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HUMAN RESOURCES MANAGEMENT WITH FUZZY LOGIC

ABSTRACT

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SUMMARY

Key words: personnel recruitment and selection, decisional systems under uncertainty, Fuzzy expert system, Multicriterial Interdependent Hierarchic Fuzzy Model (FMIH)

CHAPTER I

Theoretical and practical approaches to personnel recruitment, selection and evaluation

I.1. Theoretical models and practical applications of personnel selection

The current challenges in human resources management conclude that organizational decision makers recognize personnel management as a strategic opportunity for strengthening organizational competitive advantage. Because talent is rare, valuable, difficult to imitate and hard to substitute, organizations that attract, select and retain performant candidates (talent management) in the most effective, should be advantaged in terms of competitive against other organizations that fail at this. (Barney, Wright, 1998). However, surprisingly, a study by Rynes, Brown and Colbert (2002) concluded that in human resources field, there are big differences between the findings of conceptual research and organizational practice. This means that although personnel management should be one of the most important mechanisms in achieveing strategic competitive advantage, organization decisionmakers fail to optimally manage this resource.

The first purpose of the proposed analysis in this chapter is to provide a summary of selective key developments in personnel recruitment and selection. Research findings will be reviewed and critically analyzed regarding organizational practices in the field of personnel recruitment and selection. A second purpose of this review is to critically evaluate the link between theoretical models and practices in the personnel recruitment and selection on one hand and organizational effectiveness on the other. It stressed that there are be many gaps between research and practice and especially the lacking of studies demonstrating the business value of the personnel recruitment and selection. Eliminating that gap is necessary to transmit stronger strategic impact of HRM on organizational effectiveness.

I.1.1. Integrating personnel recruitment and selection in human resources management

The aim of any recruitment and selection process is to identify a sufficient number of candidates meeting the conditions to be selected. Although apparently this activity seems extremely simple and the routine, things are more complex because there are many possibilities to find suitable candidates for making wrong decisions, which over time will have an impact on the overall organizational efficiency.

Regarding the importance of recruitment and selection as an activity, Pilbeam and Corbridge (2006, p. 142) provides an overview of the potential positive and negative aspects, noting that: "Recruitment and selection of employees is fundamental to the functioning of an organization and there are good reasons for this process to unfold correctly. Decisions regarding improper selection lead to reduced organizational effectiveness, invalidation of the reward and staff development policies, are often unfair to candidates and create major difficulties to managers having to deal with unfit employees".

It is claimed that the validity and fairness, should be the priority indicator of a selection method within organizations. Pilbeam and Corbridge (2006, p.173) provides a summary of the predictive validity of selection methods based on the results of various surveys. However, they suggest that these measures of validity should be treated with caution as they may be affected by the performance indicators used and the way the instruments were applied. They indicate, however, both the variability between assessments and some degree of uncertainty when trying to forecast the future performance during the selection process.

I.1.2. A critical approach of personnel recruitment and selection current models

Most definitions of recruitment emphasize the collective efforts of the organization to identify, attract and influence the decisions of competent candidates for choosing a particular job. Organizational leaders are aware that talent recruitment is one of the most urgent problems. Current trends on the labor market offer multiple choices for applicants to chose between, especially for technical and services pool of jobs. This aspect throws a more problematic look over recruiting than of the personnel selection, launching the challenge of finding the best way to attract a diverse workforce. The selection will be ineffective in every way, including financially, unless a sufficient number of candidates apply within the organization. Thus, there is a growing recognition of the fact that recruitment in itself, independent of the selection, is not only critical for the competitive advantage but also to support organizational survival (Taylor & Collins, 2000).

Studying the literature, there is noted the existence of more and more reviews on the personnel recruitment and selection methods (Breaugh & Starke, 2000; Highhouse & Hoffman, 2001; Rynes & Cable, 2003; Saks, 2005; Taylor & Collins, 2000). The purpose of this chapter is not the indepth description of these methods but rather present the most recent findings, which provide the most relevant implications for organizational effectiveness.

The starting point for the effective review of recruitment strategies lies in meta-analysis proposed by Chapman, Uggerslev, Carroll, Piasentin & Jones (2005). Research comprises 71 studies in order to estimate the effect size and the relationship between predictors of recruiting (job/organization characteristics, recruiters features, perceptions of the recruitment process, fit perception, alternatives perception, employment expectation) and the results of attracting applicants (job tracking intent, the attractiveness of the job / organization, acceptance intention, job choice). This meta-analysis helps in organizing and clarifying the quite diverse issues identified in literature, namely person-organization fit perception (PO fit) and job/organization characteristics were the strongest predictors of an efficient recruitment process.

Although the implications of the research are useful, there are many issues to be analyzed in order to increase the practicability of recruitment. As Saks argues so eloquently, even though there are many studies on recruitment in the last thirty years (Breaugh & Starke, 2000), it is fair to say that: a) there are few practical implications for recruitment in organization, b) practical implications that can be gleaned from studies aimed at recruiting are known for more than a decade and c) the main practical implications are obvious and common.

Instruments used in the personnel selection (interviews, aptitude tests and personality tests) continue to capture the vast majority of researchers in human resources. There are several comprehensive reviews of recruitment practices (Evers, Anderson & Voskuijl, 2005; Schmitt, Cortina, Ingerick & Wiechmann, 2003) and discussions on practical applications of research results (Guion & Highhouse, 2006; Ployhart, Schneider & Schmitt, 2006; Ryan & Tippins, 2004). Rather than reviewing all this research, the present review summarizes the main developments. There will be examined only those personnel selection practices that are the most active research filed and demonstrates the most important practical implications, namely cognitive skills and personality tests, situational judgment tests, assessment centers, work samples and selection interview.

The central conclusion of this research is that over time, the predictive validity regarding subsequent job performance tends to diminish, classical research demonstrating decreased replicability coefficients.

I.1.3. Job performance

One way to classify performance is in terms of task-oriented behaviors (task behavior) and contextual behavior (citizenship and counterproductive) (Borman, Motowidlo, 1993). While task-oriented behaviors describe the mandatory tasks, contextual behaviors are those behaviors which do not necessarily relate to fulfill certain tasks. Citizenship behaviors are defined as those behaviors that contribute to achieving the organization's objectives, by their effect on the social and psychological context (Rotundo, M. & Sackett, PR, 2002). On the other hand, counterproductive behaviors are intentional actions of employees who circumvent the organization's objectives (Sackett, PR & DeVore, CJ, 2001).

I.2. *Human resources management based on competencies*

As described, competency based behavioral job interview represents the most implemented interview method in companies all around the world.

There is growing evidence that the popularity of competency based behavioral assessment is more widespread, a report by CIPD (2014) found that 86% of investigated organizations are using competency-based interviews in personnel selection. It is suggested that the competency based behavioral model is more meaningful in addressing personnel selection, given the speed that characterizes the current labor market, contributing therefore to ensure more effective and high performance human capital.

As stressed by Schippmann et al. (2000) competency-based models have become a trend in human resource management. While job analysis focuses primarily on the individual level, examining the specific knowledge, skills, abilities and other attributes (KSAO) necessary for individual job performance, competency-based model is an attempt to identify the dimensions of performance applicable to more than those roles and situations encountered in the professional environment. Relevant to this is the vast literature of industrial and organizational psychology in over several decades of researching the factors associated with both occupational and individual performance and organizational effectiveness. O'Reilly and Chatman (1986) suggested that two distinct variables relate to individual job performance, in-role behaviors and prosocial behaviors, which are not specifically prescribed in the job description.

Hayes et al. (2000) argue that it might be impossible to decompose a competence in an exhaustive list of items, suggesting that this competency models will always be incomplete. In

practice, universal or generic approach is most commonly adopted. As an example Tett et al. (2000) sought to identify and validate ”hyper dimensional taxonomy of managerial skills". Many of these skills are generally defined so that it subsumes a combination of factors such as personality, motivation and cognitive skills (Bartram, 2004). However, generic competences dimensional approach that satisfies all organizational contexts is unlikely to be suitable for organizations acting in completely different contexts, with different products / services and addressing various different customers (Chiabaru, 2000). As suggested by Stuart (1983), models based on simple and universal competencies, are seen on an individual level as less relevant.

The research paved the way for multilevel vision on human resources management, the latest models of human resource management practices following the emergence of human capital and the impact on organizational efficiency.

I.3. Human capital emergence: a multilevel model of personnel management

I.3.1. Conceptualizing the multilevel model of personnel management: the link between microlevel (individual characteristics) and macrolevel (organizational efficiency)

Critical analysis of the practices of personnel recruitment and selection identified a strong need for research on its impact over organizational effectiveness. This is somewhat paradoxical, given the central hypothesis of human resources management described in almost every topic treated, that personnel recruitment and selection contribute crucial to organizational effectiveness. If this were not like this, why invest so much in personnel? However, there is very little direct scientific evidence on the empirical testing of this hypothesis (Ployhart 2004 Saks, 2005; Taylor & Collins, 2000). Effectiveness analysis is particularly useful in estimating these effects, but they remain only estimates at the financial level (Schneider, Smith & Sipe, 2000).

Microresearch (individual level) examines how individual differences (knowledge, skills, abilities and other individual characteristics - KSAO) contribute to individual performance, but assume/estimate that these individual differences contribute to organizational performance. Microresearch is usually carried out according to classical perspective of industrial and organizational psychology (I/O psychology). Macroresearch (organizational level) reviews the way in which the practices of personnel recruitment and selection contributes to organizational performance, but assumes that these practices are

effective because of their influence on knowledge, skills, abilities and other individual characteristics (KSAO) of employees.

In the context of macroresearch, the unit level KSAO is called human capital and it is rarely measured. For example, research suggests that organizations that use personal well-developed practices perform better (Huselid, 1995), but the focus is on the practice itself and not on the human capital affected by the specific practice. Macroresearch is usually carried out under the strategic paradigm of strategic human resources management (SHRM).

Schneider et al. (2000) described the basic elements of such a model and later Ployhart and Schneider have examined practical (Ployhart & Schneider, 2002), theoretical (Ployhart, 2004) and methodological (Ployhart & Schneider, 2005; Ployhart & Moliterno, 2011) concepts needed to build a multilevel model of human resource management.

The emergence of multilevel human capital is a process through which the individual KSAO becomes human capital across the organization. Human capital contributes to organizational performance so that organizations with high quality human capital will have a strategic advantage. This is known as human capital advantage in the literature of macroresearch (Boxall, 1996). Of course there are other means by which the individual KSAO can contribute to macroeconomic performance, namely superior individual performance optimizes the efficiency of the organization.

Given these conceptual recent considerations on the use of personnel selection procedures to optimize organizational performance on a macro level and results of preliminary studies on the different practices of personnel management, there is proposed a fuzzy model for competency-based multilevel personnel management that will be developed and presented in Chapter IV.

I.4. Final remarks on personnel recruitment, selection and evaluation

Personnel practices (human resource management) are situated on an unbalanced position at the beginning of XXI century. Economic, social and cultural changes as well as personnel practices determine the survival and organizational performance. Managers are looking for the best techniques and tools to attract and engage talent. Often research is able to provide managers the tools, but the literature has sometimes difficulties in providing answers that demonstrate the value of these practices or solutions are so vague that they will never be put into practice. Personnel practices should dominate the war for talent strategic and sustainable competitive advantage, but it is the duty of researchers and practitioners to display

organizational science and practice value. The study of traditional practices in the recruitment and selection is important and should continue, but this is unlikely to increase the strategic value.

Multilevel staff research is particularly useful in determining organizational efficiency. All organizations use some personnel procedure, but there is no guarantee that they are used optimally or even adequately. This is unfortunate and will continue until gaps between research and practice will be resolved, demonstrating the strategic value of organizational staffing practices.

Multilevel staffing has implications for strategic human resources management (SHRM). For example, most conceptualizations of resource-based approaches claim that valuable rare, inimitable and unsubstituted resource provides a sustainable competitive advantage (Jackson, Hitt & Denis, 2003). From this perspective, the practices of recruitment (especially for lower level positions) are usually considered strategic because individual differences are common among candidates (being generic) and competing organizations mimics des practices selection of another competitor. However, Wright and colleagues (Barney & Wright, 1998; Wright, McMahan & Williams, 1994) argue that an organization's ability to attract and retain talent brings a competitive advantage. Moreover, human capital is valuable and irreplaceable, representing aggregate link between individual differences and organizational effectiveness. From this perspective, even low-management jobs and generic skills can be considered strategic because it is difficult for competitors to develop aggregated human capital.

CHAPTER II

Fuzzy logic in human resources management related decisional processes

II.1. The Fuzzy concept

The fuzzy logic stems from antique philosophy conceptions such those formulated by Plato, who enunciated the laws of thinking, or Parmenides, who emitted the hypothesis that statements may be in the same time false and true, objecting against the Aristotle's third man argument, which admits only two logic values: *true* and *false*. Plato anticipated the fuzzy logic, proposing a third region between false and true, where the two notions are overlapping. At the beginning of the 20th century, Lukasiewicz extended the Aristotle's bivalent logic, who was mathematically modeled by George Boole, proposing a new species of logic in his work entitled "On trivalent logic". The trivalent logic is that species of logic which treats judgments (logical propositions) which allow three logic values: true, false and likely. Later, it was admitted that between true and false there may be an infinite number of intermediate values. This kind of logic has sparked much controversy and was re - examined in the first decade of the twentieth century by many mathematicians such as Pierce, MacColl and Vasiliev. Knuth proposed a trivalent logic by replacing the logic values used by Lukasiewicz, respectively [0, +1, + 2], with [-1, 0 + 1], in order to simplify calculations. Despite this, the first part of the 20th century multivalent logics did not gain positions in practical applications.

The fuzzy logic is actually a multivalent logic that allows intermediate values and define their location between binary assessments, such as yes/no, true/false, black white, etc. Notions like "pretty hot" or "a little cold" can be formulated mathematically and algorithmically processed this way.

Let X be a set of objects. A fuzzy set in X is a set of ordered pairs:

$$A = \{(x, \mu_A(x) \mid x \in X)$$

where $\mu_A : X \rightarrow [0, 1]$ is the membership function. $\mu_A(x)$ represents the membership degree of element x at the set A.

Membership functions can have different shapes: triangular, trapezoidal, Gauss, sigmoidal, etc. In applications one can meet simultaneously fuzzy and Boolean sets: rectangular or singleton. The most common membership functions are triangular and trapezoidal, that are easy to implement. The use of more complicated forms is not usually bringing notable advantages in applications.

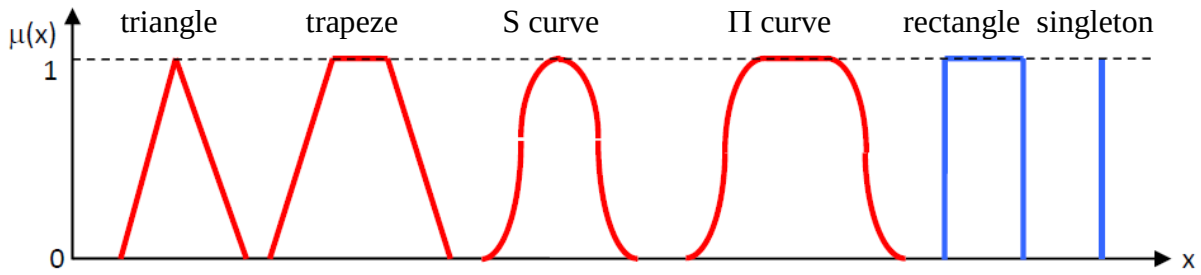

Figure II.1. Membership functions

With the help of the fuzzy sets one can be built fuzzy variables defined on a certain domain, containing linguistic descriptors/terms/labels. The graphical representation of these variables is through fuzzy cognitive frames (*frames of cognition*). These cognitive frames consist of the linguistic terms projected on the variable's universe of discourse.

