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Advisory, Negotiation and Intelligent Decision Support System for Leadership Analysis

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Abstract: The development of the Leader Model for quantitative and qualitative analyses began with the goal of integrating managerial, organizational, technical, technological, economic, legal/regulatory, innovative, social, cultural, ethical, psychological, religious, ethnic and other aspects involved in the process of a leaders life cycle. The need to determine the most efficient life cycle of a leader led to the development of the Advisory, Negotiation and Intelligent DEcision support System for Leadership Analysis (ANDES). The objective of the authors of this work for integrating text analytics, advisory, negotiation and decision support systems is to improve the quality and efficiency of intelligent decision-making regarding a leaders life cycle. This ANDES consists of an intelligent database, database management system, model-base, model-base management system and user interface.
Keywords: Leader, Model, Intelligent Systems, Integration.

1 Introduction

Leadership, according to Uhl-Bien and Russ Marion [1], is multi-level, processable, contextual, and interactive. Today's organizational leaders are faced with unprecedented complexity in the wake of increasing globalization [2].

Various systems are being developed globally for leadership analysis. These systems include information [3, 4], intelligent [5, 6], knowledge [7, 8], expert [9, 10] and decision support [11–17]. The aforementioned systems analyze their managerial, organizational, technical, technological, economic, legal/regulatory, innovative and similar aspects. However, neither the integrated economic, legal/regulatory, technical, technological, organizational, managerial, quality of life, social, cultural, political, ethical nor psychological aspects are generally paid hardly any attention at all.

The structure of this paper is as follows: Section 2, which follows this introduction, analyses the Advisory, Negotiation and Intelligent Decision Support System for Leadership Analysis. Certain concluding remarks appear in Section 3.

2 Advisory, Negotiation and Intelligent Decision Support System for Leadership Analysis

First, the existing different intelligent systems were analyzed. It included i information [3, 4], intelligent [5, 6], knowledge [7, 8], expert [9, 10] and decision support [15, 16, 18–21] systems, plus developed multiple criteria methods (CODEC, COPRAS, DUMA and DAM [18, 19]. The purpose was to determine the most efficient Advisory, Negotiation and Intelligent Decision Support System for Leadership Analysis (ANDES) to analyze a leader's life cycle. This developed support system consists of a database, database management system, model-base, model-base management system and user interface (Figure 1).

