A Fuzzy Approach to Compare Human Performance in Industrial Plants and Service-Providing Companies

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*Abstract***:** This paper presents basic concepts of fuzzy logic area used to structure an evaluation process of the performance levels of human resources who operate in both - industrial and service providing organizations. A model has been developed to each sector. The models use specific mechanisms for comparing performance seeking to define suitable standards for achieving operational, tactical and strategic goals defined by productive organizations. Some essential criteria were used for the performance evaluation, which involve Strategic Management (competitive differentiation in terms of products, services and processes); Tactical Management (human resources management) and Operational Area (management of the productive process). The results of the practical applications in industrial organizations and in service-providing companies were described and discussed. A comparative method to detect specific characteristics of each sector is described. The performance standards compose what can be called an ideal profile of decision-making agents in industrial and service-providing organizations.

Key-words: Human performance; services and industrial goods; fuzzy approach to evaluation.

1 Introduction

This paper has two objectives. Initially, a general model to evaluate human performance is structured. The model uses a fuzzy approach and allows defining performance standards for human actions. It is applied in industrial environment and in service-providing companies. Since we have made these two applications, a second objective can be formulated, in terms of proposing a comparison process to evaluate the performance of professionals who work in the two groups of organizations: companies that produce industrial goods and companies that provide different services, like hotels, stores, clinics, banks and so on.

The main focus of the paper is the human performance. It is a well known problem. In fact, the importance of the action of human resources in organizations has been continually emphasized over time. This effort can be observed in the development of a large number of tools and strategies that seek to improve the performance of the activities undertaken by people in productive areas. Yet these efforts have produced a variety of methods. It is difficult to choose the most suitable for each case, indicating the difficulty of identifying mechanisms to precisely evaluate the influence of the strategies that are planned and developed for this improvement process.

The difficulty of evaluating the action of people in companies is related to the very nature of human resources, whose complexity impedes a simple analysis. It is possible that there is here, in reality, an adverse conjunction of three factors: (1) diversity in the strategies of involvement; (2) unsuitable conditions for analysis and understanding for those that conduct the evaluation and (3) the subjective nature of the object of evaluation. In this sense, any analysis of the performance of human resources of an organization must consider the evaluation mechanism itself, which must be based on clear and objective terms, as well as the element being evaluated, to which must be applied criteria that are easy to understand and measure.

In this context, the notion of "proximity" supplies the bases for an interesting and practical process to accompany the action of human resources at organizations. This notion will be described in this work through practical application, utilizing the Theory of fuzzy sets.

This study does not focus only one type of organization. In fact, it compares the performance of professionals who work in two groups of organizations: companies that produce industrial goods and service-providing companies.

In the first case, the professionals work in industrial plants. In the practical application of the model we describe here, the companies chosen were three tile producers. In the second case, a commercial activity was considered, more precisely, six women's clothing stores. Thus, the companies chosen to evaluate quality in the services sector were commercial companies.

2 Performance Evaluation Mechanisms in Fuzzy Context

Different authors have treated the problem of considering human performance. Sometimes, in a general way, personality traits, leadership competence and organizational performance are correlated [1]. Also it has been applied to quality evaluation [2]. In this paper, we consider a particular analysis.

Fuzzy analysis has been used often for this kind of evaluation, in different situation, as public administration [3] or health care [4].

Here, we consider a different approach from those studies, using proximity concepts. The basic idea transmitted by the notion of proximity is quite simple.

Any resource at a company can be assembled from a reference that can be called the "ideal profile". This profile is composed of two sets of characteristics: necessary ones (considered essential for the exercise of the function) and desirable ones (which complement the basic profile due to the specificities that the function requires in specific environments). The evaluation of human resources is conducted by considering the "distance" between the profile of the person being studied and the profile of the ideal agent, thus configuring the level of proximity of the reality of the company in relation to the performance desired from the organization's human resources.

In order to measure the proximity, resources from Fuzzy Sets Theory are used, because they are perfectly suitable to the case in study. In the case of analysis of the action of human resources that work as decision making agents, the following elements can be defined:

S: the set of decision making agents;
s: a certain decision making agent;
Z**:** a subset of the agents that meet criteria "Z" and
R[Z(s)]**:** the degree of belonging of agent x in relation to "Z" (decision making agents that satisfy criteria "Z").

For each evaluation criteria, a membership function should be based on some specifications that the agents must present. Since, however, we want to evaluate the decision making agent "as a whole", it is necessary to aggregate the criteria in a general analysis. In formal terms, this aggregation can be represented by the intersection and union operators of the fuzzy sets, defined by the various criteria, and there may or may not be compensation among them.

To aggregate any two non-compensatory criteria, defined by fuzzy sets Z1 and Z2, Zadeh proposes, for the intersection, the use of a min operator, which selects the degree of belonging of lowest value among those being analyzed; for the union, he proposes the use of a max operator, which chooses the degree of belonging of greatest value among those in the set in question (Zadeh in [5]). For cases in which the aggregation between criteria occurs in a compensatory form, Zimmermann [6] proposes that other operators be used. For the intersection, the product of the membership functions are used; for the union, the sum of the degrees of belonging, from which is discounted the product of these same degrees, or that is,

$$R[Z1iZ2\ (s)] = R[Z1(s)]\ .\ R[Z2(s)] \text{ and}$$
$$R[Z1UZ2\ (s)] = R[Z1(s)] + R[Z2(s)] - R[Z1(s)].\ R[Z2(s)].$$

Here , "i" and "U" respectively represent the intersection and the union of the sets. In this way, considering the expressions above, two or more criteria can be aggregated to obtain a single value to evaluate the union or intersection set defined by the criteria being studied.