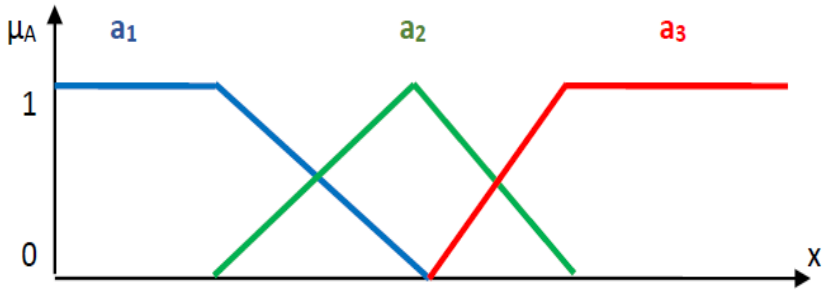

Figure II.2. The linguistic variable A with three linguistic terms

It is noted that the membership functions μ may have any value between 0 (false) and 1 (true). x = 0.5 represents the maximum uncertainty, namely the situation where we are not sure whether the value of x belongs to the linguistic term or not.

The fuzzy logic provides a flexible method for the treatment of uncertainty, with tools able to represent on the computer concepts such as *competence* for instance, by a linguistic variable *competent*, composed of several linguistic terms: incompetent, less competent, very competent, etc. This way, the fuzzy sets associate linguistic descriptions (qualitative) with numerical equivalents (quantitative).

From the above we observe that fuzzy logic is not vague, it only operating with vague concepts, it is not imprecise, it does not violate the reason, and does not produce ambiguous results. Actually the classical logic Boolean logic is a particular case of fuzzy logic.

At first glance, fuzzy mathematic is similar to the probability theory. Probability theory operates with statistical data, addressing the uncertainty of type I, which comes from the randomness of the phenomena studied.

In contrast, the fuzzy logic systems address the type II uncertainty, when available data are incomplete, vague. For instance, if an organization has a comprehensive database on personnel, probability theory is able to achieve a viable organizational diagnosis. For a new organization, probability theory is no longer a viable option for organizational diagnosis, as the disposable data are few, sparse and inconclusive.

In this situation, the fuzzy logic is the only instrument able to achieve organizational diagnosis as it can capitalize general knowledge of expert type, derived from previous statistical processing. In other words, organizational diagnoses obtained by conventional statistical methods, is knowledge based expert type fuzzy inferences. In other words, when we have enough experimental data we work with statistics. When, because of various reasons, such as the case of a new or small organization, we do not dispose of this data, we will work with fuzzy logic. Fuzzy logic alone cannot solve the problems, but helps to represent them on computer, making possible any other computer analysis.

II.2. Principles in the fuzzy logic

The studies of Professor Zadeh on fuzzy sets introduced the concept of sets without established limits, marking the beginning of a new direction in logic and establishing a new method of system analysis, where performance and operation are estimated by means of linguistic variables and not numerical. This approach is centered on improving the human decisional and rational factors. His unorthodox ideas were initially met with skepticism, but due to the huge wave of successful applications of fuzzy initiated in Japan 80s, they are now widely accepted by experts. His research related to decisions based on perceptions or on natural language represented systems were taken over and continued by an extended fuzzy community around the globe, with achievements in highly diverse areas, including psychology.

The basic principles are:

1. In fuzzy logic precise thinking is seen as a limiting case of approximate evaluation;
2. In fuzzy logic everything is reduced to degrees of membership;
3. Any logic system can be fuzzified;
4. In fuzzy logic knowledge is represented by fuzzy variables;
5. The inference is considered a process of propagation of flexible constraints.

In the case of fuzzy sets one can work with modifiers, which adjust the membership values of the fuzzy terms. We can use ratings such as *more or less*, *moderate*, etc., making possible the so-called *nuanced reasoning*.

From the fuzzy set theory have emerged in addition to the fuzzy logic and other concepts such as fuzzy probability or fuzzy numbers, each with a well-structured theory.

The *fuzzy numbers* FN are fuzzy sets defined on the real numbers space **R**. Their definition respects the following condition:

- FN are normal fuzzy sets: there are existing elements in **R** for which μ(FN) = 1;
- FN are convex;
- FN have limited support (the domain in **R** for which μ(NF) ≠ 0 is limited).
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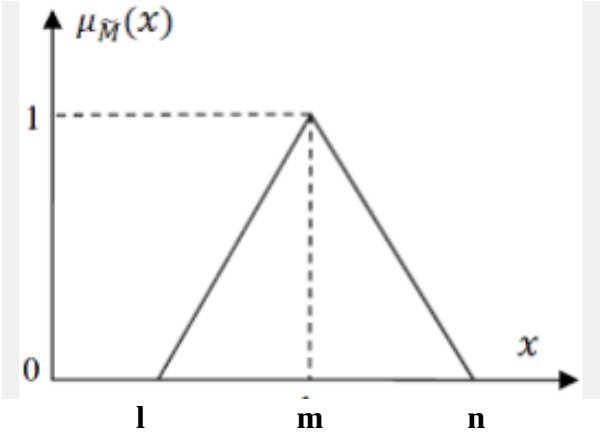


Figure II.4. Fuzzy triangular number

The triangular numbers, such as the one shown in the above figure, is represented by the three coordinates of the actual peaks of the triangle l, m and n (l, m, n).

It follows from the above that the fuzzy set theory is the most general theory of incompleteness made so far. Fuzzy logic provides the ability to represent and reason with common knowledge typically formulated and therefore has found applicability in many areas. Vague terms and rules can be represented and manipulated by computers, which is a very valuable feature in the knowledge base engineering, where the expert knowledge are usually formulated in natural language.

This is why I consider particularly useful to apply the fuzzy logic in human decision-making processes, in high risk points. As explained above, the theoretical model proposed in this thesis aims to facilitate the selection and the evaluation of staff, involving automated features. This does not eliminate the human factor as a decider, but betake automatic selection when the number of candidates is large, when one desires a very fair assessment, when the

candidates' characteristics are very similar and when a processual monitoring of all stages of the decision-making regarding the selection and evaluation of personnel is desired, briefly when we wants to avoid uncertainty and incompleteness.

II.3. MCDM – Multicriterial decision making

The Multi Criteria Decision Making (MCDM) was introduced as a promising and important area of study in the early 1970s. Basically, MCDM uses theories, methodologies and mathematical models and applications to address decision making processes which presuppose multiple criteria (objectives or attributes). Since then, the number of contributions to various theories and models that could be used as a basis for systematic and rational multi-criteria decision making, continued to grow at a steady pace. The study conducted by Bana e Costa and Vinck (1990), shows the vitality of the field and describes the multitude of methods that have been developed. When Bellman and Zadeh and a few years later Zimmermann introduced fuzzy in the field, researchers have opened the way for a new family of approaches to problems that were inaccessible and unsolvable with standard MCDM techniques.

There are four dominant MCDM methods: (1) outranking type approach, based on the pioneering work of Bernard Roy and implemented in electrical and Promethee methods; (2) utility theory approach conceptualized by Keeney and Raiffa and then implemented in various ways; a special method that is part of this category is the Analytic Hierarchy Process - AHP developed by Saaty Thomas L. (1980) as a decision analysis method based on the hierarchy of components; (3) multi-criteria optimization approach appears in the literature under the name of vector optimization, multiobjective optimization or multiobjective programming, developed by PL Yu, Stanley Zionts, Milan Zeleny and Ralph Steuer; it represents that process that has as main objective to not only find a single solution, but a set of solutions by optimizing multiple criteria simultaneously; MOLP family was built around utility theory based on compromise between the objectives, using technical reference point and ideal solutions; (4) group decision theory introduced new ways to conceptualize the group dynamics, taking into account the differences in level of knowledge, systems of value and objectives within the group members.

When fuzzy set theory was introduced in MCDM, research methods have been developed along the same lines. One of the best studies in the field was developed by Chen and Hwang (1993); the authors distinguish between fuzzy ranking methods and fuzzy multiple attribute decision making methods, containing all the above (1) - (4) fields.

II.4. Criteria interdependence in multicriterial decision making

Decision making in interdependent multi criteria context represents itself a surprisingly difficult task. Where there are clearly conflicting objectives, normally there is an optimal solution that would satisfy all the criteria simultaneously. On the other hand, if we pair goals that support each other, so that achieving an objective means reaching the other one too, then this should be exploited in order to find optimal solutions in terms of efficiency.

Not recognizing multi-criteria interdependence, problems are simplified to unrecognizable and the solutions reached using traditional algorithms have only marginal interest. Zeleny (1992) highlights the circumstances that have reduced the visibility and usefulness of MCDM: (1) time pressure reduce the number of criteria to be considered; (2) the more precisely is a problem defined, the lesser criteria are needed; (3) independent decision makers are forced to use more criteria than those that are controlled by a strict hierarchical decision-making system; (4) isolation from the disturbance of permanent changes of the context reduces the need for using multiple criteria; (5) partial and limited knowledge will significantly reduce the number of criteria and (6) cultures and organizations focused on central planning and making decisions collectively are based on aggregation principles and reducing the criteria to arrive at a consensus.

Felix (1992) presented a new theory on multi-attribute decision making based on fuzzy relationships between objectives, in which the interactive structure of objectives is explicitly deducted. Felix (1994) explains the need for automated reasoning in detail the relationship between objectives when treating non-trivial decision problems. Relations between the two objectives are defined using fuzzy inclusion and non-inclusion between support and final sets related objectives. Felix (1994) also shows an example where the decision model based on relationships between objectives can be used as a powerful method in solving MADM type of vector maximization.

The main feature of this approach is that inherence imprecision in qualitative information can be formalized by applying the theory of fuzzy sets. A fuzzy MCDM method was practically developed in the same manner like a conventional MCDM method, but is designed using fuzzy theory to deal with specifically situations where MCDM contains vague data (Chen and Hwang, 1992; Carlsson and Fuller, 1996). The introduction of the fuzzy sets in decision-making processes provides a consistent representation of qualitative or linguistic knowledge formulated in a manner that allows the use of operators and precise algorithms. In

practice, decisions showed that fuzzy logic allows decision-making process that operate with estimated values despite incomplete information.

In practice, decisions-making demonstrated that fuzzy logic allows decisional process that operating with estimated values despite incomplete information. However, it should be noted that a decision may be incorrect and could be further improved when the necessary additional information is available. Of course, the total lack of information cannot support decision-making allegedly used some logic. In the case of difficult problems, conventional non-fuzzy methods are usually resource-intensive and dependent on mathematical approximations (linearization of nonlinear problems), which can lead to poor performance. In those circumstances, Fuzzy MCDM systems often exceed conventional MCDM methods.

II.5. Fuzzy analytic hierarchy process (*Fuzzy AHP*) in personnel selection

Since imprecision (fuzziness) dominates perceptual and cognitive human processes, fuzzy set theory is best suited to be used in tasks assessing candidates and hiring decisions. Fuzzy logic provides the means by which judgments characterizing the method developed can be made without resorting to an artificial process to normalize them.

The purpose of this paper is to demonstrate the applicability of fuzzy imprecision inherent in the expression that characterizes thinking and human decision-making process regarding the evaluation and selection of candidates for a certain job. This thesis proposes an approach to minimize the decision-making subjectivity in the effective personnel evaluation and selection.

The traditional evaluation and selection process uses a statistical and experimental approach. In the experimental approach, policymakers select the understanding workloads and characteristics of professionally successful employees in preliminary selection. The process is generally governed by individual biases and stereotypes. A statistical approach supports a decision making by combining the scores in the test and the degree of fulfillment of predetermined organizational criteria (Nankervis, Compton, & McCarthy, 1993).

AHP is a strong and flexible technical approach to decision-making, aimed at assisting human decision makers in prioritizing and adopting the best decisions when required to be taken into account both qualitative and quantitative aspects of the decision. By reducing complex decision to a series of pair wise comparisons, then synthesizing results, AHP helps not only the deciding factors in reaching the best decision, but also provides a clear reason to

justify the choice. Designed to reflect the way people actually think, AHP decision theory continues to be the most valued and widely used.

AHP approach and its derivatives have been used to solve many problems encountered in research, recalling here the contributions of Yurdakul (2002), Liu and Shih (2005), Scholl Manthey, Helm and Steiner (2005), Bozdag, Kahraman and Ruan (2003) Ong, Sun and Nee (2003), Kahraman, Ruan and Dogan (2003) and many other studies.

Fuzzy AHP technique (AHP) is an advanced analytical method developed on traditional AHP method. Despite the simplicity with which AHP address both quantitative and qualitative criteria of the MCDM type problems, imprecision and vagueness of many decision problems can lead to poor decisions in terms of quality (Bouyssou et al., 2000). Thus, many researchers (Boender et al, 1989; Buckley, 1985; Chang, 1996; Laarhoven & Pedrycz, 1983; Lootsma, 1997; Ribeiro, 1996) studied fuzzy AHP, which is actually an extension of the theory of Saaty, providing evidence that the FAHP technique is more effective than AHP in addressing complex decision-making processes, because it operates with fuzzy numbers and not just with crisp values.

Contemporary literature abound in research using fuzzy sets and fuzzy logic for the personnel evaluation and selection, among which research developed by Laing and Wang (1992), Cannavacciuolo, Capaldo, Ventre and Zollo (1994), Yaakob and Kawata (1999). As mentioned, the issue of personnel selection has been resolved using fuzzy sets in the last 25 years, demonstrating that in situations not governed by vagueness and non-disorder, it is the best theoretical approach.

II.6. Final remarks

As can be noted in existing studies, there are two essential issues: the hierarchy of decision making and the evaluation and selection methodology to be used. AHP proposes a decisional hierarchy in structuring factors and sub-factors and a measurement of indicators in line with the organizational objectives. Because AHP uses crisp values, this method is insufficient to minimize subjective judgment. Additionally, Fuzzy AHP is developed in order to minimize subjectivity, operating with fuzzy numbers.

Fuzzy models are presented as a base rules, mainly composed of three blocks: input, processing block and output. When modeling the fuzzy rule base, the results are affected by the function type and expert knowledge. The methodology proposed in this thesis, regards a binivelar hierarchical structure that will be developed. The lower level will assess candidates

by measuring criterion indicators (screening) and the upper level will select candidates using a fuzzy rule base approach based on specific organizational criteria (FMIH).

Thus, this chapter summarizes the research methodology of using fuzzy logic in personnel selection and evaluation research, being a very active topic in the literature of organizational psychology.

The concepts of multicriterial interdependence and fuzzy analytical hierarchical process are decisive in ensuring the best decisional system in the selection of personnel, the central theme of this thesis.

CHAPTER III

Preliminary studies regarding the human resources management decisional process

One of the main assumptions of this research is that the selection interview is a significant predictive factor for future job performance, if properly handled.

In organizations around the world, interviews continue to be one of the most used methods to assess job candidates (Ryan McFarland, Baron, & Page, 1999; Wilk & Cappelli, 2003). Selection interview is the preferred assessment method of direct supervisors (Lievens, Highhouse and De Corte, 2005) and practitioners in HR departments (Topor, Colarelli & Han, 2007). Moreover, applicants perceive the interview as a selection method more accurate than other selection procedures (Hausknecht, Day & Thomas, 2004), already being familiar with the interview being part of a selection process (Lievens, De Corte & Brysse, 2003).

Several meta-analyzes have shown that structured interviews demonstrate increased validity, without being subject to adverse effects usually reported in tests on cognitive ability (Conway, Jako and Goodman, 1995; Huffcutt and Arthur, 1994; Huffcutt and Roth, 1998; McDaniel, Whetzel, Schmidt and Maurer, 1994; Wiesner and Cronshaw, 1988; Wright, Lichtenfels and Pursell, 1989). Schmidt and Zimmerman (2004) hypothesized that structured interviews have increased validity in predicting future job performance compared to unstructured interviews, as the methods of rating structured interviews are more reliable.

