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Selecting Best Projects based on Fuzzy TOPSIS, Fuzzy ANP and Balanced Scorecard Approaches

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Abstract

Excellence model can help the organization move forward in the right direction by providing solutions in the form of improvement projects. Lack of resources prevents organizations from implementing all improvement's projects simultaneously. Consequently, it seems necessary to make the optimal selection of the improvement projects proposed. According to the studies, unfortunately, there is no appropriate framework for the excellence model to prioritize improvement projects and make the optimal selection according to the organization's policies and strategies. In this research, a hybrid fuzzy multiple criteria decision making is combined with the balanced scorecard for the optimal selection. Research method is of descriptive and applied type, and field method is used to collect data. The total study population is 30 people. The sample size is equal to the population size. The spatial scope of the research, with a period of 2011 to 2013, is limited to Calcimin Co. whose business is in the field of production of mineral products. The data collection instrument is a researcher-made questionnaire or interview. Data analysis is based on an integrated model of research, and Matlab, and SPSS software were used for the calculations. Based on calculations on the stages of the proposed model, the priority improvement projects and the improvement project of "Create a comprehensive marketing information system in the field of commerce" were selected as the optimal improvement project that had the highest priority for implementation. Results show that the proposed model has a systematic fit with the defined procedures and known inputs.

Keywords: Balanced Scorecard, Europen Foundation for Quality Management, Multiple Criteria Decision Making, Fuzzy ANP, Fuzzy TOPSIS

1. Introduction

In the past decades, fast provident of global completion which caused by technological change and increasing of product's variation lead companies to find out importance of the constant improvement process to sustain their constant competition progress. At present, organizations and enterprises search many ways and opportunities to improve, maximal strong and to minimal weak sides of their activity. As the practice shows, the managers seek the tools to strategic management basing on well-known principles of the PDCA Circle - Plan, Do, Check and Act. Performance measurement systems dominated by financial measures have often been criticized. Researchers show that the traditional system of activity measurement, which was based on financial management, is unsuitable. Financial measures have been characterized as backward-looking, historical, aggregate, and too focused on short-term results. Non-financial measures are believed to be more predictive of future performance and more useful in "driving" performance. Increased competitive pressures, implementation of other programs like Total Quality Management (TQM), and the perceived limitations of traditional financial measures have led to increased usage of non-financial measures[1]. At the result of these limits, new measurement system appeared on discourses. The major parts of discussion in new discourse were based on new organization strategies and non financial symbols. New action measurement systems could be divided into two groups[2]:

- First group emphasizes self-assessment like Deming Prize, Malcolm Baldrige Award and European Foundation for Quality Management (EFQM).

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- Second groups are systems, which are helping managers for assessment and improvement of trade and business-like Balanced Score Card (BSC).

To determine the status of an organization on the path to excellence, the EFQM model is a practical tool to help organizations understand their shortcomings and deficiencies, in which the solutions presented in the form of improvement projects help the organization to move forward in the direction of appropriate management systems[3]. After defining these projects, organizations often face a large number of projects that will have the ability to implement all improvement projects at the same time, due to limited resources with which organizations face in today's competitive era as a result of the affected situation of industries of the countries. This requires organizations to optimally allocate the resources to projects whose implementation will lead to the growth and survival of the organization, ensure the interests of the stakeholders, and meet customer expectations, etc.[3]. However, the important thing is to choose the optimal improvement projects. As the studies show, unfortunately there is no framework for the EFQM model to determine the optimal improvement projects according to the organization's policies and strategies. In this context, this study aims to provide a model in which the combination of the fuzzy multi-criteria decision methods (including fuzzy ANP and fuzzy TOPSIS) and the balanced scorecard to weight the criteria and sub-criteria of improvement projects, in order to determine the importance level of each of them based on organizational policy, and strategies give good results for the organization so that it can prioritize the improvement projects proposed by the EFQM and identifies the optimal improvement projects.