For a particular criteria, a limit L can be set so that if $R[z(s)] < L$, a deficiency of the decision making agent is characterized in this criteria.

Obviously, $0 < L < 1$, and if L is close to zero, the criteria is considered to be of less importance; if it is close to 1, then it is a criteria of great importance.

As perceived, the notion of proximity is perfectly suitable to the concept of fuzzy sets.

3 A Practical Process of Performance Evaluation in Industrial Environments

Initially, human action in industrial plants will be considered.

Consider a professional who works at a company as a “decision-making agent”, associating his activity to the administration, management, supervision or to a similar position. It is supposed, by the specificity of the field in which he acts, that this decision-making agent should have a set of characteristics that are judged essential, and, or, desirable, to exercise the position. These characteristics will establish the basis for the evaluation criteria that are being used.

Consider these groups of criteria essential to the decision-making agent that will act in a specific function: (a) Individual attributes and (b) acquired attributes. The first group concerns attributes inherent to each people. They cannot be transferred. The second group refers attributes that can be obtained by transferring ways, like training process or formal courses.

As individual attributes we include sensorial aptitude. As acquired characteristic we consider the knowledge of the product and of the productive process; the knowledge of the basic product quality standards and the knowledge of the quality evaluation techniques in the level of products and processes.

The evaluation of the levels of service to these characteristics can be developed in various distinct contexts. This model refers to the selection of personnel to act as decision-making agents. In this case, it involves the execution of a basic evaluation that determines if an operator has the ability and aptitude to exercise the decision-making action being studied. Other models, referring to specific situations, can also be structured.

In the case studied, the decision-making agent analyzed finished product quality at the company. The objective of the model is to select technical personnel from the factory who have an aptitude and technical qualification to act in product evaluation.

Candidates for the function include company personnel or people from outside the company, as long as these other companies are very similar. The characteristics defined for the role of decision-making agent define a set of criteria, which should be considered case by case and then aggregated together.

(A) Individual Attributes – Sensorial Perception

For the determination of the level of sensorial perception of the candidate for decision-making agent, it is proposed that 100 items of the product be evaluated in which each of the senses is evaluated, either in the same piece or in a varied set of pieces.

Only the items that are effectively relevant in the evaluation of the piece should be considered. Thus, for example, in the case of tiles, it is considered important to evaluate the sense of vision (possible degradation of tones), touch (alteration of texture) and hearing (change of resistance of the piece, evaluated by the sound made from small taps to the piece). Other products can consider tests of various natures, which also involve taste (change in the flavor of foods, drinks or cigarettes for example) and smell (the change of smell of drinks or perfumes for example).

Due to the nature of the product and of the evaluation to be used in the tests to be made, different weights are attributed to each one of the senses that should be used in the tests to be made. These weights will be values on a scale from zero to one (zero indicates the absence of need to use that sense: “one” indicates its maximum importance). The TC variable indicates the number of tests made correctly in the 100 pieces presented to the candidate; P is the respective weight. So,

$$R1[(s = TC)] = P1*(TC1/100) + P2*(TC2/100) + P3*(TC3/100) + P4*(TC4/100) + P5*(TC5/100).$$

It is essential to note that the weights are between zero and one and that the sum of these weights is always 1.0. This criterion obviously cannot be compensated for by a similar test or any other criterion.

(B) Acquired Attributes

Criterion 2: Knowledge of the Product

For each product, an estimate is made of the time required for each person, acting directly in productive processes with the product in question, at this or another company, or a user of the product to evaluate the variation of the product characteristics. It is supposed that this time is, for example, 5 years. So,

$$R2[Z(s)]=s/5 \text{ , if } s < 5 \quad \text{and} \quad R2[Z(s)]=1, \text{ if } s \geq 5.$$

This criterion cannot be compensated for an equivalent criterion.

Criterion 3: Experience in the Productive Process

Consider that direct experience in the productive process at the factory begins to confer competence to the decision-making agent after, for example, 1 year of work. From 1 to 3 years, the learning tends to be quicker and more intense. Above 3 years, the worker is apt to evaluate the process. So:

$$R3[Z(s)] = s/4 \text{ , if } s \leq 1;$$
$$R3[Z(s)] = (3s/8) - (1/8), \text{ if } s > 1, s \leq 3;$$
$$R3[Z(s)] = 1, \text{ if } s > 3.$$

This criterion can be compensated if the person has contact with similar processes at another company. So:

$$R4[Z(s)] = s/8 \text{ , if } s \leq 2;$$
$$R4[Z(s)]= (s/4) - (1/4), \text{ if } s > 2, s \leq 5;$$
$$R3[Z(s)] = 1, \text{ if } s > 5.$$

Note that the time required in the latter case is greater – thus consider the adaptation that the person will have at the new company, or that is, at the company in question.

