

A fuzzy model to evaluate the motivation to quality programs

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Abstract - This article emphasizes motivation and competence as basic factors needed to optimize human action with regard to quality. To evaluate employee motivation with regard to quality, a model with objective characteristics is proposed, which uses Herzberg's Two Factor Theory, and Fuzzy Set Theory. As this is a difficult area to measure, the model proposes an objective methodology that makes it possible to detect the motivational strategies that make employees more susceptible to the reality of the enterprise. This can help managers choose the best model to motivate the employees. An application of the methodology is also presented.

Keywords – Application of Fuzzy Sets, Motivation, Quality Systems.

I. INTRODUCTION

THE ever-increasing pursuit of better results in production and enhancing product quality to increase competitiveness has resulted in the need to improve the resources available in companies.

Institutions have to take responsibility for the quality of life, and see to it that satisfying core values and social goals is one of their fundamental goals. "For businesses, this means that achieving quality of life should be considered as an opportunity that management will convert into lucrative business" [1]. Economic and social development arises from the good use of all resources by company management, for, when only economic production factors are involved, development is not achieved. To attain this, human effort and not only economic wealth are needed. The generation, allocation and optimization of these efforts are tasks that fall to management.

It is for a company's management to implement programs which target greater productivity, improvement in employees' quality of life, lower costs, better working conditions and also higher profits. In order to implement a quality program that aims at these objectives, it is necessary to define what quality policy to adopt, and above all, it is essential that the company first defines its position with regard to quality.

Quality should be seen as a factor of stability for companies, for they survive and evolve, by keeping markets,

increasing consumer confidence and gaining new market segments, only if the product is deemed a quality one, and attending to the customer should be the company's priority action. It is known that what maintains a product on the market is neither its price, nor the time scales given when it is sold, but the quality it offers [2]. Other advantages of quality for companies are: greater industrial productivity, reduction in costs, thus obtaining better prices for their products, higher profits and savings for the company, and finally, improving the company's overall efficiency.

The following definition can summarize what quality is: "Quality is the degree of adjustment of a product to the demand that it sets out to satisfy" [3]. Therefore, a product will be deemed good to the extent that it satisfies the consumer and the producer. And to achieve this desired quality, what is needed is to optimize the company's resources, both material and economic ones but above all human ones.

In the administration of Quality Systems, it is paramount to attend to human resources, for a system is based on the mutual dependence between each of its parts, and it is people who manage the other resources.

To optimize the action of human resources in a company, and to effectively make these the most important of its resources, their qualities need to be maximized and their defects minimized. The people who make up this vital resource, have particular characteristics and qualities. Human action cannot be substituted by something else in most situations. This requires the company to invest in human beings, by offering training and seeking to motivate them.

In order to motivate employees successfully, managers must also be engaged in production with quality, for we can only motivate others if we ourselves are motivated. This justifies the participation of managers in striving for quality. Motivation should be based on the perception of the individual and the reactions of employees to the company's needs [4], for example, that of producing quality.

In evaluating the training of human resources for quality, there are several aspects that have particularities and distinct weights and influence on the worker. They are difficult to evaluate, since these are situations in which judgment, perception and human emotions are considered, and which therefore require a less subjective analysis, based on objective characteristics.

The models currently used for evaluating the motivation of human resources for quality vary widely in accordance with according to the subjectivity involved. Therefore, the need

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arises to adopt a model to help managers detect what aspects need most attention, thus underpinning decision-making on what motivational strategies to adopt.

This article presents a model to Evaluate the Motivation to Quality (EMTQ), using the application of Fuzzy Sets and Herzberg's Two Factor Theory.

II. IMPORTANCE OF HUMAN RESOURCES FOR QUALITY

For the technological development of companies, there is need to ensure that the stages for training are met so that companies can respond at high speed to the needs of the consumer market. Enhancing the skills of laborers, structuring Quality Control and defining quality policies are the first stages in implementing a quality program. Enhancing the skills of laborers, by providing them with training and motivational programs, aims at making the participation of human resources in the production of quality more effective.

Some strategies, such as changes in product designs, a study of lay-out, demands for greater discipline and control over the workers, an increase in the number of parts inspected and the search for resources to satisfy the worker, are adopted to obtain a balance between quality and productivity i.e. to keep on producing more and in a better way, by reducing the indices of defective parts and the need to do things over again.

These strategies mentioned above, their possible combinations and others not mentioned reflect different ideas put forward for the organization of work.

The idea for enriching jobs is that of incorporating new tasks with greater complexity and of giving more responsibility to work posts in an attempt to do away with the consequences of monotonous work. The aim of the organization of work is to see to it that the worker is more attentive to and accepts more responsibility for what he is producing, so that there will be fewer defects and greater compliance.