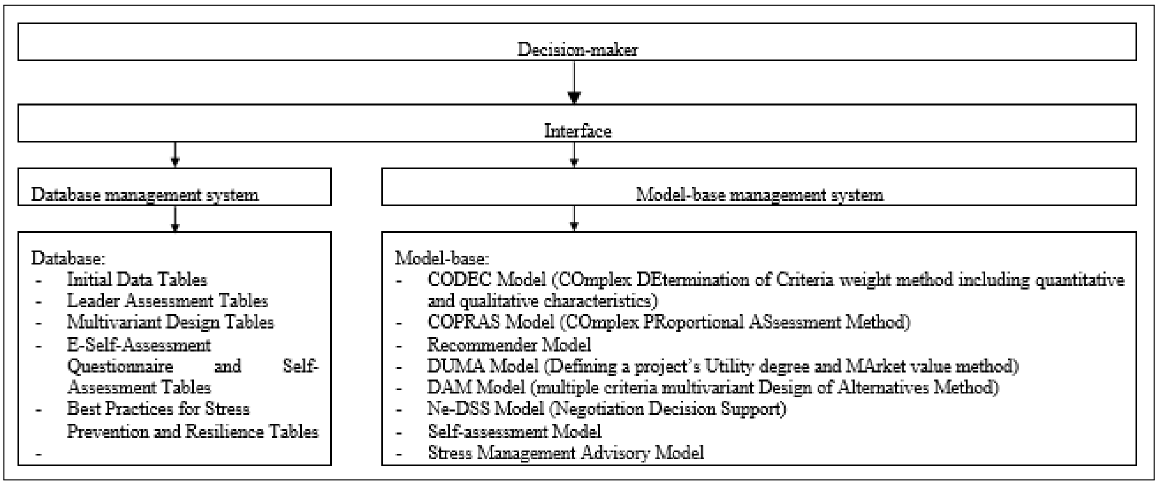

Figure 1: ANDES components

ANDES is an information system that accumulates data and information from various sources and processes them by extensive use of artificial intelligence techniques. It utilizes various multiple-criteria and artificial intelligence models and provides a decision-maker with data, information and knowledge needed for analyzing, compiling and assessing possible alternative resolutions. It can make a decision, derive the received results and safeguard them. Thus the ANDES can be based on data from various sources, allow users to transform a huge amount of unprocessed data, information and knowledge into an analysis of a problem under consideration. Development of the initial version of the *Advisory, Negotiation and Intelligent Decision Support System for Leadership Analysis* was in 2004. The testing of the *System* has been ongoing since then. A total of 176 distance-learning students tested this system. The continuous testing results resulted in improvements to the *System*. The testing of the *System* was the subject of some 18 final master theses.

2.1 Database

Presently the structure of relational databases is the most appropriate in light of the requirements raised by ANDES. A relational database stores information in tables. Every table is given a name for storing it in the external memory of the computer as a separate file. The indexes common for this table are logically interconnected. Thereby the entirety of the logically interrelated table comprises the model.

The data play very meaningful roles. Decisions are made using these as a basis. The more comprehensive the accumulated data are about an object under consideration, the more effective the decision made can be. For example, various economic, social, legal, technical, technological and other factors from the external environment impact knowledge management. The possible operations of an organization objectively change for better or for worse, as external conditions change. Usually an organization can organize its operations for more than one market. Therefore it is very important to understand and evaluate the constantly changing external micro, meso and macro environment and its impact on an organization's operations in different markets. The external and internal environments of an organization's operations can be described for each time period by basing it on specific data, information and knowledge. Organizations must react to the fluctuating external environment by making adequate strategic, tactical and operative decisions on the basis of such specific information. Since decision-making is an informational process, all of its stages, from the time of setting objectives to the ending of their implementation and evaluating their consequences, must be substantiated by searching for, visualizing, processing and analyzing necessary data, information and knowledge.

A leader interacts with a number of interested parties, all of whom are pursuing various goals and all of whom have different potentials, educational levels and backgrounds of experience. Therefore all the aforementioned parties in this field approach decision-making in various ways. It is often necessary to define these players in terms of their economic, legal/regulatory, technical, technological, organizational, managerial, quality of life, social, cultural, political, ethical and psychological aspects along with other types of information (see Figure 1). This is done to analyze the available alternatives thoroughly and to obtain an efficient compromise solution. Such information needs to appear in as much of a user-oriented manner as possible.

The presentation of information in ANDES, which is needed for decision-making, may be in conceptual (digital, numerical), textual, graphic (diagrams, graphs, drawing, etc), photographic, audio (sound), visual (video) and quantitative forms. The presentation of quantitative information involves criteria systems and models, units of measurement, values and initial weights, which fully define the variants provided. Conceptual information conceptually describes alternative solutions, criteria and ways used to determine the values and weights of the criteria and the like. Upon demand, the ANDES provides conceptual information (images, audio, video, and so on), which aids the user to get a better understanding of the alternatives in question and their defining criteria.

This way ANDES provides a decision-maker with different conceptual and quantitative information about a leader from a database and a model-base. It allows the decision-maker to analyze the above factors and determine an efficient solution.

An analysis of database structures in decision support systems by the type of problem they resolve reveals their various utilities. There are three basic types of database structures: hierarchical, network and relational. ANDES has a relational database structure, when the information is stored in the form of tables. These tables contain quantitative and conceptual information. Each table has a given name by which the computer's external memory saves it, as a separate file. Logically linked parts of the table constitute a relational model. The ANDES database consists of the following tables:

- Initial Data Tables. The data covers general facts about the leader under consideration. The leader's requirements and their significances as well as an intended salary are included.