Another line of research has primarily examined structured interviews and situational and behavioral interview in particular, to analyze whether the format / design of the interview gives clues as to the reliability and validity of this evidence. Using a metaanalytic approach, Huffcutt, Conway, Roth & Klehe (2004) showed that the validity of the study design moderates the criterion validity of the situational and behavioral interviews. Competing studies have shown increased validity than predictive studies in both types of interview: structural and behavioral.

A key design element is the existence of the interview selection standard assessment procedure (Campion et al., 1997). A number of studies have documented the importance of this aspect in the various types of interview and selection criteria. Maurer (2002) examined the use of behavioral anchored rating scale (versus the conventional method of numerical rating scale) and the use of experts as interviewers (to students) using typical situational interview questions. The author proves that both categories of interviewers, experts and students reviewed a series of filmed interviews with an increased accuracy when they have used behavioral anchors scales compared to conventional format.

The need for a behavioral interview scoring guide is critical element (Taylor & Small, 2002; Klehe & Latham, 2006). Scores in situational and behavioral interviews designed to assess teamwork correlate between, when it was used a detailed behavioral anchor scale guide (Klehe & Latham, 2005). Both situational and behavioral interviews predict equally GPA score obtained by the candidates, when there were given clear scoring instructions (Day and Carroll, 2003). Moreover, in telephone interviews when the interviewer used behavioral anchored rating scales for both types of behavioral and situational interview, there was demonstrated criterion validity relative to the rating given by the direct supervisor (there was not found a moderating effect of recruiters previous experience) (Gibb and Taylor, 2003). Finally, Höner, Sablynski and Wright (2007) showed that the structuring of the rating process, using behavioral anchored rating scales for each question, increased the fidelity of the procedure. Based on these findings, the using of scoring guides appear to be beneficial to the validity and reliability of the selection interview.

In conclusion, the studies provided information on the potential moderator role of the structure of the interview on the reliability and validity of the method. Comparisons between behavioral and situational interviews brought information on why the interview is able to predict future job performance. However, the reason for which the structured interview has higher predictive value than the unstructured design has not been conclusively established.

In the present study, there is proposed identifying the extent to which the competency-based behavioral interview predicts later job performance.

Thus, one of the main assumptions of this thesis is that the process of personnel recruitment and selection is the main way to ensure an efficient human capital within organizations. In order to demonstrate the effectiveness of competency-based behavioral interview as a method of technical personnel selection, there has been analyzed the relationship between the score received on selection interview and subsequent job performance of 51 employees within a multinational automotive company from Arad. Both the competency-based behavioral interview and individual professional performance evaluation method represent standardized techniques in the studied company, both tools measuring those skills considered fundamental at the organizational level.

The whole literature assumes the existence of strong correlations between the score received in the selection interview and subsequent job performance, thus in this thesis we propose to highlight the relationship between these two assessments and ultimately to model using fuzzy logic an alternative system of scoring selection competency-based behaviorally

interview. Fuzzy logic is the most widely accepted technique for dealing with uncertainty, given strong subjectivity that characterizes professional competency assessment.

The final purpose of these preliminary studies is the analysis of qualitative decisions on the personnel selection for elaborating an automated system for scoring the selection interview in order to represent a valid and transparent technique with a high degree of acceptance from both the organization and job candidates.

III.1. Ascertaining preliminary study on the relationship between the interview score and subsequent job performance score

III.1.1. Aims and hypothesis

This research's objective is to study of the relationship between the scores received on the competency-based behavioral interview and subsequent job performance, to demonstrate the organizational effectiveness of the procedure.

The hypothesis of the study was suggested by numerous findings of studies depicted in the literature and personal experience obtained during the assessment of applicants on technical positions.

Hypothesis:

1. ***Hypothesis*** *1 (H1): The selection interview score is a good predictor of job performance.*

III.1.2. Methodology

III.1.2.1. Participants

The research took into account a multinational automotive company which began operations in 2010 in Arad. If the number of employees initially covered only administrative staff, by 2013 the company employed 200 more people, out of which 51 participated in this research. The 51 employees represent staff in departments: administrative, logistics, human resources, quality control, production and technical, occupying positions such as: quality engineer, manufacturing engineering, administrator warehouse, launch coordinator, master schedule, human resources manager, plant controller, engineering managers, production, logistics manager, quality manager, controller, engineer laboratory, internal auditor

responsible for recruiting, human resources assistant, administration and payroll, material planner, traffic scheduler, customer quality engineer, packing responsible, incoming inspection engineer, process engineer, PPAP analyst, young graduate. The 51 employees represent the company's administrative staff and the participation in this research was voluntary.

From the data archive we have extracted for the 51 employees participating in this research, data on: gender, age, date of employment, previous work experience, score obtained in the interview, position held and department managerial responsibilities (yes or no), salary before evaluation, salary and wage increase after the evaluation. All employees have higher education, so we have not considered in this research the educational level as having an influence. Also, all jobs done are characterized by complexity, noting that some owners have the responsibilities of leadership.

Out of the 51 employees, 29 people are masculine and 22 persons are feminine. Employees are aged between 25 and 39 years. Regarding previous work experience, there was a variation between 1 and 13 years of previous job experience.

Out of the 51 employees, 12 people have managerial attributions. Monthly income ranges between 1.800 lei (young graduates) and 37.957 lei (Production Manager), and wage increase varies between 25 and 1.700 lei.

III.1.2.2. Instruments

The two instruments used in the study are Competency-based behavioral interview and job performance evaluation sheet, both being standardized techniques in the studied company, to be detailed below.

Competency-based behavioral interview

Behavioral competency based interview is a technique through which job candidates are asked to give specific examples of how they have performed in the past certain workloads that require certain skills in certain situations. The logic behind this is constant behavioral techniques, namely a person's behavior does not change fundamentally lifetime. The way in which certain tasks have been performed in the past is a good indicator of how certain tasks will probably be done in similar situations in the future.

Behavioral interviews are structured around "core competencies". Basic skills are those key skills, essential to be carried out in an extremely satisfactory occupier of the post, usually contained in the organizational competency framework. Basic competencies vary

depending on the job. For example, one of the basic competencies for a sales position will be "the ability to persuade and complete the sale" but will not be a core competency for a technical position, as in the present study. "Leadership" will be a core competency for a management position, but not for a entry-level type job. The following are some of the basic common competencies to different jobs: persuasion and negotiation skills, conflict resolution, multi-tasking, analytical skills, organizational skills, team spirit, work ethic, flexibility, perseverance and results oriented and leadership.

The structure of basic competencies for a particular job, obviously will depend on job responsibilities and duties described in the job description. In the behavioral interview the recruiter will ask questions about how candidates have performed certain work tasks in the past, are usually interested in the beliefs of candidates on how they related to a particular situation, there are also "follow-up" questions to get a clearer and more detailed picture of past professional performance. Behavioral questions will almost always start with "Tell me about a time when ..."; "Give me an example of ..."; "Describe a situation where ...".

Candidate's responses need to be specific and detailed, particular situations that relate to each question will be far more effective and successful than general responses. Ideally, candidates should briefly describe the situation, what specific action they took to have an effect on the situation, and the positive result or outcome. Organizational literature depicts two methods candidates are encouraged to use when answering behavioural questions: the STAR method represents a structured manner of responding to a behavioural-based interview question by discussing the specific situation, task, action, and result of the described organizational context; and the CAR (challenge, action, result) method. Both strategies have obvious parallels and provide applicants with a framework to tell a logical story, with a beginning (the situation/task/challenge), a middle (the action taken to solve the problem), and an ending (the results of the action taken).

The procedure for hiring assumes that candidates, who have passed the CV screening stage, will be invited for an interview at the company. The recruiter will consider a selection interview form (Appendix 1), which will be completed immediately after interview completion (approximate length of interview: 30 minutes).

The recruiter provided each candidate a score between 1 and 5, where 1 stands for very low skills, 2 – low, 3 – medium, 4 - high level and 5 very high skills, according to the following criteria: **Criterion 1**: Studies - 1. The relevance of education; 2. Involvement in activities concerning training; **Criterion 2**: Experience - 3. Work experience relevant to the job; **Criterion 3**: General Skills - 4. Setting goals and tracking their implementation, 5.

Anticipate problems and take the initiative in solving them, assuming the risk, 6. Planning activities according to priorities, 7. Work well under pressure and focuses on what is important, 8. Demonstrate motivation and enthusiasm at work, 9. Communicates easily, clearly and concisely, 10. Team player, adaptable, open to different points of view, 11. Interested own development, ambitious with realistic expectations 12. Honest person who assumes responsibility for its actions; **Criterion 4**: General aspect 13. Aspect, 14. Attitude, 15 Complete responses, 16. Formulates relevant questions; the following points will be covered only for managerial positions: **Criterion 5**: Managerial Skills - 17. Set goals and seek constructive solutions, 18. Create an atmosphere of cooperation within the team and encourage them to help each other, 19. Mediates conflicts between team members, encourages people to treat open in solving problems and 20. Lead by example and expect the same behavior from subordinates.

The method of scoring responses consists of several steps. Before the interview, HR specialists have determined what types of responses will be positive scored and what types of negative answers will count in assessing candidates. For example, a question such as "Describe a time when you worked under pressure," has the following positive and negative indicators:

Positive indices	Negative indices
• Demonstrates a positive approach to problem • Sees the problem context • Recognizes its own limitations • Asks for help when needed • Is able to compromise • Uses effective strategies to cope with pressure / stress	• It senses the challenges as problems • Unsuccessfully trys to cope on their own • Uses ineffective strategies to cope with the pressure / stress

In most cases, negative indices are divided into three categories: *minor negative indices (INmin)*, those who are considered negative behavioural answers but does not matter so much in the overall assessment; *median negative indices (INmed)* and *critical negative indices (INdec)*, those behavioural answers for which a candidate will be heavily downgraded; for example failure to request assistance when needed. Similarly, positive indicators are divided: *minor positive indices (IPmin)*, *median positive indices (IPmed)* and *critical positive indices (IPdec)*. Scores are then allocated depending on whether the candidate's behavioural answer fits these positive and negative indices; for example: 1. no overall evidence of positive

indices, mostly critical negative indices; 2. median positive indices, mostly negative indices, including critical negative; 3. limited number of positive indices, the presence of negative indices, maximum 1 critical negative; 4. satisfactory presence of positive indices, the presence of negative indices, but not critical negative; 5. majority evidence of positive indices.

If recruiters feel that there are areas that have failed to address, they could help in guiding candidate response. For example, in answering the above question "Describe a time when you worked under pressure" if the candidate has focused on how they handled the practical aspects of the problem but failed to specify how he managed stress during and after the event, recruiters may prompt with a question such as "How did you adapt to stress? ". This will provide an opportunity to present a complete picture of his behavior. Thus, prompting may be affected by recruiter's subjectivity. If the recruiter sympathizes a candidate, he/she may be more tempted to prompt the candidate.

To calculate the total score obtained by the candidate, interviewer will sum up all scores on each of the 16 dimensions (non-managerial position) / 20 (managerial position) and then divide by the number of criteria envisaged. The average obtained (1 to 5) is the total score on the selection interview, where 1 stands for very low skilled candidate, and 5 stands for very high skilled candidate.

Job performance assessment

Job performance assessment (Appendix 2) is a standardized organizational procedure being carried out at the end of each year. Depending on their score on the annual performance evaluation, decision makers determine promotion and income raise.

Regarding the annual performance appraisal, the direct supervisor procedurally awarded each subordinate a score between 1 and 5, where 1 stands for very low and 5 for very high levels of job performance, on the following criteria: 1. Specific job knowledge, 2. Quantity / quality of work, 3. Communication, 4. Interpersonal skills, 5. Organizational planning and reasoning, 6. Judgment and decision making, 7. Customer satisfaction, 8. Teamwork, 9. Adaptability to change, 10. Human resources management (for managerial positions), and 11. Performance against objectives (for managerial positions).

The 11 criteria are defined in the evaluation procedure as follows:

1. Specific knowledge at work: The ability to understand, use and demonstrate technical concepts effectively; knowledge of operating procedures and legal requirements in all aspects. Keeping abreast of developments and trends in the field of expertise. People differ depending on the knowledge they have, their depth and ability to use them to complete tasks.

2. Quality / Quantity of work: total quality completed tasks in a variety of situations, against objectives.

3. Communication: Ability to express orally and in writing thoughts, ideas, reports during individual or group situations; bringing the language and terminology to the audience level of understanding.

4. Interpersonal skills: ability to show understanding, support, diplomacy, tact and cooperation in interactions with colleagues, customers and visitors.

5. Organization, planning and thought process: Ability to plan, establish systematic objective to structure tasks to achieve goals, to set priorities and to comply programming. Ability to design, implement and control the entire process, while seeing the whole process and all systems interactions.

6. Judgment and decision making: Ability to obtain and evaluate relevant information from all relevant sources. Application of logical problem solving strategies, identification of correctable and developing creative solutions; Demonstrating the ability to make good decisions in a timely manner.

7. Customer satisfaction: Reply actively and timely responsive to the needs of internal and external customers.

8. Teamwork: Ability to contribute to group performance, to extract the best from others in order to encourage activities to strengthen the morale of the group, even under high pressure.

9. Adaptability to change: rapid response to changes occurring at procedural, technology and accountability levels; increased adaptability to changes in the tasks or working conditions.

10. Human Resource Management: Ability to select, use and effectively develop subordinates. It requires also standards recognition and respect, departmental policies and procedures (only required for managerial positions).

11. Performance against objectives: percentage is calculated according to the goals and objectives achieved since the last valuation date (only required for managerial positions).

Each criterion except the last one (C11) contains behavioral descriptions for each scale between 1 and 5. To illustrate, the behavioral descriptions related to criterion 8, teamwork, follows:

1. Unlikely that this person will be chosen for tasks that require teamwork, except occasions when personal expertise is vital to the mission of the group. Do not answers the objectives of the group but may be tempted to help when calls are made with personal

interest. The team may create unhealthy conflict. It could undermine the performance of the group with personal goals.

2. Depending on personal skills and group assignments, this person will be a positive contributor in establishing the team, but should be encouraged to participate. Does not hinder group performance and avoid conflicts unhealthy. It may seek personal recognition for the team's performance and / or minimizes the efforts of others.

3. When the group mission requires skills, then this person is most appropriate; the employee is seen as a strong contributor. On other occasions will not hinder the performance of others. Works well with most types of people and personalities and will not involve in unhealthy conflicts. Does not participate in such a conflict only if challenged repeatedly.

4. Seen as a person who contributes positively to group assignments. It works well with all types of people and personalities. Has the ability to resolve unhealthy conflicts. It makes special efforts to ensure confidence.

5. He/she is always sought and requested for group assignments. Groups related to this person are inevitably high performance. It is able to identify the strengths of the group and stimulate their participation. Has the capacity to mediate unhealthy conflicts, sometimes even before they occur. He/she makes a special effort to ensure that confidence is shared by all.

For calculating the total score obtained by the employee in the job performance assessment, the assessor will sum the subscores on each of the 9 / 11 (managerial positions) criteria and then divide by the number of performance criteria envisaged. Media obtained (1 to 5) represents the final score in the job performance assessment, where 1 stands for very low skills, 2 = low skills, 3 = average 4 = high skills and 5 for very high skills.

III.1.2.3. Procedure

Job performance scores were taken from direct supervisors, during the annual performance appraisal evaluation (2014) of the 51 participants in the study.

Initial demographic data: age, gender, education, job interview scores, previous work experience, salary growth and management attributions were taken with prior consent and confidentiality clause from the organization archive.

III.1.2.4. Results

***Hypothesis** 1 (H1): The selection interview score is a good predictor of job performance.*

To test this hypothesis there has been predicted used simultaneous regression on a sample of 51 employees. In this case, we opted for a simultaneous regression ("enter"). The result of regression analysis indicates that the interview explains 79% of the employee's performance variance included in this research, Beta coefficient = 0.894, at a $p < 0.01$, results being subjected to the effect of multicollinearity.