The importance of human action in the production of quality is higher than is usually considered. If we consider the sum total of human effort generally required to create a consumer product, the importance and impact of human behavior on the quality of the final product becomes more evident. Quality begins and ends with people, it is the result of their activities which drives the company's other resources. If there were not in this goading a concern for quality, the result of the use of the other resources will be far from achieving total quality in the company.

If employees are to accept responsibility for the quality of what they are producing, they need to have information about the importance of their work and what their part in the whole represents [5]. Therefore, the company should offer favorable conditions to train workers in the skills they need. Quality is not only a problem of motivating people and having them participate, but it is also linked to the style of management and the existing organizational environment [6].

To successfully motivate employees, managers also need to be fully committed to production with quality, because we can only motivate others if we ourselves are motivated. This justifies the participation of managers in the effort to achieve

quality. Motivation should be based on individual perceptions and on employees' reactions to the needs of the company [5], for example, that of producing quality.

III. HERZBERG'S MOTIVATION-HYGIENE THEORY

In 1966, Frederick Herzberg published his book "Work and Nature of Man", in which he proposed the Two Factor Theory in order to explain the behavior of people at work. These are: Hygiene Factors and Motivator Factors [7].

The Motivator Factors involve feelings of recognition, achievement, responsibility, advancement and growth, for they are related to the nature of the tasks the worker performs, the content of the post and successful performance on the job that may result in professional growth. Motivational factors result from the satisfaction obtained in performing the work in the light of the possibility of using the full potential that people are capable of.

These factors recompense the individual in that he or she can find their job fulfils their aspirations. The factors that lead to positive attitudes at work do so because they satisfy the need for the individual to find self-fulfillment in his or her work [8]. Motivation, therefore, must arise from situations of challenges at work, and involve factors such as achievement, responsibility, advancement, promotion, growth, job enrichment, the work itself and the recognition obtained. For Herzberg, when the motivator factors are optimal, they give rise to satisfaction, but when they are not optimal, there is 'no satisfaction'.

The Hygiene Factors are located in the environment and cover the conditions within which employees perform their work. When first-class, all they do is to avoid worker dissatisfaction but they do not lead to satisfaction. For Herzberg, hygiene acts by removing dangers to the health from people's environment, and thus they perform a mainly preventive function. Therefore, promoting hygiene factors will serve to remove impediments to positive attitudes at work. Hygiene Factors include: company policy, quality of supervision, relationship with the boss, the relationship with peers, status, salary, job security and work conditions. However, the reverse is not true. When the context of work can be characterized as first-class, there will not be satisfaction but rather 'no dissatisfaction', nor will this result in positive attitudes.

When hygiene and motivational factors are related, it is possible to understand that the former necessarily need to be secured so that feelings of dissatisfaction at work can be reduced to the maximum possible extent. However, motivational satisfaction will only appear from the moment everyone feels he or she is working towards their self-realization.

In 1976 Herzberg and Zautra published an article with the conclusion from a survey that began with a study of interviews conducted with more than two hundred engineers and accountants. For them, the factors influencing the production of job satisfaction were distinct from the factors that led to professional dissatisfaction. Thus, the opposite of professional satisfaction is not dissatisfaction, but rather 'no professional

satisfaction'; and similarly, the opposite of professional dissatisfaction is 'no professional dissatisfaction', and not satisfaction [9]. Satisfaction and no dissatisfaction are feelings that cannot be regarded as similar to each other, but are both complementary and necessary.

An extension of Herzberg's research is to distinguish the styles of motivational behavior set out by Myers [10]. On his six-year work, he interviewed 282 workers at Texas Instruments Incorporated in the Dallas divisions, about the classification proposed by Herzberg. Myers could conclude that it was valid there as well. In his opinion, the employee needs can be classified into two major categories: 'maintenance needs' and 'motivational needs'. For him, "job performance depends on the fulfillment of both motivation and maintenance needs" [10].

Motivation at work, according to Herzberg [8], may be provided by enriching tasks, also known as post enrichment, which consists of constantly replacing simple tasks with more complex ones. This should be done according to the characteristics of each person, by offering challenges which provide job satisfaction and by monitoring the employee's growth in performance. It also encourages increased productivity, reduction of absenteeism, reduced staff turnover, thus helping the development of the company.

This paper was structured based, in order to identify between the various theories on motivation available in the literature, on the preliminary selection of one that might offer the most resources possible for analyzing the data collected, and which could be related to the organizational situation. Since most theories were more closely linked to a restricted aspect, and as Herzberg's Two Factor Theory is the result of research carried out within companies, this was the theory chosen because it provides more representative coverage of human needs, which makes it possible to present more widely-drawn conclusions.

The main objective of evaluating motivation was considered to be that of highlighting what aspects of the individual or group, workers are more satisfied with and those with which they are not, which will result in analysis for later decision making and the strategies to be adopted to motivate these workers, thus serving as feedback on the motivation program adopted.