- Leader Assessment Tables. Quantitative and conceptual information about alternative leaders on the ANDES website [22] show the input data for the multiple criteria analysis in ANDES.

- Multivariant Design Tables. These contain quantitative and conceptual information on the interconnecting elements in the life cycle of a leader in the organization, their compatibilities and possible combinations, as well as data for the complex multivariant design of the elements previously described herein.

- E-Self-Assessment Questionnaire and Self-Assessment Tables.

An analysis of the available alternatives is necessary for designing and realizing an effective leader's life cycle. A computer-aided multivariant design requires the availability of tables containing data on the interconnecting elements of the life cycle of a leader in the organization, along with their compatibilities, possible combinations and a multivariant design.

The development of possible variants is possible using the aforementioned tables as the basis for a multivariant design of a leader's life cycle. The development of millions of alternatives of a leader's life cycle (including the project on the life cycle of the leader in the organization) is possible by using a multivariant design method. The capacity of these versions to meet various requirements is checked. Alternative versions that are unsatisfactory in terms of the requirements raised are excluded from further consideration. A problem involving the significance of criteria compatibilities arises in the process of designing a number of variants of a leader's life cycle. Thereby the performance of a complex evaluation of the alternatives determines that the value of a criterion weight is dependent on the overall criteria under assessment, as well as on their values and initial weights.

Numerous studies have been conducted worldwide analyzing the reliability of self-assessments. This is quite a controversial issue. A great many researchers attained reliable results proving that self-assessments are sufficiently reliable. Our investigations also demonstrate that self-assessments are sufficiently reliable. The basis for the E-Self-Assessment Questionnaire and Self-Assessment Tables is the presumption that it is possible to determine a leader's level of stress rather accurately by assigning questions for leaders according to some certain methodology and then processing them in accordance with a certain algorithm.

2.2 Model-base

ANDES models are subdivided as quantitative and qualitative by their presentations. Qualitative models (multicriteria, based on expertise) are based on subjective opinions, experiences and assessments of experts. However, when different experts assess the same characteristics of the object, the derived results are often different. This occurs due to the different experiences, educational levels, purposes, available opportunities and the like of different experts. The derived data can be made more objective by applying the expert methods. Quantitative models (i. e. text analytics) reflect the objective features of the objects under consideration, independently of the subjective assessments by experts. Such features of an object can be expressed directly by physical units of measurement (monetary units, degrees, percents, ratios and such). Qualitative models have as many positive and negative features and quantitative models have. Objects being considered by quantitative models are objectively but often not comprehensively reflected. Contrariwise, ANDES qualitative models reflect reality subjectively and comprehensively. Therefore the rationality of applying quantitative and qualitative methods often depends on specific, decision-making situations. Frequently decision-making requires a comprehensive application of quantitative and qualitative models. For example, it is best to apply qualitative research methods when analyzing the qualitative leadership characteristics (emotions, culture, religious, traditions, ethical leader behaviors, psychological capital). However, when analyzing how much money will be spent over the entire process of an office's life cycle, such as the costs of its purchase or construction, exploitation, maintenance upkeep, insurance expenses, taxes and the like, the application of quantitative methods is better.

A determination regarding the efficiency of alternative leaders often takes into account economic, legal/regulatory, technical, technological, organizational, managerial, quality of life, social, cultural, political, ethical, psychological and other factors. Therefore the model-base of the ANDES should include models enabling a decision-maker to analyze the available variants comprehensively and arrive at a suitable choice. The intention for the following models of the model-base is to perform this function:

- CODEC Model (Complex Determination of Criteria Weight Method including quantitative and qualitative characteristics)
- COPRAS Model (Complex Proportional Assessment Method)
- Recommender Model
- DUMA Model (Defining a Project's Utility Degree and Market Value Method)
- DAM Model (Multiple Criteria, Multivariant Design of Alternatives Method)
- Ne-DSS Model (Negotiation Decision Support)
- Self-Assessment Model
- Stress Management Advisory Model
- Text Analytics

Development of the CODEC Model (Complex Determination of Criteria Weight Method including quantitative and qualitative characteristics) allows for the calculation and coordination of the significances of the described quantitative and qualitative characteristics of the criteria.