These results confirm the hypothesis of the study, that job performance is predicted in a powerful measure by the interview score, which means that 79% (effect distorted due to multicollinearity) of the job performance variance can be put solely to the score obtained in the interview.

Given that the two instruments, both the selection interview and performance appraisal aimed at common issues, we expect the selection interview score to be a good predictor of job performance.

IV.1.4. Conclusions

This study's hypothesis was confirmed, thus job performance is predicted by the score received in the selection interview. Thus, the interview score accounts for 79% of the variance in job performance of the 51 employees included in this research, Beta coefficient = 0.894, at a $p < 0.01$ being subjected to the effect of multicollinearity.

The question that has risen after the confirmation of this hypothesis is why the interview selection score predict in such a strong manner the subsequent job performance?

Having access to companies data archive containing employee data on gender, age, year of employment and previous work experience, we tested the predictive power of these factors combined on both scores, both on the score obtained in the interview and job performance, finding insignificant results, namely the impact of these variables in explaining the variance was almost zero for both interview and job performance scores.

We believe that the explanation for this strong correlation is derived out of three main reasons:

1. the HR department of the studied company studied is made up of 4 people (Manager, Assistant Manager, Recruitment responsible Payroll

administrative); the instruments used are standardized, the scoring procedure is particularly clear and well defined in the instructions for evaluation, both for the interview and for performance evaluation, so the staff is familiar with both procedures;

2. both instruments offer a range of scores from 1 to 5 (testing Collinearity there has been identified a strong effect);

3. both the interview and the performance evaluation forms are centered on the almost the same professional competencies; there is a remarkable association between the criteria used.

This last aspect, it will be discussed below.

Studying the personnel evaluation criteria based on the interview form (Appendix 1) and performance assessment form (Appendix 2), we will identify the criteria overlapping percentage. Table 3 presents a comparative list of criteria contained in the selection interview and job performance evaluation form.

Tabelul 3. – Comparison between the selection interview and job performance assessment criteria

Nr.	**Selection interview criteria**	**Job performance criteria**
1.	1. Education relevance,	1. specific job knowledge,
	2. Educational extra-activities involvement,	
	3. Relevant professional experience,	
2.	4. Setting goals and pursuing them,	5. organizing and planning,
3.	5. Problems anticipation and initiative in solving them, risk taking,	6. judgment and decision-making,
	6. Prioritization,	
4.	7. Work under pressure and focus on the main objectives,	2. work quantity/quality,
5.	8. Job motivation and enthusiasm,	X
6.	9. Clear and concise communication,	3. communication,
		4. interpersonal abilities,
7.	10. Team player, open minded,	8. team work,
		9. adaptability to change,
8.	11. Interest in own development, realistic	X

	expectations,	
	12. Honest and responsible person;	
9.	13. Aspect,	X
	14. Attitude,	
	15. Complete answers,	
	16. Relevant questions;	
10.	17. Setting team objectives and look for constructive solutions,	11. performance against objectives
11.	18. Creates a positive work environment for the team,	10. human resources management
	19. Mediates conflicts,	
	20. Leads by personal example.	
12.	X	7. client satisfaction

As can be seen in Table 3, of the 12 distinct criteria identified, only 4 do not have their counterparts, namely the interview does not regard any criteria to assess the capacity of customer satisfaction, and in the evaluation of job performance there are no criteria to assess the general appearance, honesty and enthusiasm.

Given these aspects, we can conclude that the competency-based behaviorally interview and competency-based performance appraisal is based in 77% on the same evaluation criteria developed upon the behavioral consistency principle.

III.2. Preliminary study on personnel selection decision modeled with fuzzy expert system based on subsequent job performance

III.2.1. Aims and hypothesis

The objective of this study is to shape the hiring decision with fuzzy expert system, in order to identify a more efficient method for providing the final scores obtained by the candidates in the selection interview. Thus, starting from the data records of interview and annual job performance scores, the justification of this fuzzy model is to identify the extent to which a new algorithm for scoring the selection interview optimizes the prediction of subsequent job performance or practical aspects regarding day-to-day application of this selection procedure.

The idea of this fuzzy model is to calculate the final interview score by considering positive and negative indices provided by each candidate on each specific criterion. Interviewers assess candidates' competence level based on positive and negative indices detached from their behavioral answers. We have considered useful to simplify the procedure for granting final interview score by establishing decision rules based on the interdependence of these positive and negative indices rather than calculating the average of the 16/20 criteria scores. Research aim is to verify whether this new fuzzy model for calculating the final interview scores represents a valid procedure reported to post-employment job performance.

III.2.2. Methodology

The procedure for scoring candidates responses to selection interview (APPENDIX 1) consists of several steps, the main step being to determine what types of behavioural responses will be positively scored and what types of responses will trigger negative scores. In most cases, negative indices are divided into three categories: *minor negative indices (INmin)*, those who are considered negative behavioral answers but does not matter so much in the overall assessment; *median negative indices (INmed)* and *critical negative indices (INdec)*, those behavioral answers for which a candidate will be heavily downgraded; for example failure to request assistance when needed. Similarly, positive indicators are divided: *minor positive indices (IPmin)*, *median positive indices (IPmed)* and *critical positive indices (IPdec)*. Scores are then allocated depending on whether the candidate's behavioral answer fits these positive and negative indices; for example: 1. no overall evidence of positive indices, mostly critical negative indices; 2. median positive indices, mostly negative indices, including critical negative; 3. limited number of positive indices, the presence of negative indices, maximum 1 critical negative; 4. satisfactory presence of positive indices, the presence of negative indices, but not critical negative; 5. majority evidence of positive indices.

Starting form this simple structure of awarding scores based on the presence of positive and negative indices, we have extended all possible logic combination of the six subtypes of possible indices.

The inference table below presents the inference rules for automatically assigning a numerical value [1, 5], in order to calculate the final score.

INDICES	INmin	INmed	INdec

IPmin	2	1,5	1
IPmed	3,5	3	2,5
IPdec	5	4,5	4

The main window of the *ModelareDecizieSelectie* fuzzy controller is depicted in Figure. III.1.

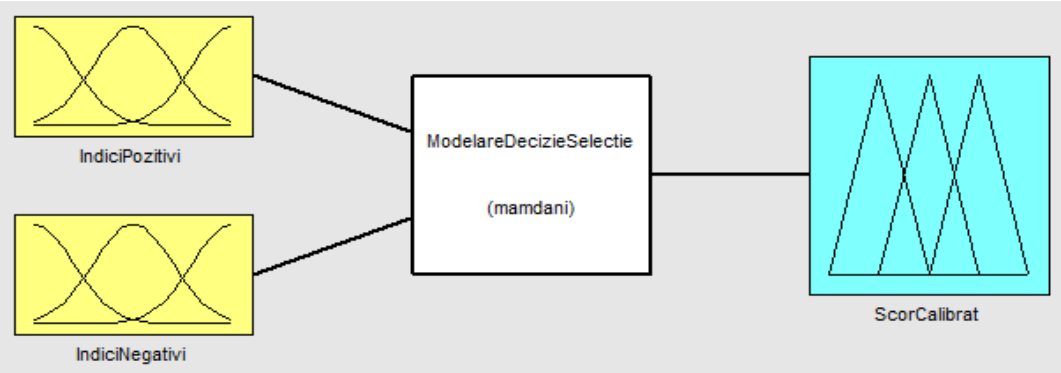


Fig. III.1 - The main window of the *Aplications_Screening controller*

The controller has two input variables, *positive indices* (*IndiciPozitivi)* and *negative indices* (*IndiciNegativi)* and an output variable, *calibrated score (ScorCalibrat).* Mamdani controller has been chosen, because it operates with fuzzy sets in both input and output.

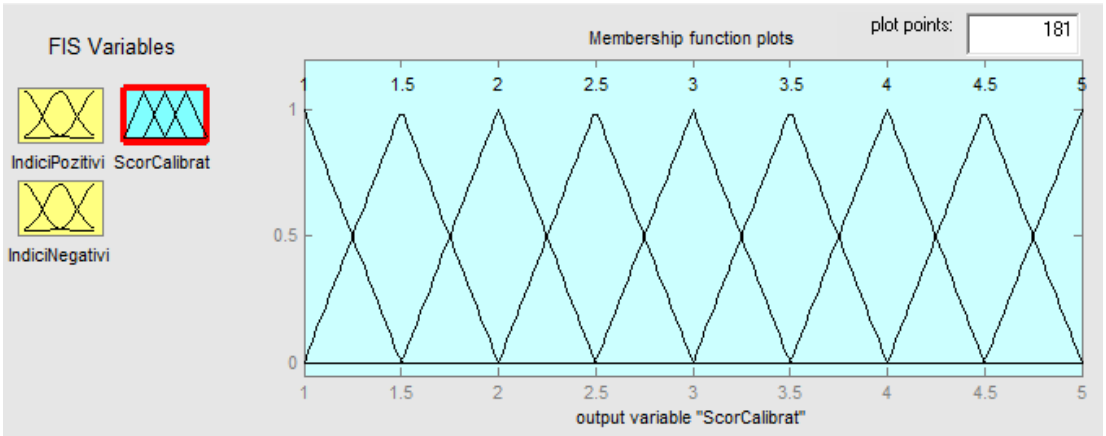
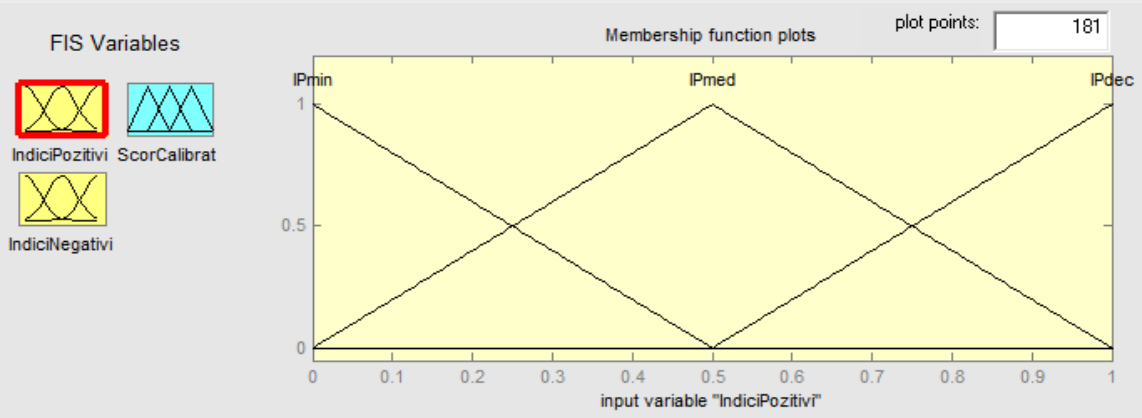


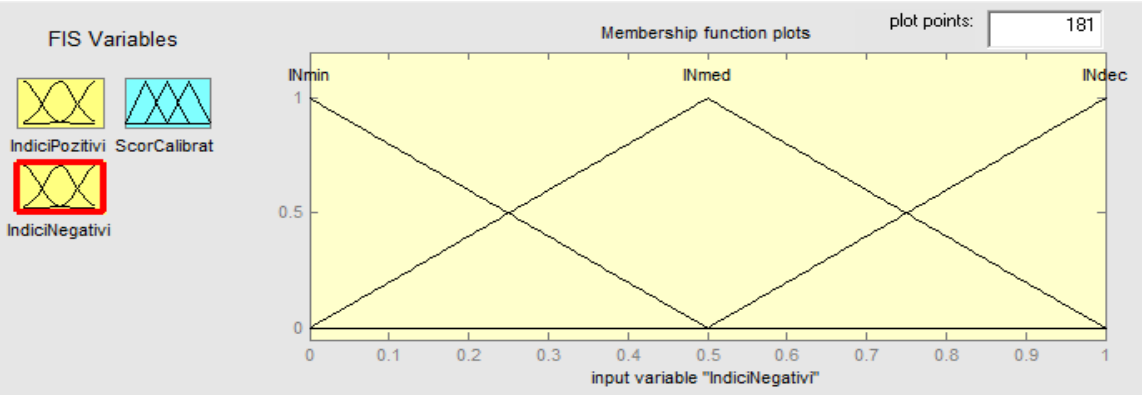
Fig. III.2 – Output variable *calibrated score (ScorCalibrat)*

Calibrated score variable (*ScorCalibrat*) has 9 linguistic variable terms, spread evenly over the definition [1, 5], which coincides with the rating scale (see Fig. III.2).

Each input variable has three linguistic terms: *minor*, *median* and *critical* (see Fig. III.3).



a) *Positive indices* variable (*IndiciPozitivi)* with *3* linguistic terms: *IPmin*, *IPmed* and *IPdec*



b) *Negative indices* variable (*IndiciNegativi)* with *3* linguistic terms: *INmin*, *INmed* and *INdec*

Fig. III.3 – Input linguistic variables

In the framework of the above system, the essential operation that decides the functioning is the inference, made by *ModelareDecizieSelectie* block depicted in Fig. III.1. The inference generates the required output decisions based on the premises specified in input

status. As with any expert system, in this fuzzy system the inference is performed using rules base of the form "**If** *the premise*, **than** *the conclusion"*. In our case, regarding the structure of input variables and linguistic terms represented in Fig. 3, the maximum number of rules that can be written is 3 x 3 = 9. It is noteworthy that an expert system can operate satisfactorily even if the designer does not write the maximum number of rules, which may occur in complicated applications with many more variables and linguistic terms. In our case the maximum number of possible rules is minimal, and each rule has a clear justification, thus the rule base presented in Fig. III.4 has exactly nine rules.

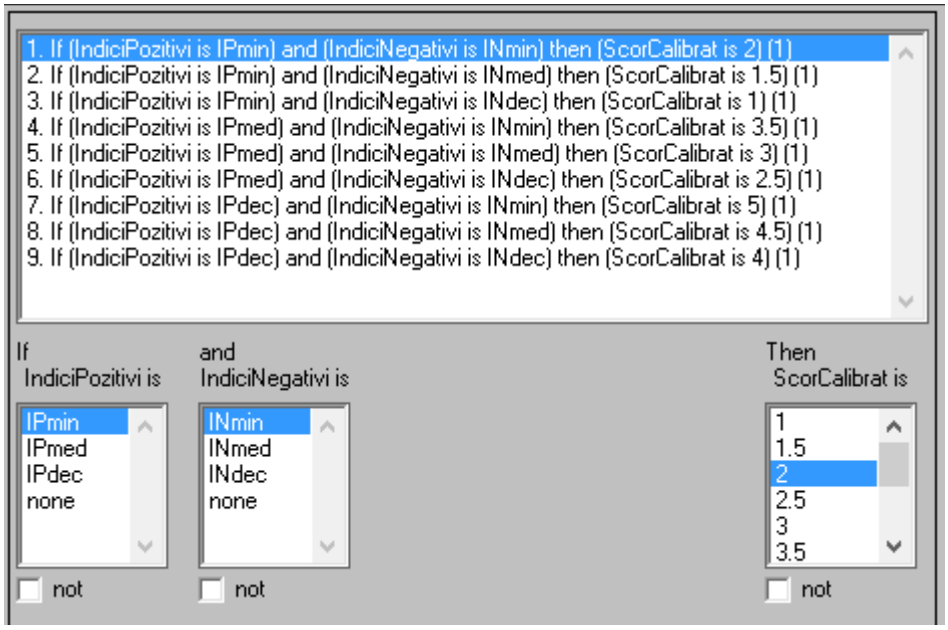


Fig. III.4 – Rules base

Adding other rules is possible by increasing the number of linguistic terms, but the effects obtained in this way will not significantly improves the decision quality.