IV. FUZZY APPROACH

Classical mathematics is very limited when it comes to working with situations where judgment, perception and human emotions are considered [11]. Therefore, a fuzzy approach was adopted for the evaluation proposed because these are situations particular to each individual, in order to reflect their feelings regarding motivation for quality.

For a joint analysis of the various aspects concerning the evaluation of motivation, the need arises to aggregate the different values determined. This can be resolved by the aggregation of several characteristics, proposed by Fuzzy Set Theory.

A fuzzy set is a class of objects with a continuum of grades of membership [12]. To create a fuzzy set is a task which is as

subjective as the very essence of the problem that it is sought to model when implementing Fuzzy Set Theory in a system.

In order to create a fuzzy set all that is needed is to define the function of pertinence on the universe of discourse. For a function of pertinence is to be admissible, it must meet the following items [13]:

- 1 - to represent faithfully the behavior of elements;
- 2 - to be consistent with the specifications of the set;
- 3 - to satisfy the condition de $0 \leq \mu_A(x) \leq 1$, for normal fuzzy sets.

In order to create a fuzzy set all that is needed is to define the function of pertinence on the universe of discourse. "A fuzzy set A in X is characterized by a membership function $f_A(x)$ which associates with each point in X a real number in the interval $[0, 1]$, with the value of $f_A(x)$ at x representing the grade of membership of x in A " [12].

To assess the motivation to quality, there are:

X_i : set of motivator and hygiene factors;

with $i = 1, \dots, 14$

x : characteristics of each motivator or hygiene factor;

A : subset of the aspects which meet criterion A

$\mu_A(x)$: degree of pertinence of the aspect x in relation to subset A

with the number of subsets being defined in accordance with the number of factors adopted for aggregation.

In several criteria, it was observed that the expected behavior of the functions of relevance $\mu_A(x)$ is repeated, such as accelerated growth, slow growth, stabilization after rapid growth, among other responses.

Therefore what were adopted were the standards of pertinence that could be used for various criteria. The objective of these standards is to facilitate the visualization of the expected behavior in each criterion, by those responsible for the assessments.

Fifteen pertinence functions were created which were used in the 41 questions. For reasons of space and bearing in mind that these functions are not the main object of this article, they will not be presented here, but are available on request.

For the standards from number 01 to 05 and from 07 to 11, we have:

$\mu_A(x)$: represents the degree of pertinence of that criterion;

x : indicates the score given to that criterion in the interval from 0 to 10, or according to what was requested;

$x = 10$: represents the maximum score, being equivalent to $\mu_A(x) = 1$;

$x = 0$: represents the minimum score, being equivalent to $\mu_A(x) = 0$; that is, the adjectives of the extremes of the intervals represent the maximum and minimum scores for each criterion, in accordance with what is being evaluated.

Five standards (number 06, and 12 to 15) were created to represent specific situations of expected behavior, where it was necessary to make the composition of different intervals from 0 to 10. In these cases, the values of the functions of pertinence are those which designate the extremes of the evaluation of that criterion, i.e. what the values are that represent the desired efficiency, where $\mu_A(x) = 1$; the

intermediate values; and the values that represent the total inefficiency in performance, where $\mu_A(x) = 0$.

It is important to stress that the values of the intervals can be altered in accordance with the policy of the company that will be applying the assessment.

A. Drawing up the Questionnaire

For data collection, there are several procedures, which vary with the circumstances of each search [14]. The main techniques for data collection are: document collection, observation, interview, questionnaire, form, measures of opinion and attitudes, tests, analysis of content, life history [15].

To perform the evaluations, a basic model for surveying information using questionnaires was constructed, which has to be answered by the workers surveyed. The questionnaire was adopted because it offers the following advantages:

- it reaches a large number of people simultaneously;
- it covers a large number of people simultaneously;
- it gets faster answers;
- there is no risk of researcher influence because he/she is not present;
- it gives a greater uniformity of response because the questionnaire is an impersonal instrument;
- it is possible to obtain a large number of data.

A questionnaire was drawn up to assess the motivation to quality, with 41 questions to assess the 14 factors. Each question of the questionnaires represents a criterion to be evaluated, i.e. a fuzzy subset. Each factor is assessed by at least two questions, which correspond to the factors listed below:

Motivator Factors:

- Work itself: questions 1, 2 and 39;
- Achievement: questions 3, 4, 5 and 6;
- Recognition: questions 7 and 8;
- Promotion: questions 9, 10, 11, and 40;
- Responsibility: questions 12, 13, and 14;
- Growth: questions 15 and 16;
- Job enrichment: questions 17 and 18;

Hygiene Factors:

- Work conditions: questions 19, 20, 21, 22, 23 and 41;
- Company policy: questions 24, 25, 26 and 27;
- Salary: questions 28 and 29;
- Relationship with the boss and peers: questions 30, 31 and 32;
- Job security: questions 33 and 34;
- Status: questions 35 and 36;
- Quality of supervision: questions 37 and 38.