Criterion 4: Experience with specific characteristics being evaluated

Work with specific characteristics of the product provides the person quick command of the item, which grows as the experience increases, for which reason a non-linear function of accentuated growth is used here. So,

$$R5[Z(s)] = (s)^{(1/3)} \text{ if } s \leq 1;$$
$$R5[Z(s)] = 1 \text{ if } s > 1.$$

This criterion can be compensated if a person has had contact with a specific characteristic in previous experiences, at similar companies. In this case a less accentuated growth value is attributed because it involves an environment different from that being considered. It means:

$$R6[Z(s)] = (s)^{(3)} \text{ if } s \leq 1;$$
$$R6[Z(s)] = 1 \text{ if } s > 1.$$

Criterion 5: Pattern Recognition

This involves a simple test, in which a set of pieces is offered to the agent, who must classify them according to given quality standards. All the pieces will be classified according to these standards as "perfect" or "defective".

The classification is made by the auditors (experienced agents) who determine the CC number of the correctly classified pieces. If the number of pieces considered is TP, we have:

$$R7[Z(s)] = CC / TP.$$

This criterion can be partially compensated by another, which refers to the knowledge of the techniques for evaluation of the quality of the pieces. In this case a tolerable defective fraction (FDT) is stipulated suitable to the process (2% for example) and consider that IDP is the defective fraction, which the decision making agent did not detect. Thus,

$$R8[Z(s = IDP)] = 1 - (IDP/FDT) \text{ , if } IDP \leq 0.02;$$
$$R8[Z(s= IDP)] = 0, \text{ if } IDP > 0.02.$$

This criterion considers, in principle, the occurrence of a positive value for the consumer's risk. If positive attributes should also be attributed to the producer's risk, then if IDF is the percentage of perfect pieces that the candidate incorrectly rejects, then there is an Acceptable Quality Level (AQL) of, for example, 0.01,

$$R9[Z(s = IDF)] = 1 - (IDF/AQL) \text{ , if } IDF \leq 0.01$$
and
$$R9[Z(IDF)]) = 0, \text{ if } IDF > 0.01.$$

Note here, the attendance of one of the items complements the others, but does not eliminate the need for its attendance.

Criteria Aggregation

To aggregate the criteria, the rules Zimmerman and Zadeh [7] described are applied. The set D of the decision-making agents considered suitable is those who met the following general criteria, with the specified membership function:

$$R/D(x) = \text{Min } \{R1; R2; (R3 + R4 – R3*R4); (R5 + R6 – R5 * R6); (R7 * R8 * R9)\}$$

4 Practical Application of the Model in an Industrial Plant

Consider the data below, extracted from a tile company, related to 3 operators who are candidates to be decision-making agents, and begin to perform the function of "inspectors of product quality guarantee". It is sought to determine here, which of them is suitable for the new function.

Items to be evaluated – Operators:

(1) TCP: Time of contact with the product (years);
(2) EXP: experience in the process(years);
(3) EXS: experience in similar processes (years);
(4) ECC: experience with the characteristic of the product at the company (years);
(5) ECA: experience with the product characteristics at another company (years);
(6) Correct tests: CTT: touch (units) and CTV: visual (units); correct (CCC) and incorrect

classifications in terms of FDT (IFDT) and AQL (IAQL).

Note that CCC, IFDT and IAQL are in %.

The evaluation measures are years, units or percentages and they are shown in the next table. CTT has the weight 0.4 and CTV has the weight 0.6. O1, O2 and O3 are the operators. So we have:

ITEM	O1	O2	O3
TCP (1)	3	4	4
EXP (1)	3	4	4
EXS (1)	2	1	-
ECC (1)	1	2	2
ECA (1)	1	1	-
CTT (2)	80	85	90
CTV (2)	94	90	82
CCC (3)	90	82	95
IFDT (3)	0.2	0.3	0.1
IAQL (3)	0.1	0.1	0.2

LEGEND: (1) Years (2) Units (3) Percents.

The values of the membership functions (MF) are then calculated. There are specific values for the individual analysis of each criterion, by operator. Finally, applying the function of aggregation of the criterion, we have:

MF	O1	O2	O3
R01[Z(s)]	0.60	0.80	0.80
R02[Z(s)]	1.00	1.00	1.00
R03[Z(s)]	0.25	0.13	0.00
R04[Z(s)]	1.00	1.00	1.00
R05[Z(s)]	1.00	1.00	1.00
R06[Z(s)]	0.88	0.88	0.85
R07[Z(s)]	0.90	0.82	0.95
R08[Z(s)]	0.90	0.85	0.95
R09[Z(s)]	0.90	0.90	0.80

Specific values for the individual analysis of each criterion, by operator

	O1	O2	O3
Criterion 1	0.600	0.800	0.800
Criterion 2	1.000	1.000	1.000
Criterion 3	1.000	1.000	1.000
Criterion 4	0.884	0.880	0.852
Criterion 5	0.729	0.627	0.722

Applying the function of aggregation of the criterion, we have:

Operators	1	2	3
R[Z(s)]	0.600	0.627	0.722

5. Some Conclusions from the Practical Application of the Model in an Industrial Plant

The application of the model leads to the following conclusions: The best candidate is number 3, followed by number 2. Candidate 1 follows closely.

The principle of classification can be used to define who is approved. This principle, which classifies the candidates in decreasing order, following the value of the aggregation function has a serious inconvenience: it is possible that no candidate is prepared, and the selection in this case must not be considered. In this way, it appears more convenient to use the principle of Level Subsets.