III.2.3. Results

The software environment in which this example was designed, the FIS interface (Fuzzy Inference System) of Matlab, offers two visual tools that can facilitate functional assays of applications, namely *View Surface* (see Fig. III.5) and *View Rules* (see Fig. III.6).

Control surfaces are loci of the outputs variables when the input variables take all possible values. The control surface is therefore a plot of the input and output variables static

characteristics, offering a summary of the fuzzy controller functioning. In Fig. 5 blue coloured areas are associated with lower scores and yellow coloured areas are associated with high scores.

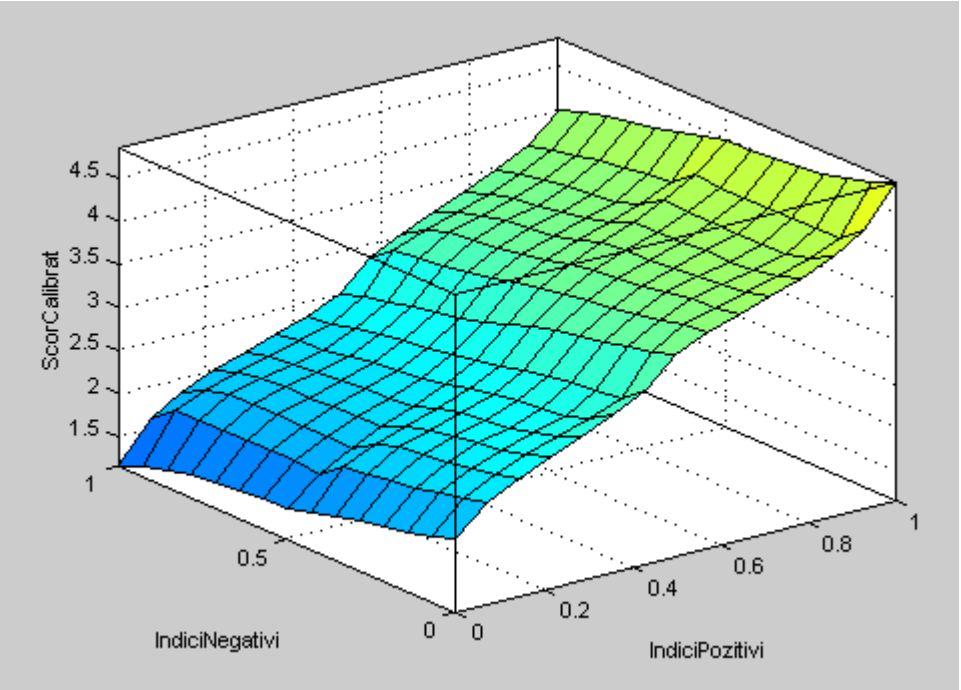


Fig. III.5 – Control surfaces: *calibrated scores* (*ScorCalibrat), positive indices (IndiciPozitivi)*, and *negative indices* (*Indici Negativi)*

Given the fact that data on which we simulated this fuzzy decision model belongs to candidates who have already been selected, an analytical eye will notice very low scores received by hired candidates in the selection interview. These candidates with very low scores would have been false positives, where the selection threshold would be increased, in the reason that company wants to select only the best candidates. The selection decision was highly permissive for the 51 studied employees. This phenomenon can be explained relatively simply due to the fact that the company wanted the vacancies to be urgently filled with candidates who applied immediately.

There are times when for a single job position, a multitude of highly competent candidates apply for and refuse another vacant position and there are also times when very few and poor competent candidates apply for a myriad of job openings; therefore companies must keep a fragile balance between what is requested and what is being offered at a

particular moment. If the procedure rejects the candidates, then job positions remain unfilled, thus creating a vicious circle that imposes a permissive hiring strategy, in this context only. Of course any company faced with abundance of candidates will have a more sensitive threshold when hiring.

The new control surface (Fig. III.7) presents lower values in the central area than those depicted in Fig. III.5, thus reducing the number of mediocre candidates.

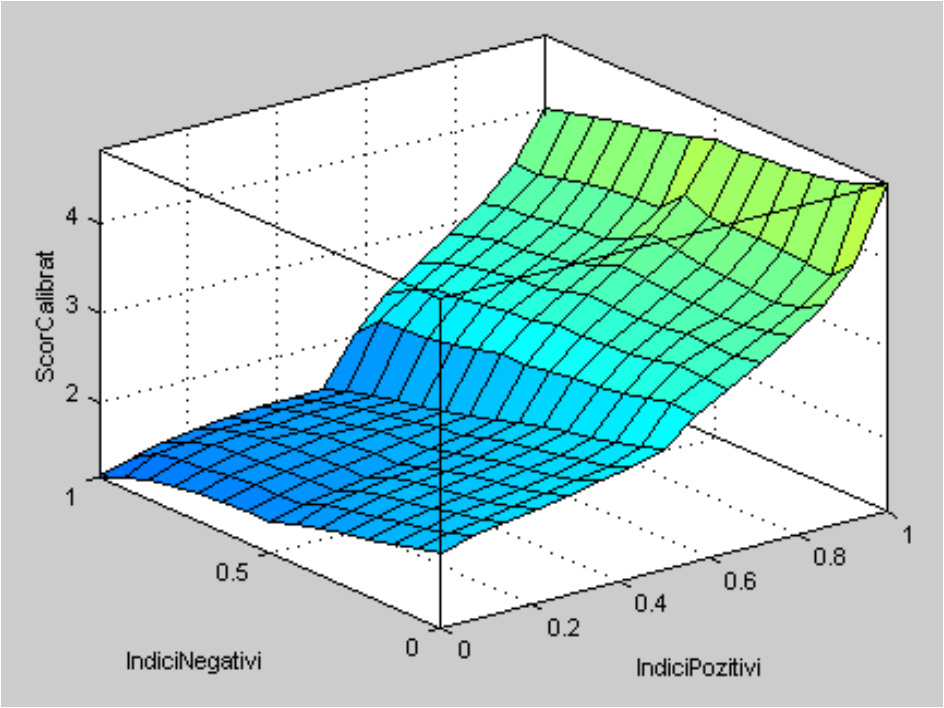


Fig. III.7 – Control surface with increased stringency

It is noted that the use of such model enables companies' rapid adaptation, efficiency, fairness and transparency in all situations encountered in practice, for any job vacancy.

III.2.4. Conclusions

To test the robustness of the fuzzy algorithm for calculating the final interview score, there has been used Pearson correlation coefficients between classic interview score (F = 2.941, SD = 0.778), fuzzy calibrated score (M = 2.98; SD = 0.787) and subsequent job performance (M = 3.020, SD = 0.786). Results demonstrate that there is a very significant correlation between classic interview score and job performance (r = 0,894 to p <0,01). There

is also a significant correlation ($r = 0.861$ to $p < 0.01$) between the fuzzy calibrated score and job performance; although if this correlation coefficient is slightly lesser than the correlation coefficient of classic scoring, the validity of the procedure is fully proven.

The most important limit of this research is represented by the very high correlations between interview score and job performance score, due to the fact that both methods are competency based behavioural assessments scored with a 1 to 5 scale. Also another limit of this research is that we only have access to already hired candidates and their subsequent job performance scores; it is difficult and almost impossible to track down a rejected candidate that has been hired somewhere else and also acquire data on subsequent job performance. There are very few organizations that use the same performance assessment criteria and metrics. Another limitation of this fuzzy algorithm, as well as of the classical system of calculating final score is not offering a clear hierarchy of candidates. Additional strategies may be deployed in order to calculate an accurate hierarchy of candidates.

Thus, this algorithm proves its efficiency in very complex selection systems that truly integrate all human resource management processes starting with job description, candidate selection, job performance evaluation and payroll.

The central conclusion of this study is that the competency based behavioural interview has an essential role in predicting future job performance of employees. The net benefit of fuzzy model for calculating the interview scores is that it can be easily implemented and extended to all existing selection procedures relying on competency base assessment.

III.3. Conceptual preliminary study on elaborating a fuzzy expert system for technical applicants screening

IV.3.1. Aims and hypothesis

The objective of this study is to develop a simple fuzzy expert system to assist professionals in the human resources department in applicants screening for a technical position. We argue the importance of using such an automated system for screening applicants when the number of applicants for a specific job is very high and at the selection interview will be invited only those candidates who fulfill the minimum conditions: the relevance of studies, professional experience and increased motivation to occupy the position.

Reasons choice of these three indicators represents the fact that candidates usually submit online their application and more often, the eliminatory criteria for selection are: technical studies, previous experience of at least 2 years in a similar position and a brief motivation letter for applying to a specific job.

III.3.2. Methodology

The main window of *Applicant_Screening* Fuzzy controller is presented in Fig. III.8.

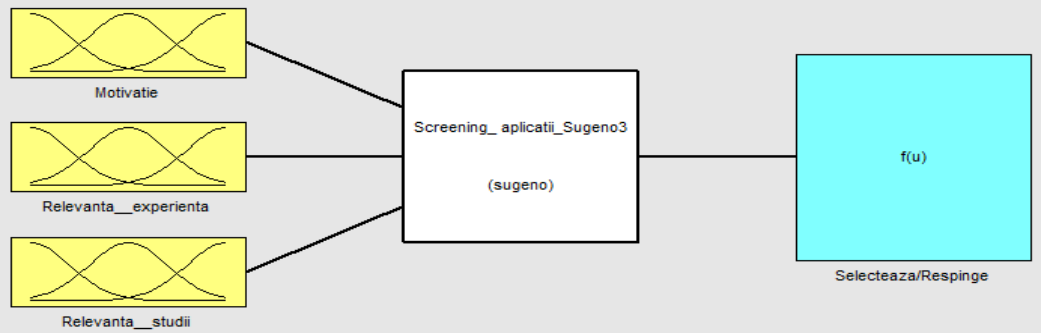


Figura III.8. Main window of *Applicant_ Screening* Controller

Since the role of this controller is to select candidates to be invited for an interview, it has only one output variable with two linguistic terms *Select* and *Reject*. We have chosen Takagi-Sugeno controller that uses as output variables singleton-type linguistic terms, namely non-fuzzy numerical values. In this case the two linguistic terms have as values *Reject* = 0 respectively *Select* = 1, which materializes the automated decision of the applicant screening model.

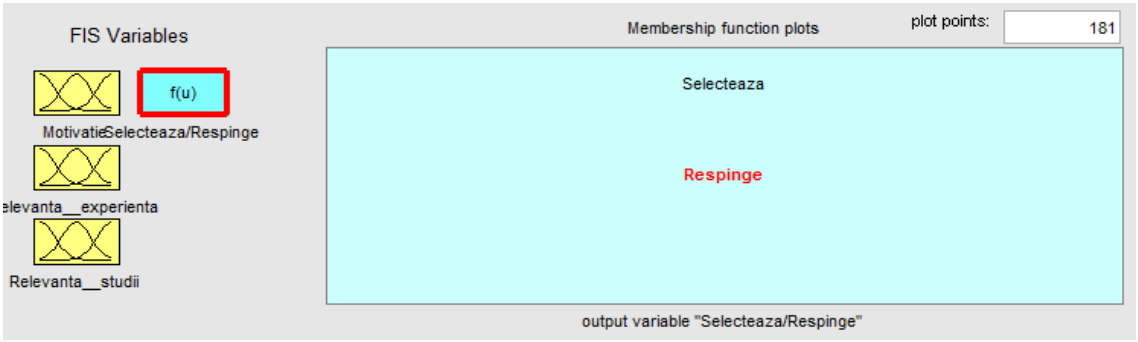
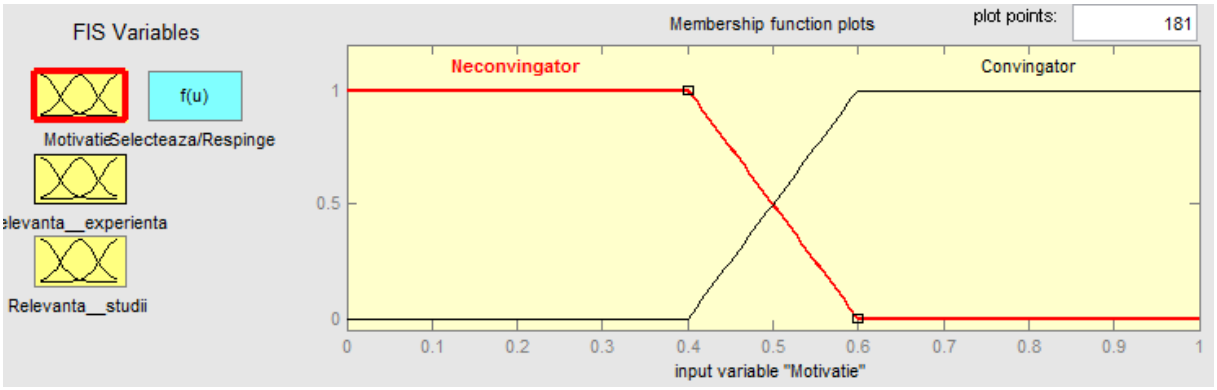
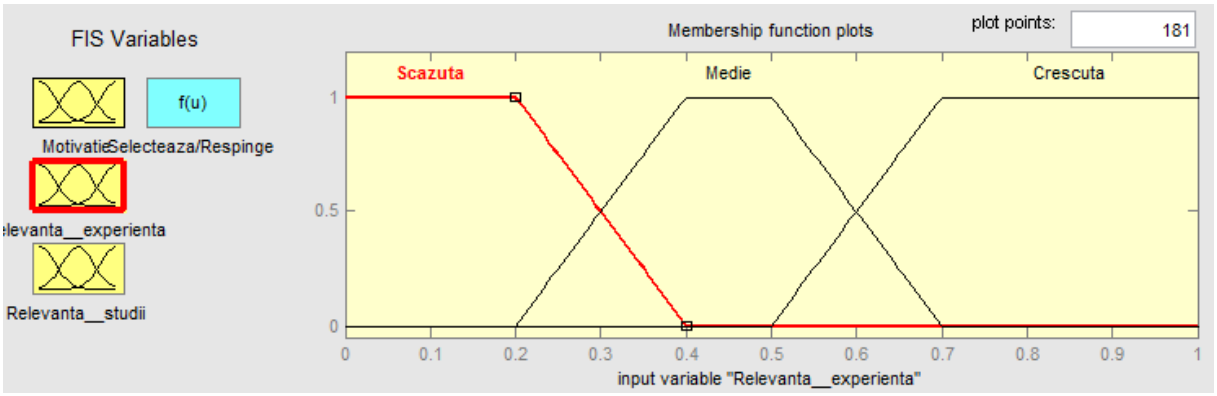


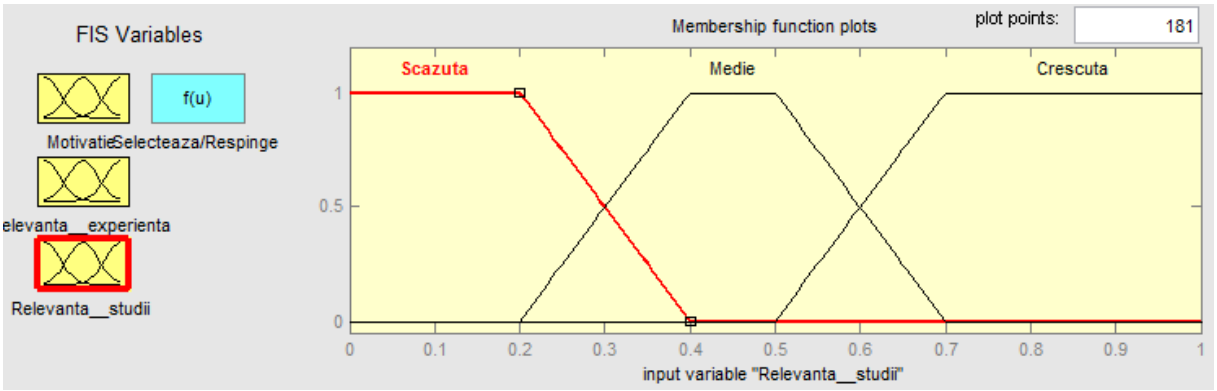
Figura III.9. OUTPUT Variable *Select/Reject*



a) Motivation variable with two linguistic terms: U*nconvincingly/Convincingly*



b) *Relevant professional experience* variable with three linguistic terms: *low/average/high*



c) *Relevant education* variable with three linguistic terms: *low/average/high*

Fig. III.10. INPUT Variables

It is noted that the shapes of the membership functions, trapezoidal in this case, were intuitively chosen based on expert experience of the designer. When data is statistically significant and screening tests results can be correlated with interviews results and job performance of the candidates that have been hired, these forms can be easily optimized.