It is necessary to emphasize that the analysis can be done by taking each employee or group, as a base because the information from each questionnaire refers to each worker consulted.

As an example of the questions, there is:

(‘Work itself’ Factor) With what frequency are tasks undertaken which target the production of quality in your job:

- 10 - routinely
- 0 - rarely

(‘Responsibility’ Factor) The responsibility which you would accept having in your job would be:

- 10 - really a lot
- 0 - none at all

(‘Company policy’ Factor) Who do you think knows the company’s quality policy:

- 10 - all staff
- 0 - no staff member

Staff should answer within the interval requested, with only the extreme values being reported on, which represent the best and worst evaluation possible, and represent the interval of the aggregation functions $\mu_A(x)$ in the interval $[0, 1]$.

It is noted that the survey of information can also be conducted through interviews or another data collection instrument. However, it is believed that the use of the questionnaire is the most appropriate, since it is not necessary for the evaluator to be physically present, thus leaving the respondent with greater freedom when giving answers.

B. Aggregation of the Factors

In order to obtain the indices which represent the 14 factors assessed, three operators available in the literature were used, thus drawing up aggregation functions indexed from F_1 to F_{14} , which correspond to the first seven motivator factors and those of numbers 8 to 14 to the hygiene factors, respectively, with the possible combinations possible between the criteria $\mu_{A_i}(x_i)$ which are related to each factor F assessed.

For the applications proposed in the evaluation model EMTQ, the operators that are most suited to the analysis required were adopted, in order to obtain results that would reflect a more rigid aggregation, without compensation, using operators that provide a critical analysis.

Thus, in aggregating the functions of each factor, when the pertinence values are very different from each other, operators were adopted with the function of aggregation which resulted in a value below the average of the two, in order to show that one of the values that were aggregated is much lower than the other. As an example, the average between $\mu_A(x) = 0.2$ and $\mu_B(x) = 0.9$ is $F = 0.55$. But the average between $\mu_C(x) = 0.5$ and $\mu_D(x) = 0.6$ is also 0.55, i.e. the average in this case does not reveal the great distance of values which there is between $\mu_A(x_i)$ and $\mu_B(x_i)$.

Thus, two types of operators were adopted to aggregate two fuzzy sets: that proposed in [16]:

$$\mu_{A \parallel \varepsilon B}(x) = (1 - \varepsilon) \cdot \min(\mu_A(x), \mu_B(x)) + \varepsilon \cdot \max(\mu_A(x), \mu_B(x)),$$

$$\forall x \in X \quad (1)$$

For the aggregation of two criteria where it is known that one of them may have the pertinence value of $\mu_{A_i}(x_i) = 0$, the operator $\varepsilon_1 = 0.5$ was used, so that in these cases, the value of the aggregation function is equal to half the aggregation value of the other criterion, without annulling the function.

The operator proposed in [17] was also used:

$$\mu_{A \gamma B}(x) = (\mu_A(x) \cdot \mu_B(x))^{(1-\gamma)} (\mu_A(x) + \mu_B(x) - \mu_A(x) \cdot \mu_B(x))^\gamma,$$

$$x \in X, 0 \leq \gamma \leq 1 \quad (2)$$

in which the operators adopted were : $\gamma_1 = 0.55$ e $\gamma_2 = 0.6$.

Where three or more fuzzy sets were aggregated, the gamma operator [18] $\gamma_3 = 0.65$ was used:

$$\mu_{F_j}(x) = \left(\prod_{j=1}^m \mu_j(x) \right)^{(1-\gamma)} \left(1 - \prod_{j=1}^m (1 - \mu_j(x)) \right)^{\gamma}, x \in X, 0 \leq \gamma \leq 1 \quad (3)$$

C. Aggregation Functions Proposed for the Herzberg Factors

The F_1 to F_7 functions adopted for aggregating each the Herzberg Motivator Factors are presented below.

Aggregation Function F_1 : 'Work itself':

$$F_1 = \{ [((1 - \varepsilon_1) * \min(\mu_{A1}(x_1), \mu_{A39}(x_{39}))) + (\varepsilon_1 * \max(\mu_{A1}(x_1), \mu_{A39}(x_{39})))) + \mu_{A2}(x_2)] - [((1 - \varepsilon_1) * \min(\mu_{A1}(x_1), \mu_{A39}(x_{39}))) + (\varepsilon_1 * \max(\mu_{A1}(x_1), \mu_{A39}(x_{39})))) * \mu_{A2}(x_2)] \} \quad (4)$$

Aggregation Function F_2 : 'Achievement':

$$F_2 = \min \{ [(\mu_{A3}(x_3) * \mu_{A4}(x_4))^{(1-\gamma)} * (\mu_{A3}(x_3) + \mu_{A4}(x_4) - \mu_{A3}(x_3) * \mu_{A4}(x_4))^{(\gamma)}] ; [(\mu_{A5}(x_5) + \mu_{A6}(x_6)) - (\mu_{A5}(x_5) * \mu_{A6}(x_6))] \} \quad (5)$$