2. Organizational and the EFQM Excellence Model

In the EFQM excellence model, the comprehensive, systematic and periodical use of the self-assessment process allows organizations to identify their own strengths and improvable areas and to define the improvement projects corresponding to the output, in the hope of improving their excellence record. As the European Foundation European Foundation for Quality Management underlines, many organizations can find too many areas for improvement when they do the first or second self-assessment, so that sometimes up to about 200 opportunities for improvement are identified in some organizations[4]. Given these circumstances, if the organizations intend to implement all opportunities and achieve their improvements, they have to spend large amounts of their resources, although many of them may have the very little impact on the organization to achieve positive results. Since resource constraints naturally exist in every organization, and managers are constantly trying to achieve maximum results with the minimum use of resources, the prioritization of opportunities and areas of improvement must be identified; and on the other hand, it is essential to select the most key issues so that organizations are constantly faced with the risk that for any reason, they may be engaged in solving less important problems and may be unaware of the key problems. The result of this strategic mistake would be both a waste of resources and the weakened hope and belief of improvement, which would be no end except boredom and peaceful coexistence with existing problems[3]. Many experts in improvement science believe that the selection of the improvement project is the Achilles heel of improvement programs, that is to say, if the improvement projects are not properly selected, the improvement programs will face the risk of ineffectiveness, and since improvement projects cannot meet the expected results, the organization will be disappointed and frustrated from improvement efforts[3]. Review of the literature and related research suggests that this selection has not been made in a deep and professional manner, and that there is no comprehensive and systematic model to respond to the challenge of selecting the key issues among a host of improvable areas resulting from a self-assessment process using the EFQM excellence model, so that organizations can pass through the sensitive and fateful bottleneck by taking certain and pre-defined steps. More suggestions in this regard have been proposed as general recommendations, each of which has significant gaps and weaknesses. In the rest of this section, we will analyze the most common existing approaches[3].

2.1 Approach for Matrix Diagram (2×2 Dimension)

this method, which was introduced by the European Foundation for Quality Management, assumes that the organization recognizes the matters of strategic importance.

2.2 Impact-easy Matrix Method

In this method, which was introduced by the European Foundation for Quality Management, two factors of Impact and easy are the foundations of decision making, that is to say, we determine the extent that each of the areas of improvement, if converted into an improvement project and then implemented, can affect the organizational performance, as well as the extent that it is possible (easy) to implement.

2.3 Bryce and Braddock Model

Bryce and Braddock [2002] believe that the ideal process of project selection includes the commitment of top executives to exactly define the priorities of the organization. From their perspective, priority is given to the areas of improvement that need to make little effort to implement, while having a high impact on organizational performance.

2.4 Importance-performance Matrix Method

this method gives priority to improvement projects in the area where there is a very weak organizational performance. In this case, these projects are very important for customers of the organization. Chase and Hayes (1991) also briefly pointed out the use of a matrix similar to the importance-performance matrix. Other researchers have also made changes in the importance-performance matrix.

According to the methods and approaches examined in this study, it can be seen that, firstly, to prioritize the improvable areas of the self-assessment process using the EFQM excellence model; there are no comprehensive and accurate approaches that have specific and defined inputs, outputs and processing steps in such a way that they can be described as a systematic model. The majority of existing methods are only general recommendations that don't have not only accurate processing steps but also clear practical steps (algorithm). To be more precise, although it is easy to model in the existing methods that can do the initial clustering of improvable areas and can significantly interact with decision makers, and sometimes some of the decision criteria have been noted in general, but they have weaknesses and gaps, the main of which are as follows[3]:

The lack of comprehensive criteria, not ranking, lack of a certain method provided for group decision making, lack of the systematic model, not considering the natural conditions prevailing business environment, lack of a suitable method for calculating the weights of criteria, general expression of criteria, and poor mathematical analysis. In addition, as the studies conducted show, unfortunately in the European quality excellence model, there is no clear framework to select optimal improvement projects based on the organization's policies and strategies[3].

Approach to balanced scorecard emphasizes the relationship between performance measures of business and strategy unit based on its four perspectives, which can help to translate strategy into objectives and measures. Thus, for the optimal selection of improvement projects, the powerful tool of the balanced scorecard is a framework for defining the optimal improvement projects according to strategic and long-term objectives of the organization.

3. Fuzzy Set Theory and its Implications

For the first time in 1965, Professor LotfiZadeh introduced fuzzy sets in the form of a paper published in the Journal of Information and Control where fuzzy was referred to as what Bertrand Russell, Jan Łukasiewicz, Max Black and others called it ambiguity or multiple values. He believed that we need a different kind of mathematics for modeling uncertainty and imprecision of events. Therefore, the fuzzy set theory is used to express the uncertainty in determining the exact or mental priorities, constraints and objectives. This theory is mathematically able to formulate many concepts, variables and systems that are vague and imprecise - as often is the case, in reality - and provides the possibility of argument-reasoning-control and decision making under uncertainty. However, the uncertainty and ambiguity, which refer to fuzziness, are related to the uncertainties associated in expressive language and way of human thinking, and is different from uncertainty that is expressed by probability theory[5].