In the framework of the present system, the key operation that decides the functioning is the inference materialized by the block *Applicant_ Screening_Sugeno* presented in Fig. 1. The inference generates the output decisions based on input specified conditions. Like any other expert system, our fuzzy expert system performs using a rules database in the form of "If the *premise*, than the *conclusion*". In our case, the structure of input variables and linguistic terms represented in Fig. 3, the maximum number of rules that can be written is 2 x 3 x 3 = 18. It is noteworthy that an expert system can operate satisfactorily even if the designer does not write the maximum number of rules, which may appear in very complicated applications with many variables and many linguistic terms. In our case the maximum number of possible rules is small, and thus each rule has a clear justification, so that the rule base presented in Fig. III.11 has exactly 18 rules.

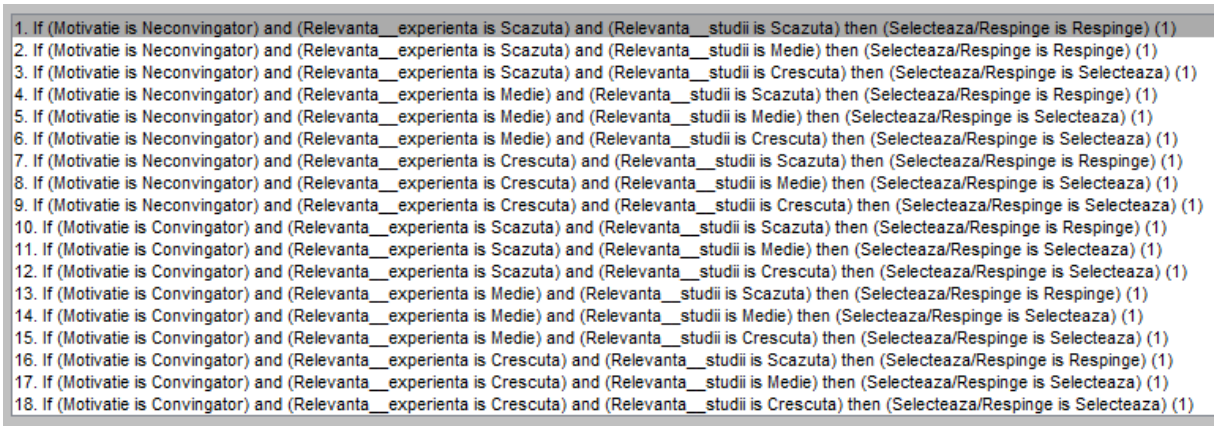


Figura III.11. Decision rules database

It is obvious that in all cases in which the *Relevant_experience* and *Relevant_education* made possible the **selection** decision, even when *Motivation* was *unconvincing*; the same decision remains when *Motivation* is *convincing*. This is the case of the decision rules 12, 14, 15, 17 and 18. On the other hand the decision rules 10, 13 and 16 produce the **rejection** decision even if *Motivation* is *convincing* because they have as premises *low Relevant_education*.

The only modification driven by the *convincing Motivation* premise appears to rule 11, which assumes the **selection** decision, because it is considered that a good motivation can in principle compensate for lack of experience, if *Relevant_education* has at least an average value.

III.3.3. Results

The Software environment in which exemplifications were developed, the FIS interface (*Fuzzy Inference System*) of *Matlab* provides two visual tools that can facilitate functional analyzes of applications, namely *View Surface* and *View Rules*.

Control surfaces are the geometric locations of the output values when input variables take all possible values. Control surface is therefore a graphical representation of input-output static characteristics, providing a synthetic image of the fuzzy controller functioning.

In Fig.III.12, the blue colored areas are associated with **rejection** decision, and the yellow color is associated with **selection** decisions. Bidimensional representations of functional dependency of *Relevant_experience – Relevant_education* has the *Motivation* as parameter; *Motivation* is set to have a 0 value for *unconvincing* and 1 for *convincing*. In the FIS interface these settings appear in the dialog box *Ref. input:* [0 NaN NaN] or [1 NaN NaN].

The graphical interpretation of *Applicant_Screening* controllers' functioning becomes obvious under these conditions.

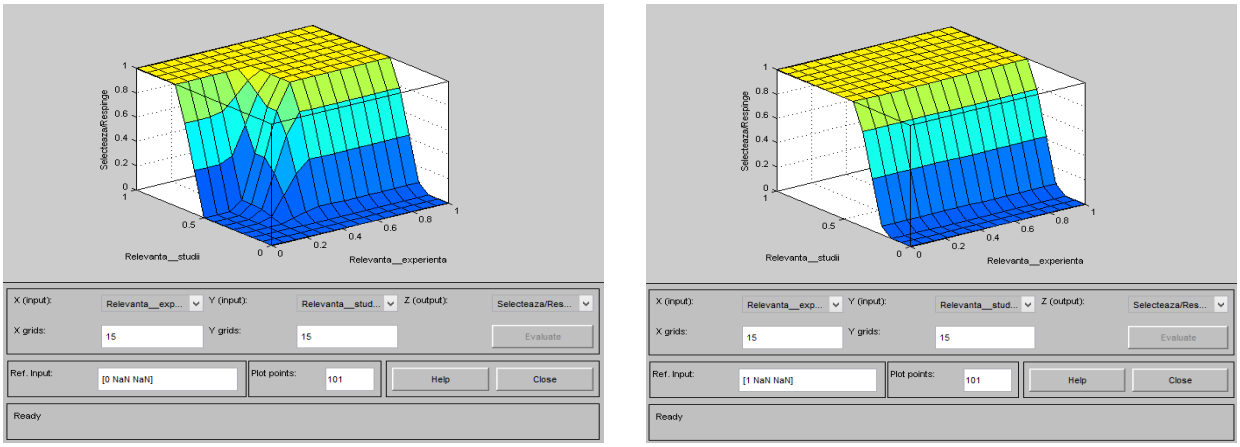


Figura III.12. Command surfaces for *Relevant_education – Relevant_experience* with *Motivation* = 0 and 1

In the dynamic representation of the inference rules, one can observe the degrees of activation of each linguistic term within each rule, and also the final result, which is then *Select*. Of the 18 rules, 7 (39%) will reject candidates and 11 (61%) will select candidates, so our model is mainly a permissive one, having a low sensitivity towards type II errors,

accepting false positives. Models' threshold is situated under average, mainly because the role of applicant screening procedure is especially oriented to eliminate candidates who do not meet the minimal criteria, as supported by organizational practice.

The main advantage of the Fuzzy expert model is the perfect transparency, provided by the inference rules that can easily be explained and understood, creating prerequisites for further adjustments and highly efficient adaptations. If for example we have a job position where there are a large number of applicants on a small number of vacancies, based on arguments we can easily rewrite some of the inference rules, for instance replacing the *Select* conclusion with *Reject* conclusion, making the model more sensitive to aspects regarded for: education, previous professional experience and job motivation.

III.3.4. Conclusions

The Fuzzy expert model developed is able to assist - from an expert perspective – a human resources consultant that will have to decide on the employment of certain candidates. Of course this model is useful only in industrial contexts, especially for technical positions, jobs that attract many applicants and the selection is required to be rigorous one.

III.4. Final conclusions

The central conclusion of these studies is that the selection interview, as has been shown, has an essential role in predicting future job performance of employees.

The net benefit of the fuzzy model for calculating the interview scores is that it can be extended to all existing selection procedures based on competence-based behavioral interview. One of the limits of the model, as well as the classic system of granting final score is not giving a clear ranking of candidates. We often find candidates with the same score, makeing more difficult the hiring decision.

The fuzzy model regarding applications screening is a simple decision-making system, which will result in the selection of those applicants per job complying three minimal conditions and often eliminatory: education, previous experience and motivation for applying on the job. The evaluation and selection purposes of ranking candidates according to the score received on the interview, referred to as the Fuzzy Multicriterial Interdependent Hierarchic model (FMIH) becomes a conceptually mathematical complex decision-making system which we will develop as original study in Chapter IV.

CHAPTER IV

Conceptualizing, elaborating and validating the Fuzzy Multicriterial Interdependent Hierarchic model (FMIH) in applicant's selection

IV.1. Aims and hypothesis

The objective of this study is to develop a robust personnel selection algorithm, by using a fuzzy analytic hierarchy process (FAHP) model which will be described and validated on the existing data of a multinational industrial company (51 employees). The model uses as input variables data recorded after the selection interview. The original model is based on interdependence criteria and analytic hierarchy data processing in deciding rigorous candidates' hierarchy.

The main hypothesis of the research is that FAHP model is more efficient that the classical model (arithmetic weighted means) when calculating the final score obtained by the candidate in the interview. This assumption is based on the fact that the FAHP model gives a clear hierarchy for all candidates entering the procedure, not just a numeric brut score, which is often identical to several candidates in the classical procedure, making it difficult to differentiate between candidates, thus complicating the selection decision.

The superiority will be established by analyzing candidates' hierarchy in both models, related to subsequent job performance hierarchy.

Thus, this experimental model will be develop based on data obtained by already hired candidates (12 candidates out of the total of 51) that have applied for an engineer position in the company, and will be validated by analyzing the correspondence with classical scores and subsequent job performance. In establishing the supremacy of the two methods, the study's interest is in obtaining a much significant correlation coefficient between the FAHP hierarchy and the subsequent job performance hierarchy than the correlation coefficients between classical scores and subsequent job performance.

IV.2. Methodology

Fuzzy analytic hierarchy process (FAHP) incorporates fuzzy to classical analytic hierarchy process, which was developed by Saaty (1980). AHP is a decision-making tool widely used in various multi-criteria decision problems. The essence of the approach is to use pair wise comparisons between multiple alternatives (in our case 12 candidates), taking into

account different criteria (selection criteria), providing a decision support tool in multi-criteria decision making. In a general AHP model, the objective is the first decisional level (in our case the employment decision of the best candidates applying to engineering positions) criteria and sub-criteria represent the second and respectively the third decisional level, and in the fourth level and last, one can find alternatives or in our case applicants/candidates (Ayhan, M. B., 2013).

As the traditional AHP technique does not include personal judgment inaccuracies, it has been improved by fuzzy approach (Javanbarg, MB., Scawthorn, C., Kiyono, J., Shahbodaghkhan, B., 2012). In FAHP, the pair wise comparisons of both alternatives and criteria are conducted through linguistic variables, which are represented by triangular fuzzy numbers (Kilincci, O., & Onal, S. A., 2011).

A triangular fuzzy number is a fuzzy number represented by three points thus: A = (a1, a2, a3).

This representation is interpreted as a function as follows:

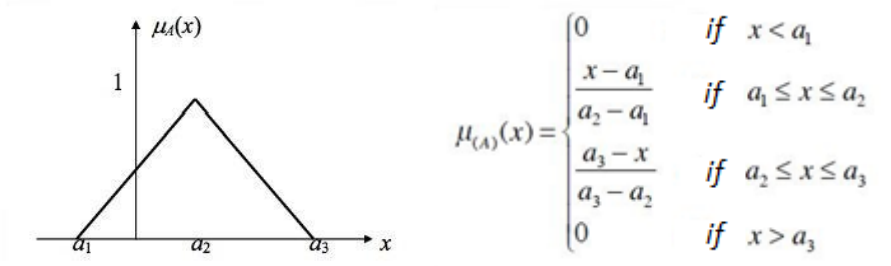


Fig. 1. Fuzzy triangular number

Although in the literature there are a variety of techniques embodied in FAHP, the present study is using Buckley method (1985) to determine the relative weights of importance of both criteria and alternatives. The following will describe the steps of the procedure:

Step 1: Comparison of alternatives and criteria using linguistic terms

Table 6 presents the correspondent linguistic variables of fuzzy triangular numbers.

Table 6. - Correspondent linguistic variables of fuzzy triangular numbers

Saaty scale	Definition	Fuzzy triangular numbers
1	*i* and *j* criteria are equal important	(1,1,1)

3	*i* criteria is less important than *j* criteria	(2,3,4)
5	*i* criteria is more important than *j* criteria	(4,5,6)
7	*i* criteria is much more important than *j* criteria	(6,7,8)
9	*i* criteria is absolutely more important than *j* criteria	(9,9,9)
2, 4, 6, 8	intermediate values assigned to adjacent judgments	(1,2,3),(3,4,5),(5,6,7),(7,8,9)

According to fuzzy triangular numbers corresponding to linguistic terms, where policy makers at the organizational level deemed *Criterion 1* (C1) is less important than *Criterion 2* (C2), in the pair wise matrix there will be completed the fuzzy number (1/4,1/3,1/2). On the contrary, in the pair wise matrix when comparing C1 to C2, there will be completed the transposed fuzzy number (2,3,4).

The pair wise comparison matrix is shown in equation 1 (1) where $\widetilde{d_{ij}^{k}}$ indicates the preference of *i* criterion over *j*, of the *k* decision-maker, expressed by fuzzy triangular numbers. In this case, "tilde" represents a triangular number. Within the current study $\widetilde{d_{12}^{1}}$ represents the first decision makers' preference of criterion C2 over C1, a value equal to (1/4,1/3,1/2).

$$\widetilde{A_k} = \begin{bmatrix} \widetilde{d_{11}^{k}} & d_{12}^{k} & \dots & d_{1n}^{k} \\ d_{21}^{k} & \dots & \dots & d_{2n}^{k} \\ \dots & \dots & \dots & \dots \\ d_{n1}^{k} & d_{n2}^{k} & \dots & d_{nn}^{k} \end{bmatrix} \quad (1)$$

Step 2: If there are more decision makers, preferences of each decision maker are averaged and computed according to equation 2 (2):

$$\widetilde{d_{ij}} = \frac{\sum_{k=1}^{K} \widetilde{d_{ij}^{k}}}{K} \quad (2)$$

Step 3: According to averaged preferences, the pair wise matrix is completed in compliance with equation 3 (3):

$$\tilde{A} = \begin{bmatrix} \widetilde{d_{11}} & \cdots & \widetilde{d_{1n}} \\ \vdots & \ddots & \vdots \\ \widetilde{d_{n1}} & \cdots & \widetilde{d_{nn}} \end{bmatrix} \quad (3)$$

Step 4: According to Buckley, the geometric means of fuzzy comparison values of each criterion are calculated using the equation 4 (4). In this case, $\widetilde{r_i}$ represents a triangular number.

$$\widetilde{r_i} = \left(\prod_{j=1}^{n} \widetilde{d_{ij}}\right)^{1/n}, \quad i = 1, 2, \ldots n \quad (4)$$

Step 5: The fuzzy weights of each criterion will be calculated according to the equation 5 (5), taking into account the following three steps.

Step 5a: Calculating the vector summation of each $\widetilde{r_i}$.

Step 5b: Calculating the (-1) power of summation vector. Arranging the fuzzy triangular number, so that it appears in an increasing order.

