this criterion the company has got the minimum value for Comparison with the Concurrence and also with Excellence References .

Strategic Planning and Quality. In this criterion the company has go the minimum value for Plans for Quality and Performance Improvement

*B. External Evaluation.*

Since no other items of Company B has value below minimum value of Company A, both are performing well

**3. Metallic Minerals Manufacturers**

*A. Internal Evaluation*

Critical Value for Company A is 0.7433

Critical Item for Company A is U4/A (t)

I.e. Development And Management Of Human Resources In this criterion the company has got the minimum value for Employee Welfare and Satisfaction.

Critical Value for Company B is 0.2366

Critical Item for Company B is U4/A (t)

I.e. Development And Management Of Human Resources In this criterion the company has got the minimum value for Employee Welfare and Satisfaction

*B. External Evaluation.*

Values of Company B below the critical value of Company A is:

(1) 0.3537

U2/A (t) Information and Analysis. It includes Comparison with the Concurrence and Also with Excellence References.

U3/A(t) Strategic Planning and Quality. It includes Strategic Planning Process of Quality and Performance of the Enterprise

(2) 0.4180

U5/A(t) Quality Management Process. It includes Supplier Quality and Quality Evaluation Process.U6/A (t) Result Obtained Related to the Quality and Operations. It includes Result Related to Business and the Support Services

(3) 0.0319

U7/A (t) Focus On The Client. It includes Determination of Client's Satisfaction

**4. Software Organization**

*A. Internal Evaluation*

Critical Value for Company A is 0.7433

Critical Item for Company A is U4/A (t)

I.e. Development and management of Human Resources. In this criterion the company has got the minimum value for Employee Welfare and Satisfaction

Critical Value for Company B is 0.3537

Critical Item for Company B is U2/A (t) & U3/A (t)

I.e. Information and Analysis. In this criterion the company has got the minimum value for Comparison with the concurrence and also with the Excellence References.

Strategic Planning and Quality. In this criterion the company has got the minimum value for Strategic Planning Process of Quality and Performance of the Enterprise

*B. External Evaluation.*

Values of Company B below the critical value of Company A is:

(1) 0.4180

U5/A (t) Quality Management Process. It includes Process Management Business and Support and Supplier Quality and Quality Evaluation Process. U6/A (t) Results related to the Quality and Operation It includes Results Related to Quality of supplier's product and services .

## **5. Tyre Manufacturers**

### *A. Internal Evaluation*

Critical Value for Company A is 0.7574

Critical Item for Company A is U2/A (t) & U3/A (t)

I.e. Information Analysis. In this criterion the company has got the minimum value for Comparison with the Concurrence and also with Excellence Reference

Strategic Planning and Quality. In this criterion the company has got the minimum value for Strategic Planning Process of Quality and Performance of the Enterprise

Critical Value for Company B is 0.7433

Critical Item for Company B is U1/A (t) & U4/A (t)

I.e. Leadership. In this criterion the company has got the minimum value for Management for the Quality'

Development and Management of Human Resources. In this criterion the company has got the minimum value for Employee Welfare and Satisfaction

### *B. External Evaluation.*

Since no other items of Company B has value below minimum value of Company A both are performing at well.

## **6. Cement Manufacturers**

### *A. Internal Evaluation*

Critical Value for Company A is 0.7433

Critical Item for Company A is U4/A (t)

I.e. Development and Management of Human Resources. In this criterion the company has got the minimum value for Employee Welfare and Satisfaction

Critical Value for Company B is 0.0625

Critical Item for Company B is U7/A (t)

I.e. Focus on the Client. In this criterion the company has got the minimum value for determination of client's satisfaction.

### *C. External Evaluation.*

Values of Malabar Cements below the critical value of Travancore Cements is:

(1) 0.4172

U1/A(t) Leadership. It includes High Direction Leadership and Public Responsibility and the Relation of the Enterprise with Social Community.

(2) 0.3537

U2/A(t) Information and Analysis. It includes Comparison with the Concurrence and also with the Excellence References. U3/A(t) Strategic Planning and Quality. It includes Strategic Planning Process of Quality and Performance of the Enterprise.

## **7. Metallurgical Industries**

### *A. Internal Evaluation*

Critical Value for Company A is 0.2366

Critical Item for Company A is U4/A (t)

I.e. Development and Management of Human Resources. In this criterion the company has got the minimum value for Employee Welfare and Satisfaction

Critical Value for Company B is 0.0692

Critical Item for Company B is U2/A (t) & U3/A (t)

I.e. Information and Analysis. In this criterion the company has got the minimum value for Comparison with Concurrence and also with the Excellence References

Strategic Planning and Quality. In this criterion the company has got the minimum value for Strategic Planning Process of Quality and Performance of the Enterprise

### *B. External Evaluation.*

Since no other items of Company B have value below minimum value of Company A, both are performing well.