4. Fuzzy Multi-criteria Decision

Decision making is a problem-solving process in which one among a variety of ways is selected to achieve the end implemental result. Most decision-making problems in the real world have different, multiple and contradictory criteria. If the conflicting qualitative factors are evaluated in the decision making, and appropriate solution is chosen from among several alternatives, it is called multi-criteria decision making[6]. Since the decision making is a very complex process due to different uncertainties in the data, subjectivity and linguistics, the fuzzy sets, when faced with situations of uncertainty, are combined with a multi-criteria decision making in many of the concepts and processes. In the fuzzy multi-criteria decision, the weights of evaluation factors and values are expressed by fuzzy numbers or linguistic variables[5].

Multi-criteria decision-making models can be divided into two major categories:

- Multiple Objective Decision Making (MODM)
- Multiple Attribute Decision Making (MADM)

5. Multiple Attribute Decision Making (MADM)

In the last two decades, a special attention has been paid to multi-criteria decision-making models by researchers in the area of decision-making. These techniques can formulate the problems related to decision making in the form of a decision-making matrix and do the necessary analyses on them. There are various methods of multi-criteria decision-making, each of which has its own characteristics and conditions of its own application[3]. Given the proposed algorithm, models of this type of decision model, which include fuzzy ANP to determine the weights of criteria and sub criteria, fuzzy TOPSIS to rank the projects optimal selection, are used in the present study.

5.1 Fuzzy Analytic Network Process

Analytical Hierarchy Process (AHP) is one of the primary methods in the multi-criteria decision-making techniques, which is suitable for solving the most complex problems. It was introduced as a method for solving problems of social and economic decisions by "Saati" in 1980, and then, was used to solve a wide range of decision-making problems. The underlying assumption in AHP is the operational independence of the upper part in the hierarchy structure from the lower part and from the criteria for each level or class[4]. "Saati" proposed the AHP method for solving problems in the case of independence between alternatives and criteria, and ANP methods for solving the problems that have dependencies between alternatives or criteria. ANP was founded by "Sa'ati" and was presented as a generalization of the AHP[7].

The ANP feedback approach replaces hierarchies (Figure 1a) with networks (Figure 1b).

In ANP, the modeling process can be divided to four steps, which are described as follows:

Step 1: The base model and structure problem:
Problem should be clear from be expressed, such a network is divided into a rational system. This network structure can be used by decision makers in brain storming session soro the methods to determine[2].

Step2: The pairwise comparisons and relative weight estimation:
Before performing the pairwise comparisons, all criteria and clusters compared are linked to each other. The pairwise comparisons are made depending on the scale shown in Table 1.

In the pairwise comparison matrix, the score of a_{ij} represents the relative importance of the component on row (i) over the component on column (j) i.e. $a_{ij} = {}^{w_i}/_{w_j}$, the reciprocal value of the expression $\left({}^{1}/_{a_{ij}}\right)$ is used when the component j is more important than the component i. The comparison matrix A is defined as follow:

$$A = \begin{bmatrix} \frac{W_1}{W_1} & \frac{W_1}{W_2} & \cdots & \frac{W_1}{W_n} \\ \frac{W_2}{W_1} & \frac{W_2}{W_2} & \cdots & \frac{W_2}{W_n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{W_n}{W_1} & \frac{W_n}{W_2} & \cdots & \frac{W_n}{W_n} \end{bmatrix} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \quad (1)$$

Then, a local priority vector (eigenvector) w is computed as an estimate of the relative importance accompanied by the elements being compared by solving the following equation: $Aw = \lambda_{max}{}^{*} w$ (2)

where, the λ_{max} is the largest eigen value of the A matrix[8].

Step 3: Formation of the initial supermatrix:
The obtained vectors are further normalized to represent the local weight vector. Supermatix is formed, local weight vectors are entered in the appropriate columns of

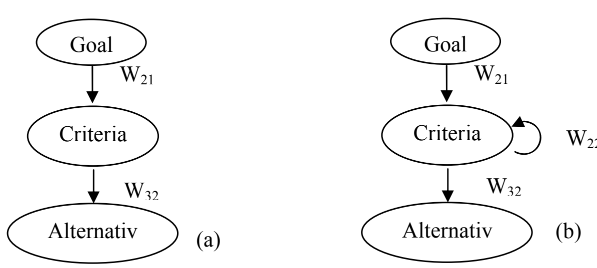

Figure 1. Hierarchy and network: (a) Hierarchy; (b) Network.