Step 5c: For calculating fuzzy weights of $\widetilde{w_i}$ criterion, each $\widetilde{r_i}$ will be multiplied with this reverse vector.

$$\widetilde{w_i} = \widetilde{r_i} \otimes (\widetilde{r_1} \otimes \widetilde{r_2} \otimes \ldots \otimes \widetilde{r_n})^{-1}$$
$$= (lw_i, mw_i, uw_i) \quad (5)$$

Step 6: Since $\widetilde{w_i}$ are fuzzy triangular numbers, they need to be de-fuzzified using the Centre of area method proposed by Chou and Chang, applying equation 6 (6). In this equation, *l, m* and *u* are fuzzy triangular numbers such as *A = (a1, a2, a3).*

$$M_i = \frac{lw_i + mw_i + uw_i}{3} \quad (6)$$

Step 7: M_i is a non-fuzzy number. This number will be normalized by applying the equation 7 (7).

$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i} \quad (7)$$

These 7 steps are performed to find the normalized weights of alternatives and criteria. Then, by multiplying the two weights there will be calculated the final scores for each alternative. This methodology is applied in the present study, the main purpose being the hierarchy of 12 candidates that have all been hired after a selection procedure.

IV.3 Results

Before designing the selection system there was conducted a qualitative analysis of organizational objectives and performance criteria. Thus, long-term organizational objectives specific to the human resources department are: improved performance, reduced time training, reducing turnover and absenteeism, simplification and transparency of job performance evaluation. These specific objectives are leading to a particular selection system design which prioritizes these components.

As already presented in preliminary studies, the two instruments used by the studied company are behavioral competency based interview (Annex 1) and job performance form (Annex 2).

Because all 12 candidates who were employed and represent alternatives in this simulation occupy non-managerial positions within the department, there has been excluded criterion 4 (managerial abilities) from the FAHP design. Figure 2 presents the design of FAHP.

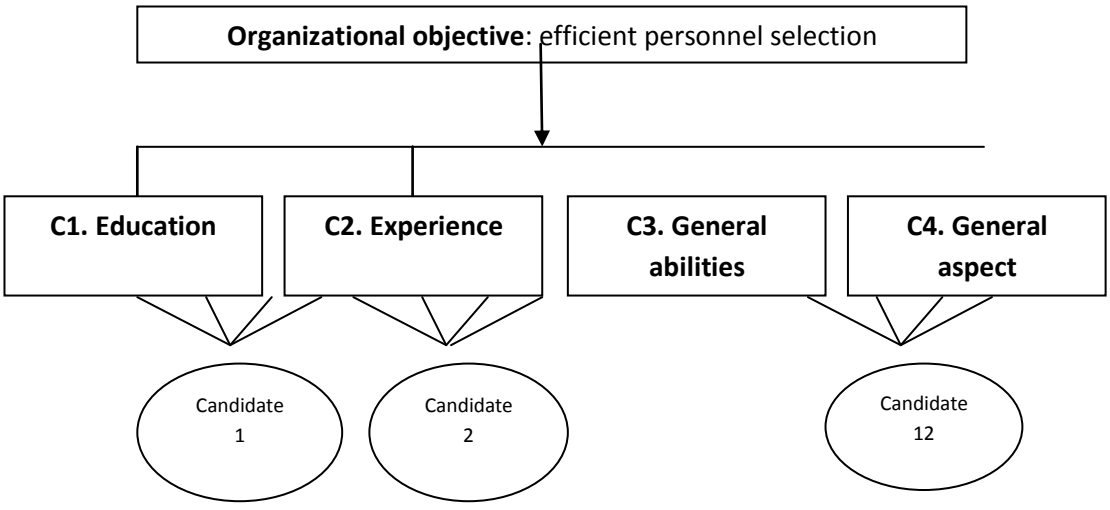


Fig. 2. – FAHP design

IV.3.1. Determining the relative weight of criteria

To determine the relative importance of the selection criteria used in the selection interview there was set a meeting with four employees from the human resources department. Depending on decision makers' preference on four selection criteria, C3> C4> C2> C1, there was designed the pair wise matrix.

Table 7. – Pair wise comparison of criteria

I	J				
		C1	**C2**	**C3**	**C4**
	C1	**(1,1,1)**	*(1/4,1/3,1/2)*	*(1/9,1/9,1/9)*	*(1/6,1/5,1/4)*
	C2	(2,3,4)	**(1,1,1)**	*(1/8,1/7,1/6)*	*(1/4,1/3,1/2)*
	C3	(9,9,9)	(6,7,8)	**(1,1,1)**	*(4,5,6)*
	C4	(4,5,6)	(2,3,4)	(1/6,1/5,1/4)	**(1,1,1)**

After completing the first three steps of the methodology, in step 4 there will be calculated the geometric mean of fuzzy comparison values of each criterion with equation 4 (4). For example, $\widetilde{r_1}$ geometric mean of fuzzy comparison values of criterion C1 (Education) is to be calculated as equation 8 (8).

$$\widetilde{r_i} = \left(\prod_{j=1}^{n} \widetilde{d_{ij}}\right)^{1/n} = \left[\left(1 * \frac{1}{4} * \frac{1}{9} * 1/6\right)^{\frac{1}{4}}; \left(1 * \frac{1}{3} * \frac{1}{9} * 1/5\right)^{\frac{1}{4}}; \left(1 * \frac{1}{2} * \frac{1}{9} * 1/4\right)^{\frac{1}{4}}\right] \quad (8)$$

$$\widetilde{r_1} = [0{,}26; 0{,}29; 0{,}34]$$

The geometric means of fuzzy comparison values of the 4 criteria are depicted in Table 8. In the last 3 lines of the table there are also presented totals and reverse values, and finally, numerical values' order is changed since fuzzy triangular number should be presented sequentially.

Table 8. – Geometric means of fuzzy comparison values

Criteria	$\widetilde{r_i}$		
C1	0,26	0,2919	0,342
C2	0,5	0,6102	0,759
C3	3,834	4,2129	4,559
C4	1,075	1,3161	1,565
Total	5,669	6,431	7,226
Reverse	0,176	0,1555	0,138
Increasing order	0,138	0,1555	0,176

In step 5, the fuzzy weight of criterion C1 - *Education* $\widetilde{w_1}$ is found using the equation 5 (5) and shown in Equation 9 (9).

$$\widetilde{w_1} = [(0{,}26 * 0{,}13); (0{,}29 * 0{,}15); (0{,}34 * 0{,}17)] = [0{,}04; 0{,}05; 0{,}006] \quad (9)$$

The relative fuzzy weights of each criterion are calculated and presented in Table 9.

Table 9. – Relative fuzzy weights of criteria

Criteria	$\widetilde{w_i}$		
C1	0,04	0,05	0,06
C2	0,07	0,09	0,13
C3	0,53	0,66	0,8
C4	0,15	0,2	0,28

In the sixth step, the relative non-fuzzy weight of each criterion M_i is calculated by averaging the fuzzy numbers for each criterion. In the seventh step, using non-fuzzy values M_i there are calculated N_i the normalized weights of each criterion. The results are summarized in Table 10.

Table 10. - Averaged and normalized relative weights of criteria

Criteria	M_i	N_i
C1	0,047	0,05
C2	0,099	0,1
C3	0,663	0,65
C4	0,21	0,21
TOTAL	1,02	1

IV.3.2. Determining weights of Alternatives/Candidates according to Criteria

After calculating the normalized non-fuzzy relative weights of criteria, the same methodology is applied to find the values for alternatives/candidates. This time, alternatives

must be pair wise compared regarding each of the four criteria, thus analysis must be repeated 4 times, for each criterion.

To facilitate the analysis, Table 11 presents the row scores of the 12 candidates in order to determine the relative importance of alternatives/candidates according to the four criteria considered (Subscales 1, 2, 3, 4).

Table 11. – Raw scores of candidates received at the selection interview

Alternative / candidate	**score C1**	**score C2**	**score C3**	**score C4**	**Interview score**
A1	5	4	3	4	4
A2	4	3	2	3	3
A3	5	3	2,8	2	3,2
A4	2	2	2,2	3	2,3
A5	5	4	3,2	3	3,8
A6	4	2	2,4	2	2,6
A7	5	4	3	2	3,7
A8	4	2	2,8	2	2,7
A9	5	5	4	4	4,5
A10	3	2	2,2	2	2,3
A11	5	4	2	3	3,1
A12	4	4	2	2,8	3,2

Depending on decision makers' preference on the 12 alternatives/candidates there were calculated 4 pair wise matrix, criteria related to C1, C2, C4 and C4. Similar to the methodology for calculating the geometric means of fuzzy comparison values of all criteria, there were calculated $\widetilde{r_i}$ and $\widetilde{w_i}$ values for all 12 alternatives/candidates depending on each of 4 different criteria. The results are depicted in Tables 12, 13, 14 and 15.In the last step, the non fuzzy M_I and normalized N_I values are calculated using centre of area method and depicted in Table 16.

Table 16. - Non fuzzy M_I and normalized N_I values of 12 alternatives with respect to C1-C4 criteria

Alternatives/ Candidates	**C1**		**C2**		**C3**		**C4**	
	M_I	N_I	M_I	N_I	M_I	N_I	M_I	N_I
A1	0,131420332	0,1270192	0,104055342	0,1007588	0,129299604	0,1216198	0,180060652	0,1696772
A2	0,051583966	0,0498565	0,047922261	0,0464041	0,02135036	0,0200822	0,076968141	0,0725297
A3	0,131420332	0,1270192	0,095230631	0,0922137	0,068755149	0,0646714	0,18624889	0,1755086
A4	0,014230362	0,0137538	0,023776312	0,0230231	0,0234967	0,0221011	0,076968141	0,0725297
A5	0,131420332	0,1270192	0,10903151	0,1055773	0,191778551	0,1803877	0,076968141	0,0725297
A6	0,051583966	0,0498565	0,022026776	0,021329	0,048255384	0,0453892	0,030490203	0,0287319
A7	0,131420332	0,1270192	0,10903151	0,1055773	0,12324408	0,1159239	0,030490203	0,0287319
A8	0,053778734	0,0519777	0,022026776	0,021329	0,087338435	0,0821509	0,030490203	0,0287319
A9	0,131420332	0,1270192	0,259526154	0,2513042	0,288533177	0,2713956	0,1862a4889	0,1755086
A10	0,02336672	0,0225842	0,022026776	0,021329	0,033994117	0,031975	0,030490203	0,0287319
A11	0,131420332	0,1270192	0,10903151	0,1055773	0,02355033	0,0221515	0,084707804	0,079823
A12	0,051583966	0,0498565	0,10903151	0,1055773	0,02355033	0,0221515	0,071064037	0,066966

Based on the results obtained in the previous steps, the normalized non-fuzzy relative weights of each alternative for each criterion are calculated. The results are shown in Table 17.

Table 17. - Normalized non-fuzzy relative weights of each alternative for each criterion

Alternatives/ candidates	**C1**	**C2**	**C3**	**C4**
A1	0,1270192	0,1007588	0,1216198	0,1696772
A2	0,0498565	0,0464041	0,0200822	0,0725297
A3	0,1270192	0,0922137	0,0646714	0,1755086
A4	0,0137538	0,0230231	0,0221011	0,0725297
A5	0,1270192	0,1055773	0,1803877	0,0725297
A6	0,0498565	0,021329	0,0453892	0,0287319
A7	0,1270192	0,1055773	0,1159239	0,0287319

A8	0,0519777	0,021329	0,0821509	0,0287319
A9	0,1270192	0,2513042	0,2713956	0,1755086
A10	0,0225842	0,021329	0,031975	0,0287319
A11	0,1270192	0,1055773	0,0221515	0,079823
A12	0,0498565	0,1055773	0,0221515	0,066966

Using the data from Table 10 and Table 17, there are calculated individual scores of each alternative/candidate for each C1-C4 criteria. The results are shown in Table 18.

Table 18. - Aggregated results of each alternative according to each criterion

	C1 weight	**C2 weight**	**C3 weight**	**C4 weight**	
Alternatives/ candidates	**0,05**	**0,1**	**0,65**	**0,21**	**Total**
A1	0,1270192	0,1007588	0,1216198	0,1696772	**0,131111922**
A2	0,0498565	0,0464041	0,0200822	0,0725297	**0,035417902**
A3	0,1270192	0,0922137	0,0646714	0,1755086	**0,094465546**
A4	0,0137538	0,0230231	0,0221011	0,0725297	**0,032586952**
A5	0,1270192	0,1055773	0,1803877	0,0725297	**0,149391932**
A6	0,0498565	0,021329	0,0453892	0,0287319	**0,040162404**
A7	0,1270192	0,1055773	0,1159239	0,0287319	**0,098292924**
A8	0,0519777	0,021329	0,0821509	0,0287319	**0,064163569**
A9	0,1270192	0,2513042	0,2713956	0,1755086	**0,244745326**
A10	0,0225842	0,021329	0,031975	0,0287319	**0,030079559**
A11	0,1270192	0,1055773	0,0221515	0,079823	**0,048069995**
A12	0,0498565	0,1055773	0,0221515	0,066966	**0,04151189**

The final score was calculated by summing the multiplications of each criterion weight with each alternative weight.

IV.4. Conclusions on FAHP's superiority over the classic model in calculating candidates interview score

In order to establish the superiority of the method, both scores (classic and FAHP) will be correlated to subsequent job performance score. Table 19 depicts candidates' interview raw scores and ranks calculated with the classic method and FAHP and candidates' job performance raw scores and ranks.

Table 19. - Candidates' row scores and ranks in: classic interview, FAHP and job performance

	Classic interview score	Classic interview rank	FAHP interview score	FAHP interview rank	Job performance score	Job performance rank
A1	4	2	0,131111922	3	4	3
A2	3	8	0,035417902	10	2,8	10
A3	3,2	3	0,094465546	5	3,7	4
A4	2,3	11	0,032586952	11	2,7	11
A5	3,8	4	0,149391932	2	4,3	2
A6	2,6	10	0,040162404	9	2,9	9
A7	3,7	5	0,098292924	4	3,6	5
A8	2,7	9	0,064163569	6	3,1	7
A9	4,5	1	0,244745326	1	4,8	1
A10	2,3	12	0,030079559	12	2,5	12
A11	3,1	7	0,048069995	7	3	8
A12	3,2	6	0,04151189	8	3,2	6

To determine which of the two methods of ranking candidates based on the interview score is more efficient compared to subsequent job performance, Kendall's tau coefficient was used.

In statistics, Kendall correlation coefficient represents a technique used to measure the degree of association between two ordinal variables (ranks).

The candidates' rank calculated with FAHP is more significantly associated with candidates' job performance rank ($r = 0,909$ la $p < 0,01$) than candidates' classic interview rank ($r = 0,848$ la $p < 0,01$). The degree of association between the interview FAHP score and subsequent job performance is significantly increased, demonstrating the superiority of FAHP over the classic method for assessing candidates in an interview.

Thus, this study summarizes and exemplifies the use of fuzzy logic in personnel selection research methodology, a very actual topical in the literature of organizational psychology. The concepts of multi-criteria interdependence and fuzzy analytic hierarchy process are decisive in ensuring the optimal decision system in personnel selection. This approach represents a valid model to accommodate inherent imprecision of human resources management processes.

The proposed personnel selection FAHP model has the following advantages:

1. The hierarchical structure is consistent with organizational objectives and strategies. Policymakers may recognize relationships between different objectives and are able to assess their influence using hierarchical modeling.

2. Policymakers can break down the complex problem of personnel selection into more simple and logical decisions.

3. The model is flexible enough to integrate additional factors in the decision process.

4. The model does not reduce the costs of personnel selection process, but reduces conflict and hidden costs in the implementation phase.

Given the multitude of criteria used in personnel selection procedures, this activity is one of the most important tasks of the human resources department. Because most of these criteria conflict with each other, candidates should be evaluated effectively. Although there are alternative techniques such as TOPSIS, ELECTRE, PROMETHEE, DEMATEL, ANP, etc., this study chose to use a hybrid Fuzzy AHP. Since decision makers' preferences depend on both tangible and intangible criteria, these imprecise linguistic variables need to be represented by fuzzy set theory.