## **8. Chemical Industries**

### *A. Internal Evaluation*

Critical Value for Company A is 0.7574

Critical Item for Company A is U2/A (t) & U3/A (t)

I.e. Information and Analysis. In this criterion the company has got the minimum value for Comparison with the concurrence and also with Excellence References  
Strategic Planning and Quality. In this criterion the company has got the minimum value for Strategic Planning Process of Quality and Performance of the Enterprise and Plans for Quality and Performance Improvement.

Critical Value for Company B is 0.3018

Critical Item for Company B is U7/A (t)

I.e. Focus on the Client. In this criterion the company has got the minimum value for Compromise with the Client

*B. External Evaluation.*

Values of Company B below the critical value of Company A is:

(1) 0.3537

U2/A(t) Information and Analysis. It includes Comparison with the Concurrence and Also With Excellence References. U3/A (t) Strategic Planning and Quality. It includes Strategic Planning Process of Quality and Performance of the Enterprise and Plans for Quality and Performance Improvement.

## **9. Health Care Industry**

*A. Internal Evaluation*

Critical Value for Company A is 0.7433

Critical Item for Company A is U1/A (t)

I.e. Leadership. In this criterion the company has got the minimum value for Management for the Quality

Critical Value for Company B is 0.2366

Critical Item for Company B is U1/A (t)

I.e. Leadership.. In this criterion the company has got the minimum value for Management for the Quality.

*B. External Evaluation.*

Values of Company B below the critical value of Company A is:

(1) 0.5127

U7/A (t) Focus on the Client. It includes Results Related to Client's Satisfaction and Comparison of the Client's Satisfaction.

## **VII. CONCLUSION**

Several interesting practical conclusions were obtained from the model applications in at least 20 real situations. Initially, it must be denoted that the idea of applying fuzzy sets to the Quality Management proceedings came from the practical observation. Thus, it is a proposal of strong empirical content. The model operational structure assumed the global parameters of various Quality Award like National Brazilian Quality Awards, Malcolm Baldrige Quality Awards, Tata Business Excellence Model, and Deming Prize etc.

Analyzing from the practical point of view, the fuzzy approach is reliable. Moreover, the fuzzy logic does not oppose users' intuitive actions. It can be concluded that the fuzzy set theory is a relevant tool for modeling the quality evaluation process.

Using this Fuzzy Model we have analyzed the critical areas of the companies taken for comparison. Both internal evaluation and External evaluation have been adopted for analysis. Based on the critical area pointed out, Proper suggestions are given for improvement. The suggestions are taken from the characteristics of those Successful companies in the particular criteria. They are:

### **1. High Direction Leadership**

- Senior leaders should deploy organization's vision and values through leadership system to the workforce, to key suppliers and partners and to customers and other stakeholders.
- They should create a sustainable organization through the accomplishment of mission and strategic objectives, innovation, performance, leadership and organizational agility.
- Performance evaluation should be done to senior leaders for leadership improvement

### **2. Management for the Quality**

- Senior leaders should encourage the workforce by enhancing the importance of quality improvement.
- They should create a positive workforce culture and develop and enhance their leadership skills
- They should encourage frank two way communication throughout the organization.

### **3. Public Responsibility and the Relations of the Enterprise with the Social Community**

- Senior leaders should anticipate public concerns with current and future products and operations
- They should address any advice impact on society of products and operations.
- They should be prepared for these impacts and concerns in a pro active manner, including conserving natural resources and using effective supply chain management process.
- Leaders should monitor and respond to branches of ethical behavior in governance structure

### **4. Comparison with the Concurrence and also with Excellence References**

- select and ensure the effective use of key comparative data and information to support operational and strategic decision making and innovation
- Effectively make use of the voice of the customer data and information (including complaints) to support operational and strategic decision making and innovation.