Table 1. Comparison scale

Linguistic scale for importance	Linguistic scale for performance	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Equal importance	Very poor	1, 1, 1	1, 1, 1
Weak importance (of one over the other)	Poor	2, 3, 4	1/4, 1/3, 1/2
Strong importance	Fair	4, 5, 6	1/6, 1/5, 1/4
Demonstrated importance over the other	Good	6, 7, 8	1/8, 1/7, 1/6
Absolute importance	Very good	8, 9, 10	1/10, 1/9, 1/8

the matrix of influence among the elements, to obtain global priorities. The supermatrix representation of a network with three levels is shown in Figure 1b:

$$w = \begin{array}{l} \\ \text{Goal(G)} \\ \text{Criteria(C)} \\ \text{Alternatives(A)} \end{array} \begin{array}{c} \begin{array}{ccc} G & C & A \end{array} \\ \begin{pmatrix} 0 & 0 & 0 \\ w_{21} & w_{22} & 0 \\ 0 & w_{32} & 1 \end{pmatrix} \end{array} \tag{3}$$

W_{21} is a vector that represents the impact of the goal on the criteria, W_{22} is a vector that represents impact of the interdependences among criteria, W_{32} is also a vector that represents the impact of criteria on each of alternatives, and I is the identity matrix. Any zero value in the super-matrix can be replaced by a matrix if there is an interrelationship of elements within a cluster or between to clusters[8].

Step 4: Formation of the weighted super-matrix :
An eigenvector is obtained from the pair-wise comparison matrix of the row clusters with respect to the column cluster, which in turn yields an eigenvector for each column cluster. The first entry of the respective eigenvector for each column cluster is multiplied by all the elements in the first cluster of that column, the second by all the elements in the second cluster of that column and so on. In this way, the cluster in each column of the super matrix is weighted, and the result, known as the weighted super-matrix, is stochastic. In this study, logarithmic least square's method is used for getting estimates for fuzzy priorities $\tilde{W}_i$.ANP can be used to calculate the relative importance of the criteria and outrank the alternatives. In our proposed model, FANP will be used only to calculate the triangular fuzzy weights for the relative importance of the criteria and the interdependence priorities of the criteria (Eq. (4)) will be used to support fuzzy TOPSIS and ELECTRE for outranking the alternatives[9].

$$w = \begin{pmatrix} 0 & 0 \\ w_{21} & w_{22} \end{pmatrix} \tag{4}$$

The logarithmic least squares method for calculating triangular fuzzy weights can be given as follows:

$$\tilde{W} = (w_k^l, w_k^m, w_k^u)\ k = 1,2,3,....,n. \tag{5}$$

where,

$$w_k^s = \frac{(\prod_{j=1}^n = a_{kj}^s}{\sum_{i=1}^n (\prod_{j=1}^n a_{ij}^m)^{\frac{1}{n}}}, s \in \{1, m, u\} \tag{6}$$

5.2 Fuzzy TOPSIS

TOPSIS is based on the concept that the most preferred alternative should not only have the shortest distance from the positive ideal solution, but also have the longest distance from the negative ideal solution. According to this technique, the best alternative would be the one that is nearest to the positive-ideal solution and farthest from the negative ideal solution[8].

Fuzzy TOPSIS steps can be outlined as follows[8]:

Step 1: Choose the linguistic ($\tilde{x}_{ij}$, i=1,2,3,…,n, j=1,2,3,…,J) for alternatives with respect to criteria. To avoid complexity of mathematical operations in a decision process, the linear scale transformation is used here to transform the various criteria scales into comparable scales. The set of criteria can be divided into benefit criteria (the larger the rating, the greater the preference) and cost criteria (the smaller the rating, the greater the preference). Let; $(\tilde{x}_{ij} = (a_{ij}, a_{ij}, a_{ij}); \tilde{x}_j^- = (a^-{}_j, b^-{}_j, c^-{}_j)$ and $\tilde{x}_j^* = (a_j^*, b_j^*, c_j^*)$. Get B and C are the sets of benefit criteria and cost criteria, respectively, we have

$$\tilde{r}_{ij} = \frac{\tilde{x}_{ij}}{\tilde{x}_{ij}^*} = \left(\frac{a_{ij}}{a_j^*}, \frac{b_{ij}}{b_j^*}, \frac{c_{ij}}{c_j^*}\right), j \in B$$

$$\tilde{r}_{ij} = \frac{\tilde{x}_{ij}^{-}}{\tilde{x}_{ij}} = \left(\frac{a_j^{-}}{a_{ij}}, \frac{b_j^{-}}{b_{ij}}, \frac{c_j^{-}}{c_{ij}}\right), j \in C \quad (7)$$