Aggregation Function F_3 : 'Recognition':

$$F_3 = [(\mu_{A7}(x_7) * \mu_{A8}(x_8))^{(1-\gamma)} * (\mu_{A7}(x_7) + \mu_{A8}(x_8) - \mu_{A7}(x_7) * \mu_{A8}(x_8))^{(\gamma)}] \quad (7)$$

Aggregation Function F_4 : 'Promotion':

$$F_4 = \{ [(\mu_{A9}(x_9) * Z_4 * \mu_{A40}(x_{40}))^{(1-\gamma)}] * [1 - (1 - \mu_{A9}(x_9)) * (1 - Z_4) * (1 - \mu_{A40}(x_{40}))]^{(\gamma)} \} \quad (8)$$

where:

$$Z_4 = [(\mu_{A10}(x_{10}) + \mu_{A11}(x_{11})) - (\mu_{A10}(x_{10}) * \mu_{A11}(x_{11}))] \quad (9)$$

Aggregation Function F_5 : 'Responsibility':

$$F_5 = \{ [(\mu_{A12}(x_{12}) * \mu_{A13}(x_{13}) * \mu_{A14}(x_{14}))^{(1-\gamma)}] * [1 - (1 - \mu_{A12}(x_{12})) * (1 - \mu_{A13}(x_{13})) * (1 - \mu_{A14}(x_{14}))]^{(\gamma)} \} \quad (10)$$

Aggregation Function F_6 : 'Growth':

$$F_6 = [((1 - \varepsilon_1) * \min(\mu_{A15}(x_{15}), \mu_{A16}(x_{16}))) + (\varepsilon_1 * \max(\mu_{A15}(x_{15}), \mu_{A16}(x_{16}))) \quad (11)$$

Aggregation Function F_7 : 'Job enrichment':

$$F_7 = [(\mu_{A17}(x_{17}) * \mu_{A18}(x_{18}))^{(1-\gamma)} * (\mu_{A17}(x_{17}) + \mu_{A18}(x_{18}) - \mu_{A17}(x_{17}) * \mu_{A18}(x_{18}))^{(\gamma)}] \quad (12)$$

The F_8 to F_{14} functions adopted to aggregate each of the Herzberg Hygiene Factors are presented below:

Aggregation Function F_8 : 'Work conditions':

$$F_8 = \min \{ [(\mu_{A19}(x_{19}) * \mu_{A41}(x_{41}))^{(1-\gamma)} * (\mu_{A19}(x_{19}) + \mu_{A41}(x_{41}) - \mu_{A19}(x_{19}) * \mu_{A41}(x_{41}))^{(\gamma)}] ; [((1 - \varepsilon_1) * \min(Z_8, W_8)) + (\varepsilon_1 * \max(Z_8, W_8))] \} \quad (13)$$

where:

$$Z_8 = [(\mu_{A20}(x_{20}) * \mu_{A21}(x_{21}))^{(1-\gamma)} * (\mu_{A20}(x_{20}) + \mu_{A21}(x_{21}) - \mu_{A20}(x_{20}) * \mu_{A21}(x_{21}))^{(\gamma)}] \quad (14)$$

$$W_8 = [(\mu_{A22}(x_{22}) * \mu_{A23}(x_{23}))^{(1-\gamma)} * (\mu_{A22}(x_{22}) + \mu_{A23}(x_{23}) - \mu_{A22}(x_{22}) * \mu_{A23}(x_{23}))^{(\gamma)}] \quad (15)$$

$$\mu_{A22}(x_{22}) * \mu_{A23}(x_{23}))^{(\gamma)}] \quad (15)$$

Aggregation Function F_9 : 'Company policy':

$$F_9 = \min \{ [((1 - \varepsilon_1) * \min(\mu_{A24}(x_{24}), \mu_{A25}(x_{25}))) + (\varepsilon_1 * \max(\mu_{A24}(x_{24}), \mu_{A25}(x_{25})))]; [((1 - \varepsilon_1) * \min(\mu_{A26}(x_{26}), \mu_{A27}(x_{27}))) + (\varepsilon_1 * \max(\mu_{A26}(x_{26}), \mu_{A27}(x_{27}))) \} \quad (16)$$

Aggregation Function F_{10} : 'Salary':

$$F_{10} = [((1 - \varepsilon_1) * \min(\mu_{A28}(x_{28}), \mu_{A29}(x_{29}))) + (\varepsilon_1 * \max(\mu_{A28}(x_{28}), \mu_{A29}(x_{29}))) \quad (17)$$