According to this principle, a given level is set for the membership function and only those candidates who are above this level are considered. This is where the classification occurs. Thus, if for this case it is established that L = 0.7, only candidate 3 is approved.

The question of how to set the level for the level group is not difficult to resolve. Simply observe that the model allows performance standards to be set. In fact, considering two or more decision-making agents to be experienced, the tests above are applied and the lowest value obtained by the agents is considered as the minimum performance value. The model determines a standard that can be used whenever needed, when there are changes in the process, in the evaluation processes, in the characteristics, or even in the product.

Finally, it should be observed that the model shows the deficiencies of each candidate submit to the test and allows developing corrective and preventive actions to resolve the issue. For example, in the case above, the following is noted: (1) Criterion 2 and 3 are those most completely attended by all the candidates; criterion 1 and 5 display the largest deficiencies in the entire group. (2) Candidate 3 does not have experience at another company. This criterion, however, was compensated for by other factors, such as the fact he is the candidate with the highest number of correct classifications of the pieces submit to him. (3) The candidate chosen has greater deficiencies in criterion 1 and 5, which confirms the general level of the group.

A study of the model above shows that an acceptable level for this case is 0.6544. This amount is based on uniform attendance to the various evaluation criteria. Only candidate 3 would be classified if this limitation was imposed on the selection.

In addition to the adjustment observed to the situation where the models are inserted and of the contribution to obtain the results sought, it is equally important to highlight the efficiency with which a solution to the problem was obtained.

In fact, the use of fuzzy logic allows a fast, reliable and practical procedure to be structured to evaluate the action of human resources of an organization. This can be observed by the facilities of programming of the operational procedures of the model, controls in the execution of processing, objectivity in handling data, the possibility for critical analysis of the results and the security of information obtained. In a cost-benefit analysis, this factor can compensate the costs that the implementation of the system can bring.

Below we will analyze the evaluation of performance in the services environment.

6 Evaluation of Human Performance in Services Environment

Also here consider a professional who works at a company as a “decision-making agent”, associating his activity to the administration, management, supervision or to a similar position. In the same way as before, it is supposed, by the specificity of the field in which he acts, that this decision-making agent should have a set of characteristics that are judged essential and or desirable, to exercise the position.

Again, these characteristics will establish the basis for the evaluation criteria that are being used.

To maintain the similarity between the different situations, consider these groups of criteria essential to the decision-making agent that will act in a specific function: (a) Individual attributes and (b) acquired attributes. The first group concerns attributes inherent to each people, as an individual attribute. They cannot be transferred. The second group refers skills that can be obtained by transferring processes, like training process, formal courses, lectures or some other way.

In the industrial environment, as individual attributes we have included sensorial aptitude. Here, we have a different vision. Individual characteristics, considered here to be nontransferable, include the ability of a salesperson to offer a product to an undecided consumer, so that he or she makes the purchase. This means that the seller captured the consumer’s desire, and knew how to offer the right product. It is a subjective attribute that depends on the experience of the salesperson and the knowledge he or she has of consumers and available products, but principally, of the capacity that the seller has to associate a specific product to a determined consumer.

As acquired characteristic we consider, first, the knowledge of the available products.

The knowledge that the seller has of the entire sales process will be considered below, including forms of payment, exchange policy for goods or the availability of products for immediate delivery or after a certain time.

The following criterion considers the knowledge of quality patterns for various products, so that this technical information can be quickly passed on to the consumer, in a clear and perfectly understandable manner.

Finally, a quality evaluation process will be considered. This refers to the selection of the products that will be destined to each store, so that each product can serve a specific market share.

As before, in the service area we observe that the evaluation of the levels of fulfillment to these characteristics can be developed in several contexts.

This model refers to the selection of personnel to act as decision-making agents in the commercial activities. In this case, it involves the execution of a basic evaluation that determines if a seller has the ability and aptitude to understand costumer preferences, and also to execute the decision-making action according to his activities.

Different actions in the sell environment should require different models.

In the case studied, the decision-making agent acts in the analysis of the quality of the products that will be made available in the stores. In addition, he or she conducts the sale, or that is, has direct contact with the consumer.

The goal of the model is to select human resources of the company that have an aptitude and technical qualification to act in the evaluation of the products that will be provided in each store and that will be able to make the sales. The candidates for the function are initially people who work in the company. But good candidates who work in organizations similar to those studied here will also be considered.

The stores studied work only in the women's clothing sector.

7 A Practical Process of Performance Evaluation in Service-providing Companies

As before, the characteristics defined for the role of decision-making agent define a set of criteria, which should be considered case by case and then aggregated together.

Note that fuzzy approach has been used in evaluating quality at service areas ([8] and [9]). This last paper suggests a methodology of usability evaluation of information systems in public administration based on fuzzy logic theory.

(A) INDIVIDUAL ATTRIBUTES – Subjective Perception

To determine the level of the subjective perception of the candidate for decision-making agent, it is proposed that an evaluation be conducted of various sales processes.

The monitoring of the action of the candidate at the store considers a set of 50 client contacts and the percentage of success.

Five weights were selected for various intervals referring to the value of the purchase (higher value implies greater weight).