CAPITOLUL V

Conclusions and final remarks, theoretical and practical implications

Choosing the right staff and the needed skills to meet the challenges begins with the human resources selection process. In other words, the essential component of an organization's success lies in making correct decisions regarding the selection of future employees.

The recruitment and selection process of human resources plays an important role in modeling the efficiency and performance of organizations, when organizations are able to hire and retain candidates who already possess relevant skills and are also able to make a correct prediction on the future performance of their work. Thus, the recruitment and selection process represent a hot domain, and if until recently the process of providing human resources was regarded as a routine in organizational life, nowadays the organizations are paying and increasingly more interest in this aspect, considered as a source of competitive advantage.

There is evidence of increased interest from organizations to use standardized methods for selecting employees, which respect the principles of validity, reliability and fairness. It was noted that for decades, labor psychology has had a significant influence on how the workforce is recruited and on the development of rigorous selection procedures and staff evaluation (Arnold et al, 2005, p 135).

Thus, the overall objective of the thesis is to examine several contemporary approaches of recruitment and selection and of the personnel evaluation process, in order to improve professional performance. In Chapter 1 current approaches of recruitment, selection and personnel evaluation are presented, viewed in theoretical and practical perspective.

The recruitment and selection process of human resources is not working in a vacuum, isolated from social trends, so it is very important to look at current research trends in the field. This aspect of ensuring employment is however subject of some potential difficulties. Many of the selection methods widely used are generally perceived as being of no confidence in realistic prediction of future job performance of employees. Thus, it is extremely important to get a realistic assessment of the process by all stakeholders, including the selected and rejected candidates.

The personnel selection involves a series of choices made by deciding factors, including the optimal method of recruitment, the job analysis and the use of specific selection measures. In a narrower sense, the selection of staff represents the taking of the decision to hire or promote candidates, involving the decision of which candidates will be accepted and

which will be rejected. The quality of a decision is given by the proportion of right elections among applicants (Born & Scholarios, 2005).

Thus, the ultimate goal of personnel selection is to maximize the right choices and minimize the mistakes made during the selection process. In pragmatic terms, a good decision when selecting human resources ensures that the productivity of newly elected persons exceeds the costs of their recruitment, selection, training and compensation. Most research in personnel selection were focused on prediction and not on making decisions. The specific literature abounds with studies that emphasize on evaluation methods of selection and on how to determine the best predictors of work performance. Undoubtedly, this knowledge has been invaluable to organizations in the selection of most effective employees. While most studies focus on methods that provide useful insights concerning the future performance of employees, researches focused on the narrow aspect of the decision process in selection are missing.

In Chapter II theoretical approaches and applications of fuzzy modeling in the selection of personnel are presented, highlighting the impact of integrating these methods into the human resources practitioners' current work.

Taking into account that the overall objective of this thesis is to examine the current approaches of the recruitment process, selection and personnel evaluation in order to optimize work performance, in Chapter III three preliminary studies analyzing the current state of personnel selection and of work performance in organizational practice are presented.

The first study aims to identify the extent to which the selection interview based on behavioral skills predict later job performance. The score received in the interview explains 79% of how job performance ranges for the 51 employees included in this research, Beta coefficient = 0.894, at a threshold $p < 0.01$ being subjected to the effect of multicollinearity. These results confirm the hypothesis 1, that work performance is predicted in a high measure by the score received in the interview, which means that 79% (effect distorted by multicollinearity) of how varying professional performance can be made responsible on the score obtained during interviews, given that both samples are based on skills and behavioral consistency principle.

The second study includes the developing of a fuzzy expert system modeled according to a database belonging to a multinational automotive company in Arad, aimed to simulate the hiring decision, with available data on subsequent work performance of selected candidates. The idea of this fuzzy model is to calculate the final score to interview selection by considering the positive and negative indices received by each candidate on each criterion considered in the selection interview. It was check whether this new fuzzy model for calculating the

scores to the selection interview is more robust than the classical algorithm by reporting both scores to the score obtained for the post-employment job performance.

Taking into account that the data on which we simulated this fuzzy decision model belongs to candidates who have been selected, one can observe very low scores accepted. These candidates with very low scores would be considered false positives. Thus, the decision of selection was highly permissive for the 51 employees studied. This phenomenon can be explained relatively simply because inside the company studied the posts must be occupied quickly with candidates who immediately apply. There are moments when for a single job are applying many competent candidates who refuse another position and there are also moments when few and poorly professional trained candidates apply. If the procedure rejects them, the positions remain unoccupied, which is creating a vicious circle.

The main advantage of this type of fuzzy expert models is the perfect transparency, given by the inference rules that can be easily explained and understood, which creates prerequisites for further adjustments and highly efficient adaptations. If for example we have an application where there are a large number of candidates for a small number of jobs, we can rewrite some of the rules, in the sense of growing of the sensitivity of decisional model.

As noted, there is a very strong correlation between the classic score received to interview and those received to further professional performance ($r = 0,894$ to $p < 0,01$). One observe a highly significant correlation ($r = 0,861$ to $p < 0,01$) between the calibrated score and the work performance. Although the correlation coefficient is significantly lower than that obtained in the case of the classic score, the validity of the procedure is fully proven. The two scores both classic and fuzzy represents in fact the same thing, the evaluation method is identical, but one renounce to the arithmetic average calculation of the 16/20 criteria, opting for the record of positive and negative indices obtained from candidates' answers to the standardized questions contained in the behavioral interview grid. Although it was not obtained an increased correlation coefficient in the case of calibrated scores (fuzzy) the method is innovative in the literature and presents a validity reporting it to the subsequent performance work.

The conclusion of this study is that the job interview, as it has been demonstrated, has an essential role in predicting of future job performance of employees. The net benefit of fuzzy model for calculating the scores is that it can be extended to all existing selection procedures based on competence behavioral interviews. One of the model’s limits, as well as of the classic system of granting final score, is that it not provides a ranking of the candidates. We often find candidates with the same score, aspect that makes more difficult hiring decisions.

The third study presents the development of a fuzzy expert system to assist human resources specialists in screening of databases with applicants on technical positions, aiming a first selection of candidates which demonstrate fulfillment of eliminatory criteria (education, experience, motivation).

The objective of this study was to develop a simple fuzzy expert system to assist professionals in human resources departments when screening applicants for a technical position. We argue the importance of using such an automated system for screening applicants in the context when the number of applicants per job is very high and the selection interview will invite only those candidates who fulfill the minimum conditions for the relevance of studies, professional experience and increased motivation to occupy the position.

A personal conclusion considering the results of this study and the results included in the mentioned metaanalyzes is that no clear rules exist on how these variables interact and how they influence each other, it's all about the organizational context in which the measurement is made and about the specific time conjuncture of that organization, when measuring the variables. No organizational context remains unchanged so no personal constructs related to work remain at the same level.

The conclusion of this research is that the selection interview, as it has been shown, has an essential role in predicting of future job performance of employees. If you choose the variant of a competency-based behavioral interview, employees will better understand what is expected from them. The moment of assessing the professional performance represents in fact a retest of the same skills, but passed through the supervisor that could directly observe employee behavior. At the interview, the recruiter only estimated, after discussions, the measure in which future employee will be able to demonstrate these skills at work.

Although the work performance is a vague construct and desirable organizational behavior and familiarity of employee's practice of permanent professional evaluation tend to make excessive bureaucratic professional performances, practice shows that the choice of most suitable candidates results in substantially reduced expenditure training and not finally decrease the dropout rate, absenteeism and increased turnover. It is obvious that this study does not provide answers on how it can be increase employee performance, however this study provides evidence on the choice of candidate which will be able to have work performance. The developed fuzzy expert model is able to assist from the perspective of an expert a human resources consultant which will have to decide on the selection of certain candidates for interview. Certainly this model is useful only in the context of a greater jobs competition where many candidates are applying and the selection is required to be a rigorous one.

In the light of these findings, in the chapter IV it was developed an original robust conceptual model for recruitment, addressed by the hierarchical analytical fuzzy model (FAHP) that has been described and validated on the existing data of the multinational company studied, with inputs data resulted from the interview selection. The original Fuzzy Multicriterial Interdependent Hierarchic model (FMIH) is based on interdependence criteria and on processuality analytical hierarchical in decision making on the hierarchy of the candidates in order of the optimal selections. In this chapter it was analyzed from cognitive perspective the decision of personal recruitment, namely through the study and ranking of the selection criteria according to their importance in the overall assessment of performance in the interview. The main hypothesis of the research was that the FMIH model is superior processual to the classic model for calculating of the final scores obtained by the candidates at the interview. This assumption is based on the fact that FMIH offers a clear hierarchy for all candidates entering the procedure, not just a numeric score, which often is identical to several candidates for the classic procedure, making it difficult to differentiate on the basis of clear evidence between them. This superiority was established by analyzing the hierarchy of candidates in both models, reported to their later work performance.

The fuzzy analytical hierarchical process (AHP) incorporates classical theory of fuzzy analytical hierarchical process, which was developed by Saaty (1980). AHP is a decision making tool widely used in various multi-criteria decision approach different problems. The essence of the approach is to use comparisons between pairs (pair wise comparisons) between multiple alternatives (in our case 12 candidates in the quality department - from 51 employees of the company), taking into account different criteria (selection criteria), provides a tool multi criteria decision support in the decision making process. As traditional AHP technique does not include imprecision of personal judgments, it has been improved by fuzzy approach. In FAHP, comparisons between pairs of both the criteria and the alternatives are conducted through linguistic variables, which are represented by triangular fuzzy numbers. Although in the literature there are a variety of techniques embodied in FAHP in the scope of this study is using Buckley's method (1985), in order to determine the relative weights of importance for both criteria and alternatives.

As noted, the rank of candidates determined by calculating with FAHP method of interview score correlates strongly with the rank candidates in terms of job performance ($r = 0,909$ to $p < 0,01$) than the rank determined by calculating the score at interview by the classical method ($r = 0,848$ $p < 0,05$). Thus the degree of association between the score obtained in the interview calculated with FAHP and professional performance is significantly increased.

This optimization shows that AHP method for assessing of candidates to interview is superior to the classical algorithm.

Thus, in this conceptual study it was developed and exemplified a fuzzy model FMIH for the evaluation and selection of employees. This approach represents a valid model to accommodate inherent imprecision to all human resource management processes.

The proposed staff selection model has the following advantages: 1. the hierarchical structure is concordant with the objectives and strategies of the organization. The decision factors may recognize the relationships between different objectives and can evaluate their influence by hierarchical modeling; 2. The decision factors can decompose the complex problem of personnel selection in more simple and more logical decisions of involved factors; 3. The model is flexible enough to integrate additional factors in the assessment; 4. The model does not reduce the costs of the selection process, but reduces conflict and hidden costs in the implementation phase.

Given the multitude of criteria used in the selection procedures, the decision process is much more difficult, this activity is one of the most important tasks of the human resources department. Because most of these criteria are in conflict with each other, the candidates must be efficiently evaluated. Although alternative techniques such as TOPSIS, ELECTRE, PROMETHEE, DEMATEL, ANP, etc., does exist, this study chose to use a fuzzy hybrid model AHP, called IIMF. Since preferences of decision factors depend on both tangible and intangible criteria, these imprecise linguistic variables is necessary to be represented by fuzzy sets.

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ANEXA 1 – Fișa interviu

Candidate Assessment Sheet

Name: ……

Recruitment Team: ……

Recruitment Agency: ……

Targeted Position: ……

Professional Motivation (Career Plans; Why ____; etc…)

		N/A	1	2	3	4	5	Comments
Studies	Relevant Studies for the job.							
	Involved in various activities.							
Professional Experience	Relevant experience for the post							
General Skills	He establish his goals and he realize them.							
	Anticipates problems and acts on his own initiative, taking calculated risks.							
	Plan their activities according to priorities.							
	Works well under pressure, focusing on what is important.							

	Demonstrates motivation and enthusiasm for his work.							
	Communicates very easy, clear and to the point. Team Player, Adaptable, Open at different viewpoints.							
	Is interested in its development. Ambitious and with realistic expectations.							
	It is a honest person who takes responsibility for his actions.							
Only for Management	Set goals for its employees and seeks constructive in their achievement.							
	Creates a cooperative atmosphere within the team and encourages people to help each other.							
	Mesiates conflicts between members of his team, encouraging people to deal openly and solve their problems.							
	Leads by personal example, expext the same behavior from its employees.							
Appearance at interview	Outfit							
	Attitude							

	Completely and to the point answers.							
	Formulates relevant questions.							

Assessor: Date:

English : ❑ Begineer ❑ Medium ❑ Fluent

……: ❑ Beginner ❑ Medium ❑ Fluent

Mobility : ❑ International ❑ National ❑ Unwilling to travel

Other comments(Points for future discussions, etc…)

Logistics :

Availability : ❑ Immediately ❑ Latest : ……..……

Current Salary Package : ……..

Requested Salary Package: ……..

Decision:

❑ Recruitment ❑ Reorientation …… (Unde?) ❑ On hold ❑ Reject

Signature: ……

Date : ……

ANEXA 2- Performance appraisal form / Fișa de apreciere a performanței în muncă

SALARIED ASSOCIATE PERFORMANCE APPRAISAL

YEAR _____

Name:			
Position:		Review Date:	
Location:		Department:	

Overall Performance Rating and Comments	
Rating (check one):	**Comments (if any):**
Exceeds Standards 5	
Usually Exceeds Standards 4	
Meets Standards 3	
Usually Meets Standards 2	
Does Not Meet Standards 1	

Supervisor Signature: _____

Reviewed By: _____

(Next higher level of management)

Associate Signature: _____

(Your signature does not imply agreement)

A copy of this form is to be provided to the associate upon completion of the evaluation process. Submit the original to the Human Resources Department.

Job Specific Knowledge	**1**	**2**	**3**	**4**	**5**
Comments:					

Quality / Quantity of Work	**1**	**2**	**3**	**4**	**5**
Comments:					

Communication	**1**	**2**	**3**	**4**	**5**
Comments:					

Interpersonal Skills	**1**	**2**	**3**	**4**	**5**
Comments:					

Organization, Planning & Process Thinking	**1**	**2**	**3**	**4**	**5**
Comments:					

Judgment & Decision Making	**1**	**2**	**3**	**4**	**5**
Comments:					

Customer Satisfaction	**1**	**2**	**3**	**4**	**5**
Comments:					

Teamwork	**1**	**2**	**3**	**4**	**5**
Comments:					

Adaptability to Change	**1**	**2**	**3**	**4**	**5**
Comments:					

Management of Human Resources (not required for non-supervisory associates)	**1**	**2**	**3**	**4**	**5**
Comments:					

Performance Against Objectives (optional – attach performance objectives)	**1**	**2**	**3**	**4**	**5**
Comments:					

Associate Training Plan – Required Training – Essential for the associate's current position. Must indicate timing (i.e.: Month of anticipated completion).

Associate Training Plan – Developmental Training – Useful, but not necessary for the associate's current position.

Associate Comments – Optional – Associate comments must be reviewed and initialed by all members of management who signed the original review. Attach additional sheets if necessary.
Associate Comments Reviewed By: _____ _____ _____ _____

Performance Objectives and Results For Eg. 2011

(Year)

Performance Against Objectives: Rating in this area is optional. Total weight for objectives section of review = _____%. (Optional)

Objective Number	**Objective Statement and Desired Result**	**Objective Weight**	**Actual Results and Comments**

Objectives and weighting of objectives are to be established by the associate and supervisor at the start of each annual review cycle. Attach additional sheets if necessary.

Performance Objectives For Eg. 2013

(Year)

Performance Against Objectives: Rating in this area is optional. Total weight for objectives section of review = _____%. (Optional)

Objective Number	**Objective Statement and Desired Result**	**Objective Weight**	**Actual Results and Comments**

Objectives and weighting of objectives are to be established by the associate and supervisor at the start of each annual review cycle. Attach additional sheets if necessary.