Aggregation Function F_{11} : 'Relationship with the boss and peers':

$$F_{11} = [((1 - \varepsilon_1) * \min(Z_{11}, \mu_{A32}(x_{32}))) + (\varepsilon_1 * \max(Z_{11}, \mu_{A32}(x_{32}))) \quad (18)$$

where:

$$Z_{11} = [((1 - \varepsilon_1) * \min(\mu_{A30}(x_{30}), \mu_{A31}(x_{31}))) + (\varepsilon_1 * \max(\mu_{A30}(x_{30}), \mu_{A31}(x_{31}))) \quad (19)$$

Aggregation Function F_{12} : 'Job security':

$$F_{12} = [(\mu_{A33}(x_{33}) * \mu_{A34}(x_{34}))^{(1-\gamma)} * (\mu_{A33}(x_{33}) + \mu_{A34}(x_{34}) - \mu_{A33}(x_{33}) * \mu_{A34}(x_{34}))^{(\gamma)}] \quad (20)$$

Aggregation Function F_{13} : 'Status':

$$F_{13} = [(\mu_{A35}(x_{35}) * \mu_{A36}(x_{36}))^{(1-\gamma)} * (\mu_{A35}(x_{35}) + \mu_{A36}(x_{36}) - \mu_{A35}(x_{35}) * \mu_{A36}(x_{36}))^{(\gamma)}] \quad (21)$$

Aggregation Function F_{14} : 'Quality of supervision':

$$F_{14} = [(\mu_{A37}(x_{37}) * \mu_{A38}(x_{38}))^{(1-\gamma)} * (\mu_{A37}(x_{37}) + \mu_{A38}(x_{38}) - \mu_{A37}(x_{37}) * \mu_{A38}(x_{38}))^{(\gamma)}] \quad (22)$$

V. PRACTICAL APPLICATIONS OF THE MODEL

One of the analyses that the EMTQ model allows for is that of presenting results person by person, since as the questionnaires can be identified, managers can obtain information on what motivational factors are most lacking for each subordinate studied, and can thus examine the result coming from having assessed the satisfaction and dissatisfaction of the factors for each person individually while group analysis allows evaluation of how the company's practices and policies with respect to a specific group of employees are shaping up.

The evaluation model has been applied in small, medium and large companies, of both the public and private sectors. This article will present the results from two companies: a large public company in the service sector which operates throughout the national territory in Brazil, and will be identified only as Public Enterprise (PE) and a private company in the metallurgy sector, identified only as Metallurgical Company (MC).

The evaluation of three of the PE employees, deemed Interviewee 1, Interviewee 2 and Interviewee 3 is given below.

For the first person, by making use of having applied the

questionnaire drawn up and the fuzzy aggregation defined in the EMTQ model, it was possible to observe that the motivational factors most lacking and which must be analyzed immediately by the leader are 'Achievement', 'Promotion' and 'Recognition'. The strongest motivational factor was 'Responsibility'.

Motivational Factors – Interviewee 1 (PE):

- Work itself - $F_1 = 0.865$
- Achievement - $F_2 = 0.411$
- Recognition - $F_3 = 0.584$
- Promotion - $F_4 = 0.525$
- Responsibility - $F_5 = 0.946$
- Growth - $F_6 = 0.748$
- Job enrichment - $F_7 = 0.799$

Hygiene Factors – Interviewee 1 (PE):

- Work conditions - $F_8 = 0.511$
- Company policy - $F_9 = 0.638$
- Salary - $F_{10} = 0.764$
- Relationship with the boss and peers - $F_{11} = 0.809$
- Job security - $F_{12} = 0.731$
- Status - $F_{13} = 0.866$
- Quality of supervision - $F_{14} = 0.959$

With regard to the hygiene factors, it was verified that for Interviewee 1 'Work Conditions' and 'Company Policy' are those which received the poorest evaluations, whereas 'Quality of supervision' is the strongest point of the hygiene factors for this person.

For the second employee, using the fuzzy aggregation defined in the EMTQ model, it was possible to observe that the motivational factors most lacking and which must be analyzed immediately by the leader are 'Promotion', 'Recognition' and 'Achievement'. These three are the same as for Interviewee 1, but not in the same order. The strongest motivational factor was also 'Responsibility', as it was for the first employee. This seems to be the strong point of the job for both of them.

Motivational Factors – Interviewee 2 (PE):

- Work itself - $F_1 = 0.705$
- Achievement - $F_2 = 0.468$
- Recognition - $F_3 = 0.454$
- Promotion - $F_4 = 0.214$
- Responsibility - $F_5 = 0.818$
- Growth - $F_6 = 0.853$
- Job enrichment - $F_7 = 0.716$

Hygiene Factors – Interviewee 2 (PE):

- Work conditions - $F_8 = 0.776$
- Company policy - $F_9 = 0.368$
- Salary - $F_{10} = 0.639$
- Relationship with the boss and peers - $F_{11} = 0.795$
- Job security - $F_{12} = 0.607$
- Status - $F_{13} = 0.893$
- Quality of supervision - $F_{14} = 0.593$

Regarding the hygiene factors for Interviewee 2, it was verified that 'Company Policy' and 'Quality of supervision' are those which received the poorest evaluations. The strongest one for this Employee was 'Status'.