- Compare the data management system with excellent references to identify defects
- 5. Strategic Planning Process of Quality and Performance of the Enterprise
  - Organization should have a well defined strategic planning and the process of defining strategy should identify blind spots.
  - Strategic planning process address to short and long term planning time horizon.
  - Strategic planning should also address to the key element like strength, weaknesses, opportunities and threat.
- 6. Plans for Quality and Performance Improvement
  - Organization should convert its strategic planning into action plans.
  - key performance measures or indicators should be identified to track the achievements and effectiveness of action plans
  - The action plans should be deployed throughout the organization to workforce and to key suppliers and partners as appropriate to achieve key strategic objectives.
- 7. Employee Involvement
  - Determine the key elements that affect workforce engagement.
  - Foster an organizational culture that is characterized by open communications, high performance work and an engaged workforce.
  - Formal and informal assessment methods and measures should be used to determine workforce engagement.
- 8. Employees Education and Training
  - provide education and training for your workforce members and leaders
  - Learning and development system should address organization's core competencies, strategic challenges and accomplishments of action plans, Ethics and ethical business practices and customer focus
  - Evaluate the effectiveness and efficiency of learning and development system.
- 9. Employee Welfare and Satisfaction
  - Address the workplace environmental factors, including accessibility to ensure and improve workforce health, safety and security.
  - pay attention to workforce; its needs to ensure continuity, prevent workforce reduction and minimize the impact of workforce reduction
  - Support workforce via policies, services and benefits.
- 10. Processes Management-Business and Support Services
  - identify the current level of market place performance, including market share or position, market and market share growth and new market entered
  - Analyse financial viability etc to grow your business. Proper services should be provided to the customer after delivery.
- 11. Supplier Quality
  - Ensure that supplier selected are qualified and positioned to enhance performance and customer satisfaction.
  - Continuously evaluate supplier performance and discard poorly performing suppliers.
- 12. Quality Evaluation Process
  - Project manager of the company has to create a team dedicated for quality control.
  - The performance of the quality control team should be monitored regularly by the project manager against quality control plan, schedule and budget.
- 13. Related to Business and the Support Services
  - Analyse current levels and trends in key measures or indicators of financial performance including aggregate measures of financial returns, financial viability or budgetary performance
  - Follow up with customers on the quality of the product, customer support and transactions to receive immediate and actionable feedback.
- 14. Client Relationship Management
  - Market, build and manage relationship with customers to achieve customers and build market share, Retain customers, meet their requirements and exceed their expectations in each stage of customer life cycle,
- 15. Compromise with Clients
  - Customer complaints management process should ensure that the complaints are resolved promptly and effectively.
  - Enable the clients to conduct their business with organization and provide feedback on products.
- 16. Determination of Client's Satisfaction
  - Determine your customer's satisfaction and dissatisfaction level.
  - Measurement should capture actionable information for use in exceeding customer's expectation and securing customer's engagement.
- 17. Comparison of the Client's Satisfaction
  - Obtain information on customer's satisfaction relative to their satisfaction with competitors.
  - obtain information on customer's satisfaction relative to the satisfaction level of customers of other organization providing similar products

The results can be concluded by cross evaluating the twenty companies. If we analyze the twenty companies as a whole, we can see that 60 % of the companies have their critical value in "Strategic Planning and Quality". They have to concentrate more on "Strategic Planning Process of Quality and Performance of the Enterprise". About 50% of the companies have their critical area in "Information and Analysis" and "Development and Management of Human

Resources”. They have to concentrate more in “Comparison with the Concurrence and also with Excellence References” and “Employee Welfare and Satisfaction”. About 40% of the companies have their critical area in “Focus on the Client”. They have concentrate more in “Compromise with the Client”.

About 35% of the companies have their critical area in “Leadership”. They have to concentrate more in “Management for Quality” and “Supplier Quality”. Only 15% of the companies have their Critical area in “Result Obtained Related to the Quality and Operations”. Such companies have to concentrate more in “Results Related to Business and the Support Services”. A graphical representation is shown in Fig 2 .From this figures we can infer that approach of the companies towards Strategic planning and Quality is poor.

From the minimum values obtained from the fuzzy model we can analyze that lowest minimum value is obtained for the companies Pigment Manufacturer Company B and Cement Manufacturer Company B. Their value is 0.0625. They are the weakest ones among the twenty companies. Even though TQM is implemented in these companies, they are not that much effective. They have to improve their approach towards TQM. The Highest Minimum value is obtained for the companies Tyre Manufacturer Company A and Chemical Industry Company A. They got the value 0.7574.The companies Pigment Manufacturer Company A, Software Organization Company A, Tyre manufacturer Company B, Healthcare Industry Company A are also having value near to highest minimum value. Their fuzzy model minimum value is 0.7433 which is very near to 0.7574.So these companies have implemented TQM more effectively when compared to others. A graphical representation is shown in Fig 3

The reliability analysis done by using Minitab, the Cronbach’s Alpha obtained is 0.8886 which is greater than 0.7.This Cronbach’s value indicates high reliability of the questionnaire. If the attributes taken to evaluate the twenty eight items addresses to the Criteria are relevant and effective. Since the Choices for questionnaire are taken from universally accepted Malcom Baldrige Quality Awards, the Questionnaire is valid.

### VIII. DIRECTION FOR FUTURE RESEARCH

The Quality Management evaluation is a process having wide objectives, involving the organization and its action in the environment. In order to reach these objectives, special indicators like sectors, areas, process, functions, activities and finally individual and group contributions are used. In this project Fuzzy model pointed out the critical areas and has given proper suggestions for improvement. Re-evaluation of Quality Management process can be done after implementing these suggestions in the organizations under study. This will improve the effectiveness of the TQM implemented. Here we have taken the ISO certified companies for the evaluation. All the criteria taken for evaluation have already implemented in these companies and we are just measuring its effectiveness. So this Fuzzy Model sounds more beneficial to a newly established companies or organizations under deployment. Such companies and ISO certified companies can be taken for comparison. This will help them to implement TQM in an efficient manner.