Development of the multiple criteria COPRAS Model (Complex Proportional Assessment Method) enables a user to obtain a reduced criterion for determining the complex (overall) efficiency of alternatives. This generalized criterion is directly proportional to the relative effect of the values and weights of the criteria under consideration regarding the efficiency of the alternatives.

The DUMA Model determines the utility degree and market salary of leaders. It establishes the competitive salary for a leader on the market. The basis for this model is a complex analysis of all the benefits and drawbacks of a leader. A leader's utility degree and the estimated market salary of a leader are directly proportional to the system of the criteria, which adequately describe them, and the values and weights of those criteria, according to this Model.

Development of the DAM Model of a multiple criteria, multivariant design of a leader's life cycle enables a user to design, with the aid of a computer, up to 100,000 alternative versions. Quantitative and conceptual information are the bases for any life cycle variant obtained in this way.

The bases for the ANDES are the models described above. ANDES can generate millions of alternative versions of leader life cycles (including a project for determining the life cycle of the current leader in the organization). ANDES performs a multiple criteria analysis of a leader's life cycle, determines a leader's utility degree and selects the most beneficial variant for a leader.

A model base, management system can provide various models according to a user's needs. The results of its obtained calculations become the initial data for some other models when using some certain model. Such a model could be for determining the initial weights of the criteria, for designing a leader's life cycle in a multivariant method (including a project on the life cycle of the current leader in the organization), for analyzing by multiple criteria and for setting priorities. Meanwhile the results of the latter, in turn, are acceptable as the initial data for some other models (such as for determining the leader utility degree, for providing recommendations and for other undertakings).

The *Ne-DSS Negotiation Decision Support Model* is for use by leaders engaged in different negotiation circumstances. One such example could be the purchase of office premises. A leader performing a multi-criteria analysis of all real estate alternatives selects the objects for starting the negotiations. The leader marks (ticks a box with a mouse) the desirable negotiation objects. The Letter Writing Model generates a negotiations e-mail after the selection of the desired objects. It then sends the e-mail to all real estate sellers once the user clicks "Send". The buyer and the seller may perform real calculations (the utility degree, market salary and purchase priorities) of the real estate with the help of ANDES during negotiations. The bases for these calculations are the characteristics describing the real estate's alternatives, obtained during negotiations (explicit and tacit criteria system and criteria values and weights). Development of the final comparative table is in accordance with the received results. Use of ANDES permits the performance of the multiple criteria analysis and selection of the best real estate for purchase version, following the development of the final comparative table.

There are two main categories of rules and procedures in the Ne-DSS Model:

- It compiles suggestions for leaders to employ along with the reasons for the recommended further negotiations with a particular leader.

- It composes a comprehensive, negotiation e-mail for each of the selected broker leaders. The Ne-DSS uses information inherited from the previous ANDES calculations and predefined rules and procedures and composes a negotiation e-mail for each of the selected broker leaders. The e-mail includes a reasonable suggestion for a decrease in the price of the real estate. The e-mail also references the calculations performed by ANDES.

Development of the Self-assessment Model took place while analyzing similar studies that were conducted worldwide. Areas of special attention were the criteria systems used, integration of such criteria into one general assessment, use of aggregation methods, reliability level of the results and tendencies of the results. The authors of this work based their work on the aforementioned and other studies.

A brief analysis of the above COPRAS Model (Complex Proportional Assessment Method) and DUMA Model (Defining a Project's Utility Degree and Market Value Method) follows, as an example.

COPRAS Model (Complex Proportional Assessment Method) The determination of the utility degree and value of the alternative under investigation and establishment of the priority order for its implementation does not present much difficulty if the criteria numerical values and weights have been obtained and the multiple criteria decision making methods are used.