For Interviewee 3, the motivational factor with the lowest

level of satisfaction was 'Promotion' despite this individual being highly satisfied with three other factors. As to the hygiene factors, the worst were 'Company Policy' and 'Salary' despite the factor of 'Quality of Supervision' showing a high evaluation, as can be observed below.

Motivational Factors – Interviewee 3 (PE):

- Work itself - $F_1 = 0.944$
- Achievement - $F_2 = 0.799$
- Recognition - $F_3 = 0.802$
- Promotion - $F_4 = 0$
- Responsibility - $F_5 = 1$
- Growth - $F_6 = 1$
- Job enrichment - $F_7 = 1$

Hygiene Factors – Interviewee 3 (PE):

- Work conditions - $F_8 = 0.977$
- Company policy - $F_9 = 0.431$
- Salary - $F_{10} = 0.500$
- Relationship with the boss and peers - $F_{11} = 0.794$
- Job security - $F_{12} = 0.704$
- Status - $F_{13} = 0.897$
- Quality of supervision - $F_{14} = 1$

Another analysis which the EMTQ model permits is that of analyzing the motivation of the group as a whole, so that analysis can be made of what factors are most lacking and which ones are most satisfied. In this case, after the fuzzy treatment of the data, the following facts can be pointed up in the analysis of the evaluation of motivation of a group of 14 people who work in the same department of the Public Enterprise.

It was possible to observe in the Public Enterprise that the motivational factors that obtained the worst evaluation in the group were 'Achievement' and 'Promotion'. As to professional progress, thus is compatible with the characteristics of a public enterprise, where the career is stagnant at some point, and can only change after the employee has passed a new competitive public examination. With regard to the low collective assessment of the 'Achievement' factor, managers must urgently work together with employees to find activities that result in greater satisfaction. As for the factors of 'Responsibility' and 'Growth', managers do not need to worry at the moment about them, but they cannot fail to see to it that their levels do not fall below the current level.

The evaluation of three of the MC employees is given below. They were designated Interviewee 4, Interviewee 5 and Interviewee 6, so as not to be confused with the results already presented for the three employees of the PE company.

For Interviewee 4, the motivational factors with the highest levels of satisfaction are 'Growth' and 'Responsibility', but they are not strong enough. The motivational factor with the no satisfaction level was 'Achievement'. Regarding the hygiene factors for Interviewee 4, it was checked that 'Work conditions' and 'Quality of supervision' were the ones for which this person needs most support from his bosses.

Motivational Factors – Interviewee 4 (MC):

- Work itself - $F_1 = 0.275$
- Achievement - $F_2 = 0$

- Recognition - $F_3 = 0.441$
- Promotion - $F_4 = 0.656$
- Responsibility - $F_5 = 0.731$
- Growth - $F_6 = 0.776$
- Job enrichment - $F_7 = 0.499$
- Hygiene Factors – Interviewee 4 (MC):
- Work conditions - $F_8 = 0.356$
- Company policy - $F_9 = 0.618$
- Salary - $F_{10} = 0.528$
- Relationship with the boss and peers - $F_{11} = 0.493$
- Job security - $F_{12} = 0.770$
- Status - $F_{13} = 0.656$
- Quality of supervision - $F_{14} = 0.380$

For Interviewee 5, the motivational factors have good levels of assessment, except for 'Achievement' and 'Recognition', despite displaying maximum evaluation for 'Responsibility'. As to the hygiene factors, it is observed that this person presents good levels only for 'Company policy' and 'Job security'.

Motivational Factors – Interviewee 5 (MC):

- Work itself - $F_1 = 0.877$
- Achievement - $F_2 = 0.409$
- Recognition - $F_3 = 0.639$
- Promotion - $F_4 = 0.950$
- Responsibility - $F_5 = 1$
- Growth - $F_6 = 0.893$
- Job enrichment - $F_7 = 0.799$

Hygiene Factors – Interviewee 5 (MC):

- Work conditions - $F_8 = 0.556$
- Company policy - $F_9 = 0.977$
- Salary - $F_{10} = 0.584$
- Relationship with the boss and peers - $F_{11} = 0.498$
- Job security - $F_{12} = 0.946$
- Status - $F_{13} = 0.500$
- Quality of supervision - $F_{14} = 0.698$

For Interviewee 6, the motivational factors which generate most dissatisfaction are 'Achievement' and 'Promotion', but this person finds the work interesting. Regarding the hygiene factors, it can be observed that there is only a good evaluation for 'Status', but on the other hand, very poor evaluations for 'Relationship with the boss and peers' and 'Salary'.