The TC variable indicates the number of successful sales; P is the respective weight. The intervals for the weights are given in the table below, as an example.

Note that values close to 1, in this indicator, signify a high percentage of sales and high values of these sales.

Interval ($)	Less than 200	200 – 500	501 - 800
weight	0.40	0.50	0.75

Interval ($)	801 – 1.000	More than 1.000
weight	0.90	1.00

So,

$$R1[(s = TC)] = P1*(TC1/100) + P2*(TC2/100) + P3*(TC3/100) + P4*(TC4/100) + P5*(TC5/100).$$

This criterion obviously cannot be compensated for by a similar test or any other criterion.

(B) ACQUIRED ATTRIBUTES

Criterion 2: Knowledge of the Product

For each product (a dress, for instance, or any other woman's item of clothing), an estimate is made of the time required for each person, acting directly in productive processes (selecting, defining or selling) with the product in question, at this or another store or shopping company, or a user of the product, to evaluate the variation of the product characteristics, like colors, texture or combination capacity. It is supposed that this time is, for example, 3 years.

So,

$$R2[Z(s)] = s/3 \text{ , if } s < 3 \text{ and}$$
$$R2[Z(s)] = 1, \text{ if } s \geq 3 .$$

This criterion cannot be compensated for an equivalent criterion.

Criterion 3: Experience in the Productive Process

Here, the productive process means effective actions in the shopping area.

Consider that direct experience in the process of interacting with costumers begins to confer competence to the decision-making agent after, for example, 1 year of effective practical work. From 1 to 3 years, the learning tends to be quicker and more intense. Above 3 years, the seller is apt to interact successfully with costumers. So:

$$R3[Z(s)] = s/4 \text{ , if } s \leq 1;$$
$$R3[Z(s)] = (3s/8) - (1/8), \text{ if } 1 < s \leq 3;$$
$$R3[Z(s)] = 1, \text{ if } s > 3.$$

This criterion can be compensated if the person has contact with similar processes at another company. So:

$$R4[Z(s)] = s/8 \text{ , if } s \leq 2;$$
$$R4[Z(s)]= (s/4) - (1/4), \text{ if } 2 < s \leq 5;$$
$$R3[Z(s)] = 1, \text{ if } s > 5.$$

Note that the time required in the latter case is greater. It considers the adaptation that the person will have at the new company, or that is, at the service company we are studying here.

Criterion 4: Experience with specific characteristics being evaluated

As we have stated before, the interaction with costumers highlights some specific characteristics of woman's clothing pieces. It provides the seller quick command of the item, which grows as the experience increases. Also here, for this same reason, a non-linear function of accentuated growth is used here. So,

$$R5[Z(s)] = (s)^{(1/3)} \text{ if } s \leq 1;$$
$$R5[Z(s)] = 1 \text{ if } s > 1.$$

This criterion can be compensated if a person has had contact with a specific characteristic in previous experiences, at similar companies. In this case a less accentuated growth value is attributed because it involves a sell environment different from that being considered. It means:

$$R6[Z(s)] = (s)^{(3)} \text{ if } s \leq 1;$$
$$R6[Z(s)] = 1 \text{ if } s > 1.$$

Criterion 5: Pattern Recognition

This criterion, for the service area, was completely redefined.

If the product serves quality criteria, as in the case of criterion 2, there is no reason to develop a process of pattern recognition. For this reason, the criterion was totally reformulated. What we wish to evaluate here is the allocation of the products to the stores. That is: as soon as an industrial product is associated to a certain pattern, using a pattern recognition process, the decision-making agent must decide to which store a product should be sent.

What is expected here, in this choice, is that the product is sold in a given period. If this occurs, the product was allocated to the correct "pattern" and it is considered "perfect" (for example: the dress was sold in less than a week).

Otherwise, it will be classified as "defective" (dress was not sold after a week of display in the window). Here we have a classification similar to the model for industrial goods.

CC is the number of the correctly classified clothing pieces. If the number of pieces considered is TP, we have:

$$R7[Z(s)] = CC / TP.$$

Also here this criterion can be partially compensated by another, which refers to the knowledge of the techniques of sales of products with more accessible terms, or that is, the realization of events that encourage, facilitate or promote sales.

The FDT fraction refers to the expected percentage of unsold products; IDP is the real percentage of what was not sold, even in special conditions. In the same way, an average index of success of sales (AQL) can be created, and generate a criterion based on the ability to meet this indicator.

This is an indictor that measures the average quality of the salesperson, or the average expected value of sales above a certain amount. If VM is this amount, we define IDF = 1 – VM. Thus,

$$R8[Z(s = IDP)] = 1 - (IDP/FDT) \text{ , if } IDP \leq FDT$$
and
$$R8[Z(s= IDP)] = 0, \text{ if } IDP > FDT.$$

Also we can define an Acceptable Quality Level (AQL) of, for example, 0.10. So, we have:

$$R9[Z(s = IDF)] = 1 - (IDF/AQL) \text{ , if } IDF \leq 0.10$$
$$\text{and } R9[Z(IDF)]) = 0, \text{ if } IDF > 0.10.$$

Note here, the attendance of one of the items complements the others, but does not eliminate the need for its attendance.