The results of the comparative analysis of the alternatives are presented as a grouped decision making matrix where columns contain n alternatives being considered, while all quantitative and conceptual information pertaining to them is found in lines.

This method assumes direct and proportional dependence of significance and priority of investigated versions on a system of criteria adequately describing the alternatives and on values and weights of the criteria. The system of criteria is determined and the values and initial weights of criteria are calculated by experts. All this information can be corrected by interested parties taking into consideration their pursued goals and existing capabilities. Hence, the assessment results of alternatives fully reflect the initial data jointly submitted by experts and interested parties.

The determination of significance and priority of alternatives is carried out in four stages.

Stage 1. The weighted normalized decision making matrix D is formed. The purpose of this stage is to receive dimensionless weighted values from the comparative indexes. When the dimensionless values of the indexes are known, all criteria, originally having different dimensions, can be compared. The following formula is used for this purpose:

$$d_{ij} = \frac{x_{ij} \cdot q_i}{\sum_{j=1}^{n} x_{ij}}, i = \overline{1,m}; j = \overline{1,n}. \tag{1}$$

where x_{ij} - the value of the i-th criterion in the j-th alternative of a solution; m - the number of criteria; n - the number of the alternatives compared; q_i - weight of i-th criterion.

The sum of dimensionless weighted index values d_{ij} of each criterion x_i is always equal to the weight q_i of this criterion:

$$q_i = \sum_{j=1}^{n} d_{ij}, i = \overline{1,m}; j = \overline{1,n}. \tag{2}$$

In other words, the value of weight q_i of the investigated criterion is proportionally distributed among all alternative versions a_j according to their values x_{ij}.

Stage 2. The sums of weighted normalized indexes describing the j-th version are calculated. The versions are described by minimizing indexes S_{-j} and maximizing indexes S_{+j}. The lower value of minimizing indexes (salary, costs of lifelong learning, etc.) is better. The greater value of maximizing indexes is better (innovation, labour productivity, etc.). The sums are calculated according to the formula:

$$S_{+j} = \sum_{i=1}^{m} d_{+ij}; S_{-j} = \sum_{i=1}^{m} d_{-ij}, i = \overline{1,m}; j = \overline{1,n}. \tag{3}$$

In this case, the values S_{+j} (the greater is this value (alternative 'pluses'), the more satisfied are the interested parties) and S_{-j} (the lower is this value (alternative 'minuses'), the better is goal attainment by the interested parties) express the degree of goals attained by the interested parties in each alternative. In any case the sums of 'pluses' S_{+j} and 'minuses' S_{-j} of all alternatives is always respectively equal to all sums of weights of maximizing and minimizing criteria:

$$S_{+} = \sum_{j=1}^{n} S_{+j} = \sum_{i=1}^{m} \sum_{j=1}^{n} d_{+ij},$$
$$S_{-} = \sum_{j=1}^{n} S_{-j} = \sum_{i=1}^{m} \sum_{j=1}^{n} d_{-ij}, i = \overline{1,m}; j = \overline{1,n}. \tag{4}$$

In this way, the calculations made may be additionally checked.

Stage 3. The significance (efficiency) of comparative versions is determined on the basis of describing positive alternatives ('pluses') and negative alternatives ('minuses') characteristics. Relative significance Q_j of each alternative a_j is found according to the formula:

$$Q_j = S_{+j} + \frac{S_{-min} \cdot \sum_{j=1}^{n} S_{-j}}{S_{-j} \cdot \sum_{j=i}^{n} \frac{S_{-min}}{S_{-j}}}, j = \overline{1, n} \tag{5}$$

Stage 4. Priority determination of alternatives. The greater is the Q_j the higher is the efficiency (priority) of the alternative.