Motivational Factors – Interviewee 6 (MC):

- Work itself - $F_1 = 0.804$
- Achievement - $F_2 = 0.324$
- Recognition - $F_3 = 0.764$
- Promotion - $F_4 = 0.524$
- Responsibility - $F_5 = 0.712$
- Growth - $F_6 = 0.696$
- Job enrichment - $F_7 = 0.931$

Hygiene Factors – Interviewee 6 (MC):

- Work conditions - $F_8 = 0.355$
- Company policy - $F_9 = 0.537$
- Salary - $F_{10} = 0.241$
- Relationship with the boss and peers - $F_{11} = 0.219$
- Job security - $F_{12} = 0.763$
- Status - $F_{13} = 0.944$
- Quality of supervision - $F_{14} = 0.575$

Another analysis made in the Metallurgical Company (MC) using the EMTQ model was that of the motivation of one group as a whole, so that an analysis can be made of what factors are most lacking and which ones are most satisfied. In this case, the responses of 20 employees were analyzed who work in the same production sector of the company and who answered the questionnaire presented.

It was possible to observe that most employees were not satisfied with the motivational factors of 'Promotion' and 'Responsibility'. Despite this, the factors of 'Work itself' and 'Recognition' showed high levels of satisfaction. This demonstrates that managers should work together with employees to improve the distribution of responsibilities and to acknowledge the competence of each, in order to improve promotions in the company.

As to the hygiene factors, it was observed that managers should review some of their policies, since in most factors there was an intermediate evaluation, demonstrating that there are gaps to be worked on. However, the factors of 'Salary' and 'Quality of supervision' were the factors that had the worst ratings. As this is a private company that wants to maintain its competitiveness and that depends on the competence of its personnel, the policy on salaries should be revised lest the greatest talents be lost.

VI. RESULTS

When one examines the structure proposed in the EMTQ model with the problems faced in the companies surveyed in order to involve their human resources in the effort towards achieving quality, it is concluded that the model has reached its goal, for it was possible to diagnose the staff's level of satisfaction with regard to motivational factors and those of dissatisfaction as to the hygiene factors.

The practical applications allowed the viability of the model proposed to be noted, and provided evidence of the differences between the evaluations of employees, with there being particular characteristics in each company, and it being possible to vary the operators ϵ and γ in the aggregations for different companies, depending on the value that each company attributes to the motivational and hygiene factors in its human resources policy.

The EMTQ model also allows for analysis of the individual perception in relation to each of the factors surveyed and the group's perception, thus making it possible to visualize the group's motivation. And so it is possible for managers to draw up a program of motivation based on the real needs of their staff.

The perception as to what motivates can be different for both the reality of employees of each company and the company's view regarding their staff's opinions, such that managers should listen to their employees in order to draw up a program on motivating staff towards quality that keeps reality firmly in mind.

It was observed in data collection and in the review of the literature that there is a need to conduct a study to understand the effects of participation in a training program on the

motivation for quality, i.e. as the expectations created during a training course are being met through a motivational program, in addition to visualizing the attitudes arising from the application of motivational strategies in the expectation of learning taking place during new training programs. Such a study should be one of the research studies to be undertaken based on this article.

VII. CONCLUSIONS

The adoption of the Fuzzy Sets Theory for handling data collected in the proposed model for the evaluations, with objective characteristics, proved to be an instrument that can provide data for decision making. The methodology adopted made it possible to analyze the aspects that influence the action of human resources for quality, especially motivation, where the various aspects researched may have different weights according to the policies adopted in each company.

In relation to work, it was observed there is great difficulty in preparing a script for a questionnaire that should contain all the criteria necessary for the evaluation of each aspect, and restrictions in the definition of standards and functions that are suited to the proposed assessments. It was found that several approaches proposed in the literature are not complete. Herzberg's Theory has the limitation of not considering the organizational conditions of work, but only the safety aspects of the environment.

The questionnaire prepared was implemented in different companies. This article presents the results obtained in a large public company in the service sector, which operates throughout Brazil and in a medium-sized metallurgical company. The field study results showed the model to be well suited for application in different types of companies (of small, medium and large size).

The application of the EMTQ (Evaluate the Motivation to Quality) model with the use of Fuzzy Sets revealed the motivational factors that need improvement.

This allowed feedback to guide investments in the knowledge of the companies. Thus, the model can contribute to the organization by projecting an organizational context which promotes behaviors focused on making the effort to achieve quality, and also on learning and innovation.

As is known, Fuzzy Set Theory can be used where it is difficult to determine with precision the boundaries of the sets, and thus provides a gradual transition of the relationship of pertinence of the elements to the set, as that on a continuous scale, such as is the case for satisfaction and human motivation.

The model also showed it was flexible as to the alterations of standards, thus making it possible to fit the standards and the fuzzy operators to each company's quality policies.

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