CRITERIA AGGREGATION

To aggregate the criteria, the rules Zimmerman and Zadeh described are also applied here. The set D of the decision-making agents considered suitable is those who met the following general criteria, with the specified membership function:

$$R/D(x) = \min\{R1; R2; (R3 + R4 - R3*R4); (R5 + R6 - R5 * R6); (R7 * R8 * R9)\}$$

Note that the general criteria function is the same. But the elements of the formula have completely different meanings.

8 Practical Application of the Model in Service-Providing Environment

The process of applying the model to the case of services is exactly the same as before, and will not be repeated in detail, establishing it only in the elements considered and in the final results.

Here, six candidates were analyzed. The model should determine the one most appropriate for the function and the order of classification of the others. Note that the candidates have specific characteristics.

The following items are considered by criterion, for each candidate:

(1) TC: Sells and respective weights (%);
(2) TCP: Time of contact with the product (years);
(3) EXP: Experience in the specific sell function (years);
(3) EXS: Experience in similar processes (years);
(4) ECC: Experience with the characteristic of the product at the company (years);
(5) ECA: Experience with the product characteristics at another company (years);

(6) CCC: Correctly classified clothing pieces in the sense of criterion 5 (%);
(7) FDT: Expected percent of products not sold (%)
(8) IDP: Real percent of not sold products, even in special conditions (%).
(9) AQL: Acceptable Quality Level (%).
(10) IDF = 1 – VM, where VM is the average value of sales more than a certain value (%).

In the table, Ci is the candidate i.

	C1	C2	C3
TC (1)	85	87	88
TCP (2)	2	2	3
EXP (2)	2	3	3
EXS (2)	1	1	4
ECC (2)	2	3	2
ECA (2)	1	1	1
CCC (1)	75	80	85
FDT (1)	20	20	20
IDP (1)	10	10	5
AQL (1)	10	10	10
IDF (1)	5	4	2

	C4	C5	C6
TC (1)	80	75	70
TCP (2)	4	5	7
EXP (2)	4	4	7
EXS (2)	3	2	1
ECC (2)	4	2	2
ECA (2)	2	4	1
CCC (1)	85	65	70
FDT (1)	20	20	20
IDP (1)	0	0	25
AQL (1)	10	10	10
IDF (1)	4	4	12

LEGEND: (1) Percents; (2) Years.

The values of the membership functions (MF) are then calculated. There are specific values for the individual analysis of each criterion, by operator. Finally, applying the function of aggregation of the criterion, we have:

MF	C1	C2	C3
R01[Z(s)]	0.90	0.85	0.90
R02[Z(s)]	0.67	0.67	1
R03[Z(s)]	0.875	1	1
R04[Z(s)]	0.125	0.125	0.75
R05[Z(s)]	1	1	1
R06[Z(s)]	1	1	1
R07[Z(s)]	0.75	0.80	0.85
R08[Z(s)]	0.50	0.50	0.75
R09[Z(s)]	0.5	0.6	0.8

MF	C4	C5	C6
R01[Z(s)]	0.88	0.90	0.75
R02[Z(s)]	1	1	1
R03[Z(s)]	1	1	1
R04[Z(s)]	0.25	0.5	0.125
R05[Z(s)]	1	1	1
R06[Z(s)]	1	1	1
R07[Z(s)]	0.85	0.65	0.70
R08[Z(s)]	1	1	0
R09[Z(s)]	0.6	0.6	0

Specific values for the individual analysis of each criterion, by operator

Criterion	C1	C2	C3
1	0.90	0.85	0.90
2	0.67	0.67	1
3	0.8906	1	1
4	1	1	1
5	0.1875	0.24	0.51

Criterion	C4	C5	C6
1	0.88	0.90	0.75
2	1	1	1
3	1	1	1
4	1	1	1
5	0.51	0.39	0

Applying the function of aggregation of the criterion, we will have:

Candidates	R[Z(s)]
C1	0.1875
C2	0.2400
C3	0.5100
C4	0.5100
C5	0.3900
C6	0.0000

9 Some Conclusions from the Practical Application of the Model in Service-Providing Companies

The first conclusion is that criterion 5 is too rigorous. It even eliminates the sixth candidate, which is the one with the most experience. With this criteria included, the best candidates are the third and fourth. The others follow, with a good distance between them. If the last criterion is eliminated, another table would be constructed.

Candidates	R[Z(s)]
C1	0.67
C2	0.67
C3	0.90
C4	0.88
C5	0.90
C6	0.75

Note that there is no big change in classification, except in terms of candidate six, which comes to be the fourth best. This situation can require the organization to create a new set of criteria, given that the current one may not be suitable.

Anyway, also here the principle of classification can be used to define who is approved. This principle, which classifies the candidates in decreasing order, following the value of the aggregation function R[Z(s)], has now two inconveniences: it is possible that no candidate is prepared, and the selection in this case must not be considered and the set of criterions is not adequate. But the criterions can be changed at any time by the organization. And to the first problem, we can use again the principle of level subsets.

As we have seen, according to this principle, a given level is set for the membership function and only those candidates who are above this level are considered. This is where the classification occurs. Thus, if for this case it is established that $L = 0.5$, only candidates 3 and 4 are approved, considering the original ranking.

We can use here the same principles of industrial environment to the question of how to set the level for the level subset.

A detailed analysis of the performance of the candidates shows that the model emphasizes certain criterion and gives less weight to others. This situation can always be changed, according to what is convenient for the company.