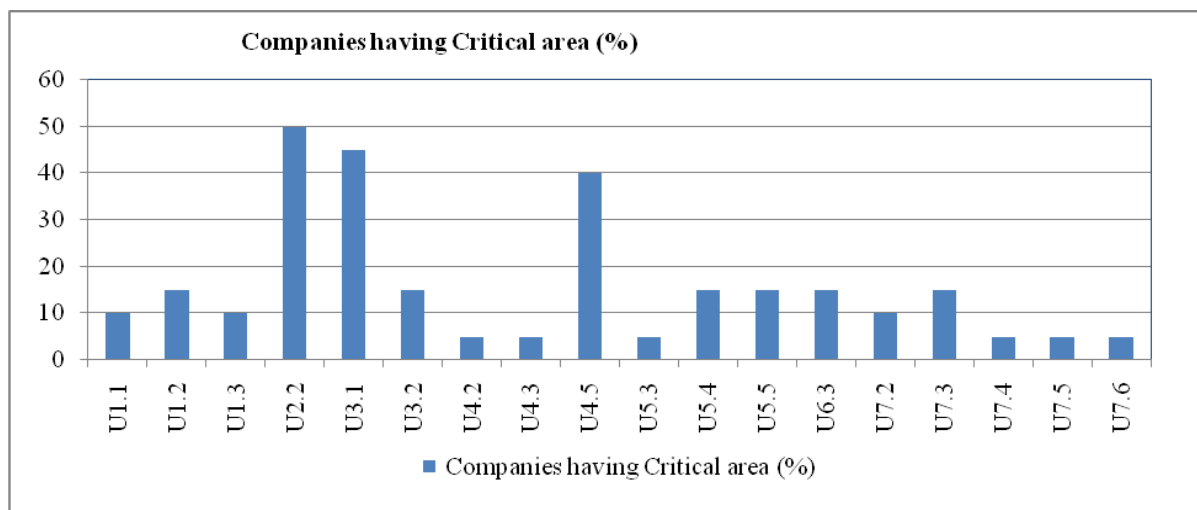


Fig 2: Graphical Representation of Companies and their Critical Items

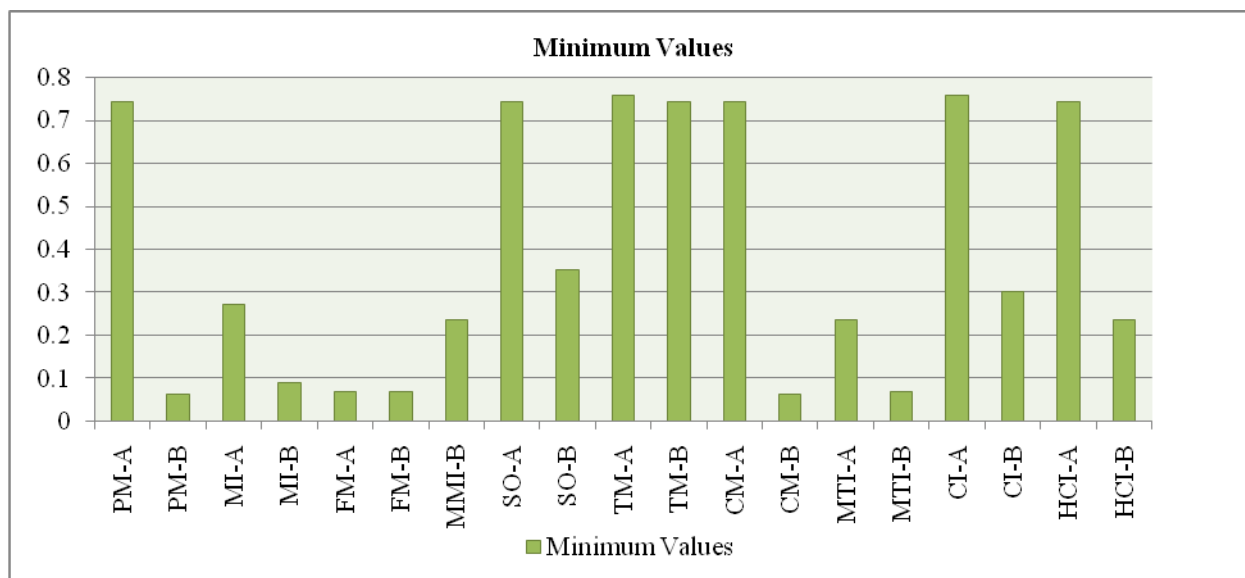


Fig 3: Companies and their Fuzzy Minimum Values

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