The analysis of the method presented makes it possible to state that it may be easily applied to evaluating the alternatives and selecting most efficient of them, being fully aware of a physical meaning of the decision-making process. Moreover, it allowed to formulate a reduced criterion Q_j which is directly proportional to the relative effect of the compared criteria values $x_i j$ and weights q_i on the end result.

DUMA Model (Defining a Project's Utility Degree and Market Value Method) The leader's utility degree and market salary are determined in seven stages. **Stage 1.** The formula used for the calculation of leader's a_j utility degree N_j is given below:

$$N_j = (Q_j : Q_{max})100\%, \tag{6}$$

here Q_j and Q_{max} are the significances of the leader obtained from the equation 5.

The degree of utility N_j of leader a_j indicates the level of satisfying the needs of the stakeholders interested in the leader. The more goals are achieved and the more important they are, the higher is the degree of the leader utility.

A degree of leader utility reflects the extent to which the goals pursued by the interested parties are attained. Therefore, it may be used as a basis for determining leader market salary. The more objectives are attained and the more significant they are the higher will be leader degree of utility and its market salary.

Stage 2. The efficiency degree E_{ji} of money (salary, etc.) invested into leader a_j is calculated. It shows by how many percent it is better (worse) to invest money into leader a_j compared with leader a_i. E_{ji} is obtained by comparing the degrees of utility of the leaders considered:

$$E_{ij} = N_j - N_i. \tag{7}$$

The received results are presented as a matrix clearly showing utility differences of the leaders.

Stage 3. The average deviation k_j of the utility degree N_j of the leader a_j from the same index of other leaders $(n-1)$ is being calculated.

$$k_j = \sum_{i=1}^{n} E_{ji} : (n-1). \tag{8}$$

Stage 4. The development of a grouped decision making matrix for leader multiple criteria analysis. The market salary of a leader being valuated is calculated according to a block-diagram presented in Figure 2.

At the beginning, a grouped decision making matrix for leader multiple criteria analysis is developed, the first criterion of which is based on the actual salary of the leader compared and the value of a leader being valuated. The initial value of a leader being valuated is obtained from the following equation:

$$x_{11} = \sum_{j=2}^{n} x_{1j} : (n-1). \qquad (9)$$

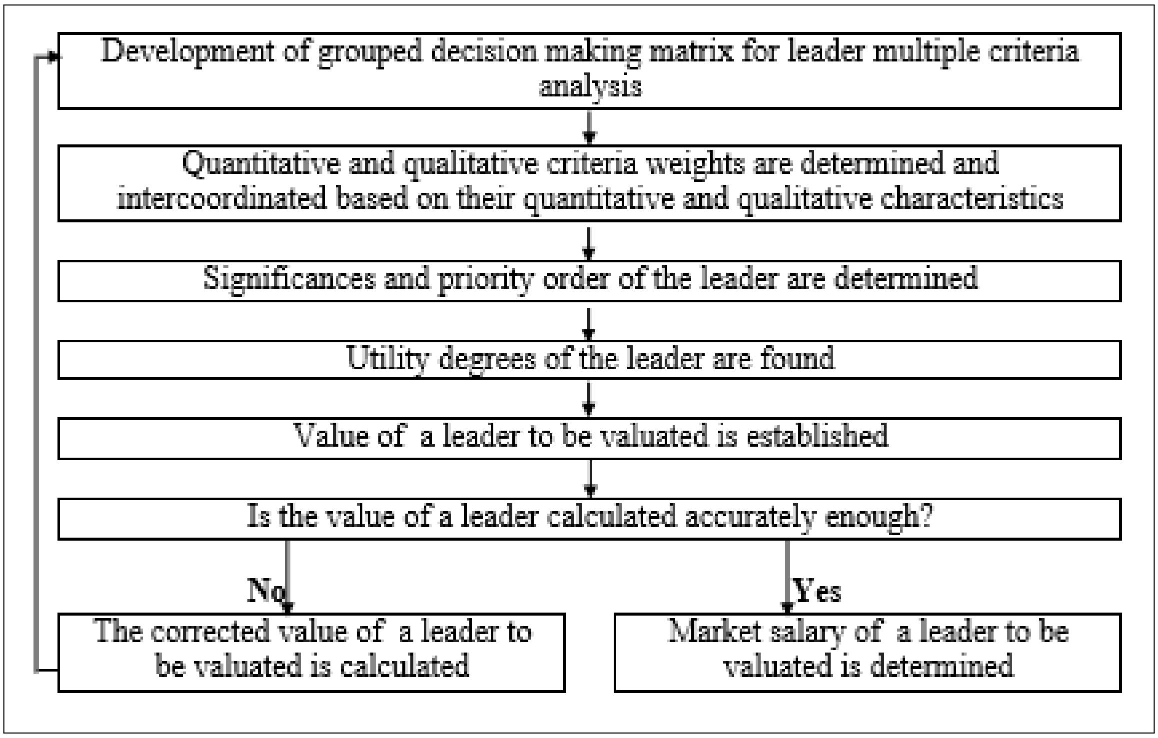

Figure 2: Block-diagram of leader market salary estimation

In this matrix, a leader a_1 to be valuated should be assigned the market salary (x_{11-R}). Other leaders ($a_2 - a_n$) salaries ($x_{12} - x_{1n}$) known. All the values and weights of the criteria relating to other leaders are also known.

The problem may be stated as follows: what market salary x_{11-R} of a valuated leadera_1 will make it equally competitive on the market with comparison standard leaders ($a_2 - a_n$)? This may be determined if a complex analysis of the benefits and drawbacks of the leader is made.

Using a grouped decision making matrix and the equations 1-9 the calculations are made

Stage 5. The corrected value x_{11-p} of a leader to be valuated a_1 is calculated:

$$x_{11-p} = x_{11} * (1 + k_1 : 100). \qquad (10)$$

Stage6. It is determined whether the corrected value $x_1 1 - R$ of a leader being valuated a_1 had been calculated accurately enough:

$$|k_1| < s, \qquad (11)$$

where s is the accuracy, %, to be achieved in calculating the market salary x_{11-p} of a leader a_1. For example, given $s = 0,5\%$, the number of approximations in calculation will be lower than at $s = 0,1\%$.

Stage 7. The market salary x_{11-R} of a leader a_1 to be valuated is determined. If inequality 11 is satisfied the market salary of a leader a_1 may be found as follows:

$$x_{11-R} = x_{11-p} \qquad (12)$$

If inequality 11 is not satisfied this means that the value of a leader being valuated had not been calculated accurately enough and the approximation cycle should be repeated. In this case, the corrected value$x_{11} = x_{11-p}$ of a leader being valuated is substituted into a grouped decision making matrix of leader multiple criteria analysis and the calculations according to the formulae 1-12 should be repeated until the inequation 2.20 is satisfied.

Solving the problem of determining the market salary x_{11-R} of a leader a_1 being valuated, which would make it equally competitive on the market compared with the leaders $(a_2 - a_n)$, a particular method of defining the utility degree and market salary of a leader was suggested. This was based on a complex analysis of all the benefits and drawbacks of the leader considered.

According to this method the leader utility degree and the market salary of a leader being estimated are directly proportional to the system of the criteria adequately describing them and the values and weights of these criteria.

The Case Study [22] presented illustrates the efficiency of the ANDES in practice.

3 Conclusions

An Advisory, Negotiation and Intelligent Decision Support System for Leadership Analysis (ANDES) was offered as an example for demonstrating the integration of advisory, negotiation and decision support systems. In the future, there are plans to extend the use of the ANDES in Martynas Mazvydas National Library of Lithuania. The plans for the next stage in the development of the ANDES involve integrating this System with biometrics (Computer Mouse Advisory System), Recommended Biometric Stress Management System and Pupil Analysis System [18] systems, which the authors herein have also developed. Such an integration of intelligent and biometrics systems would provide even better assessments of the emotional states of leaders and the submissions of personalized recommendations to them.

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