At the same way as before, it should be observed that the model shows the deficiencies of each candidate submit to the test and allows developing corrective and preventive actions to resolve the issue. It can be done using the particular results of the tables.

We can observe, for example, that candidate 6 had a poor performance, despite having considerable experience (more than the others). His specific mistakes in terms of evaluation of product quality, however, had great impact on his performance. Thus, his experience was not enough to compensate these faults.

10 A Comparative Analysis

A comparison of the models applied in the field of industrial goods and in the service-providing organizations show some interesting differences and some similarities between the two situations.

Initially, it can be seen that the two processes involve human resources. This is a priority for any organization. For this reason, the usefulness of the model appears to be characterized.

The similarities between the models emphasize the importance of qualification of the human resources. The factors listed in the models emphasize this issue. Note, however, that experience does not always make people qualified.

For this reason it is important in both cases to separate formal training from practical training activity. Both are important; but one does not substitute the other. This conclusion is true for the two environments studied. In this sense, note that the criteria selected were suitable and their adjustment to each environment were correct.

The most notable difference found when comparing the two models concerns the fact that industrial goods are concrete, while services are intangible. Thus the evaluation of the quality of a product is easier to be made than the evaluation of quality in services.

The model that evaluates services tends to be more subjective, with greater impact on intuitive evaluations. This can be seen in the criteria listed in the two models. The criteria for evaluation of industrial products are direct, visible and palpable objectives. In services, even if the amount of sales is a concrete indicator, subjective variables, such as consumer satisfaction with the sales process itself, are very important and difficult to evaluate.

A second important difference refers to the sensitivity of the model. Since the elements that compose the second model vary more quickly, there can be important alterations in the performance of the human resources in a short space of time. This variation also occurs in industrial plants, but at a much lower speed.

The parameters that compose the criteria for evaluation of industrial products usually become stabilized when certain levels of technical qualification and experience in certain contexts were achieved. These variations are quite visible in the models discussed here.

Another difference to consider is related to the interaction with consumers. In industrial products, there is always a high level of support activity and low direct interaction with the client.

A car manufacturer, for example, has little interaction with the client, who is in the dealership for a short time when compared to the time of design and production. For this reason, the evaluation of the quality attributes is done more consistently. This is reflected in the values of the elements that compose the criteria. Meanwhile, in services, the number of support activities is small and the interaction with the client greater.

The time that the client spends in a hotel, for example, coincides with the time services are provided. In addition, the consumer can interfere in the service during its production (by complaining about poor service for example). The "defect in service" can be corrected during the service.

This situation shows that, in tangible goods, the relations with consumers are focused on sales, marketing and assistance in using the product. The model shown here only emphasizes the productive process. This finding allows opening new areas for evaluation. In services, the direct relations with clients are emphasized (principally the interaction process); and for this reason there is a demand for greater flexibility in the process: after all, the client participates in the process and is physically present.

This flexibility makes the parameters of the model quite agile and their values are very dynamic. The latter finding reveals that the models have different scopes, actions and management processes: while in the first case the quality appears in the product (result of the process), in the second it appears in the interaction between client and company. These are the central elements of quality evaluation.

Finally, it can be seen that the models can interact within the same environment. In fact, at industrial companies, there can be service areas, with product-support activities, which involve basic information about the use of the product (manuals), installation, technical assistance, etc. The service, here, offers client support, in terms of direct facilities that the company makes available to its clients or of services for actions they request. The product support is part of the product quality (in this case, quite tangibly).

Client support, meanwhile, refers to quality of service. Thus, an industrial company can use both models, both to evaluate the products themselves as well as to provide the support offered to them. And a service company, can, in addition to evaluating its interaction with the client, also evaluate the products provided – as in stores (goods and services) or restaurants (service and food).

The effort to create and consolidate an effective involvement of people in the development and operation of organizations always existed and will always exist – in industrial factories or services companies.

The human being is, in fact, an essential component of organizations. It was always like that and always will be.

In reality, the importance of the action of people in organizations is not questioned. The question is how to involve people in the effort to produce quality. In addition to the principal problem (diversity of methods, tools and strategies to do so), there is inherent difficulty in the evaluation itself.

Evaluating human resources is always a complex task. Human resources have very special characteristics. It is always very difficult to evaluate them. It is always complicated to understand them. It is a notable challenge to involve them. It is the resource that demands the most investment, effort and time to generate consistent results. It is the most complex of the resources at an organization.

If questioning if such an effort is worthwhile, it should be noted that human resources are those that offer the highest and best returns. They are those that generate creative solutions; propose more efficient forms of action; and suggest faster, cheaper and more efficient work methods. They foresee special situations in processes and products. They interpret trends and create preventive actions. They seek new objectives. They overcome new challenges.

Given these returns, it is always worthwhile to invest in them. This study intends to contribute to this evaluation process with an objective model, aimed at the special characteristics of each decision-making agent who has an important role in industrial organizations and service providers.

In addition to contributing to structuring the objective model for evaluating human resources, this study also intends to reveal the differences in the actions of people in industrial and service environments. These differences are emphasized in the parameters that compose the criteria for each model and in the values that the criteria assume.

Whenever possible, an attempt was made to establish uniformity in these criteria in the two models, creating similar criteria and above all, maintaining the membership functions, the processes for compensation and non-compensation and the aggregation of criteria.

This identity of the models allowed tracing a comparative table between the two environments of action of human resources (industrial and services), revealing similarities and differences between them, but, above all, developing the entire process for an integrated Quality Management model.

11 Management Processes Defined by the Proposed Models

The models proposed allow defining criteria for three managerial levels for both – industrial plants and service-providing companies. Thus, it is considered, that as a general rule, Strategic Management requires a strategic vision, or that is, the recognition that the action of human resources has a decisive impact on an organization's survival. It is clear that this survival depends on factors outside the company.

The strategic dimension of the quality of products and services thus depends on giving priority to the efforts of people and sectors to completing attend the environment where the company operates. This environment goes beyond the consumer market and includes all of society. The ability to define the abilities of people thus creates a strategic distinction for organizations.

Tactical management, in turn, involves the management processes at organizations and the forms of involvement of human resources. All of the managerial mechanisms depend on local culture, existing values and available abilities. To correctly evaluate these characteristics is a decisive factor for the success of the managerial model of organization.

Meanwhile, the operational management refers to the direct action of human resources in the productive activities.

The analysis of the ideal profile and current operational conditions of labor allow obtaining a view of the set of company operations. It also generates greater facility for obtaining global improvements in the process. Note that the improved actions of human resources in the productive field generate results that have impact on products and tend to serve consumers. They are results that appear rapidly, have good visibility and for this reason, tend to be important motivational factors.

The model described here, as seen, influences Strategic Management by defining how human resources can constitute a competitive distinction in terms of their action in the productive processes and their influence on products. The model influences Tactical Management, since, it determines profiles, ideas and level of proximity of the resources available in relation to these standards. Finally, it also influences Operational Management, by measuring the typical activities in the development of the productive processes.

In particular, when analyzing the listed criteria, it is noted that the complete knowledge of the product and of the production process can generate important innovations in terms of adaptation to their use, creating a highly competitive distinction in services and products (Strategic Management); the evaluation of sensorial aptitude allows proper allocation of personnel to the productive activities (Tactical Management); the knowledge of the basic quality standards of the product combines consumer demands to the operation of the productive process (Strategic Management and Operational Management) and the command of the techniques of evaluation of quality level of products and processes guarantees control of the productive process (Operational Management with market perspective).

In this same context, it can be noted that other criteria can be added to the evaluation model, as a function of the nature of the organization, the characteristics of its activities and of its politics for operation in the market. Finally, it is important to note that the results of the practical applications in industrial organizations show results that are very close to those in companies that produce services.

12 Conclusions

The effort to create and consolidate an effective involvement of people in the development and operation of organizations always existed and will always exist. The human being is, in fact, an essential component of organizations. It was always like that and always will be.

In reality, the importance of the action of people in organizations is not questioned. The question is how to involve people in the effort to produce quality. In addition to the principal problem (diversity of methods, tools and strategies to do so), there is inherent difficulty in the evaluation itself.

Evaluating human resources is always a complex task. Human resources have very special characteristics. It is always very difficult to evaluate them. It is always complicated to understand them. It is a notable challenge to involve them. It is the resource that demands the most investment, effort and time to generate consistent results. It is the most complex of the resources at an organization.

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References:

[1] Shih, Meng-Long; Lin, Shouhua; Hsiao, Shu-Hua; Huang, Liang Ming; Chiu, Chaochang. The Study of the Correlation among Personality Traits, Leadership Competence and Organizational Performance. *WSEAS Transactions on Business and Economics*. Vol. 6, 2009. pp. 11 – 20.

[2] Bouhouche, Salah; Yahi, Mostefa, Hocine, Benjam; Bast, Jürgen. Quality Evaluation Based Fuzzy Residual Modelling. Application in Hot Rolling. *WSEAS Transactions on Systems and Control*. Issue 5, Volume 3, May 2008. pp. 447 – 452

[3] Hub, Miloslav; Zatloukal, Michal. Methodology of Fuzzy Usability Evaluation of Information Systems in Public Administration. *WSEAS Transactions on Information Science & Applications.* Issue 11, Volume 5, November 2008. pp. 1573 – 1583.

[4] Yu, Sen-Chi; Lin, Yuan-Horng. Applications of Fuzzy Theory on Health Care: An Example of Depression Disorder Classification Based on FCM. *WSEAS Transactions on Information Science & Applications*. Volume 5, Issue 1, 2008. pp. 31-36.

[5] Dubois, D. & Prade, H. *Fuzzy Sets and Systems*. New York, Academic Press, 1980.

[6] Zimmerman, H.J. *Fuzzy Set Theory*. Boston, Kluwer-Nijhoff Publishing, 1985.

[7] Zadeh, L. Fuzzy Sets. *Information and control.* Vol. 8, N. 3, 1965.

[8] Yeh, Chung-Hsing; Way, Philip Yiu-Ming. Fuzzy Knowledge-Based Decisions for Airline Seat Booking. *WSEAS Transactions on Systems.* Issue 4, Volume 2, October 2003. pp. 970-977.

[9] Hub, Miloslav; Zatloukal, Michal. Methodology of Fuzzy Usability Evaluation of Information Systems in Public Administration. *WSEAS Transactions on Information Science & Applications*. Issue 11, Volume 5, November 2008. pp. 1573 - 1583