Step 2: The normalization method mentioned above is designed to preserve the property in which the elements $\tilde{r}_{ij}\ \forall i;\ j$ are standardized (normalized) triangular fuzzy numbers. Considering the different importance of each criterion, the weighted normalized fuzzy-decision matrix is constructed as

$$\tilde{V} = [\tilde{v}_{ij}]_{*n \times j} \{i = 1,2,....,n, j = 1,2,....j\}$$

$$\text{where } \tilde{v}_{ij} = \tilde{r}_{ij}(.)w_i \quad (8)$$

Step 3: According to the weighted normalized fuzzy decision matrix, normalized positive triangular fuzzy numbers can also approximate the elements $\tilde{\upsilon}_{ij}; \forall i;\ j$. Then, the fuzzy positive ideal solution (FPIS, A*) and fuzzy negative-ideal solution (FNIS, A^-) can be defined as

$$A^* = \{\tilde{v}_1^*, ..., \tilde{v}_1^*\} = \{\max v_{ij} | i \in I\}\{i = 1,2,...n, j = 1,2,...,J\} \quad (9)$$

$$A^- = \{\tilde{v}_1^-, ..., \tilde{v}_1^-\} = \{\max v_{ij} | i \in I\}\{i = 1,2,...n, j = 1,2,...,J\} \quad (10)$$

where, I is criteria.

Step 4: The distance of each alternative from A^* and A^- can be currently calculated as

$$D_j^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}^*, \tilde{v}_j^*)\{j = 1,2,...,J\} \quad (11)$$

$$D_j^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}^*, \tilde{v}_j^-)\{j = 1,2,...,J\} \quad (12)$$

where, D is the distance measurement between two fuzzy numbers.

Step 5: A closeness coefficient is defined to determine the ranking order of all possible alternatives once D_j^* and D_j^- of each alternative Aj (j = 1,2, …, J) has been calculated. The closeness coefficient represents the distances to the fuzzy positive-ideal solution (A^*) and the fuzzy negative-ideal solution (A^-) simultaneously by taking the relative closeness to the fuzzy positive ideal solution. The Closeness Coefficient (CCj) of each alternative is calculated as

$$CC_j = \frac{D_J^-}{D_J^- + D_J^+}, \quad \{j = 1,2,...,J\} \quad (13)$$

It is clear that CCj = 1 if Aj = A^* and CCj = 0 if Aj = A^-. In other words, alternative Aj is closer to the FPIS (A^*) and farther from FNIS (A^-) as CCi approaches to 1. According to the descending order of CCj, we can determine the ranking order of all alternatives and select the best one from among a set of feasible alternatives.

6. Proposed Method

The research method used in this study is of descriptive and applied type, with regard to the subject of study. The independent variables in this study are the four perspectives of the balanced scorecard, and the dependent variable is the improvement projects of the organizational excellence model. In addition, indicators to measure the long-term goals of the organization are based on the four perspectives of the balanced scorecard. Data collection method is a field study, and collection of information is made with the head counting method that includes the entire population. The population consists of 30 senior managers and middle managers of the company, managers of the factories, middle managers of the factories, experts in the Planning Department of the Calcimin Co., who are active in the self assessment, drafting of declarations, and the implementation of improvement projects within the organization. The study sampling is of non-probability and selective type. As the sample size is equal to the population size, the former in this study includes 30 people in the statistical population. Test period to collect data and to obtain an acceptable sample is 2011 to 2013. The spatial scope of the study is limited to Calcimin Co. (Publicly traded company) that is one of the active listed companies that is active in the production of mineral products. Data collection instrument in this study includes questionnaire or interview. There are five questionnaires that are the result of information obtained from the list of improvement projects of the organizational excellence model for prioritization and optimal selection. The perspectives of the balanced scorecard are used as criteria, and indicators drawn from four perspectives of the balanced scorecard are the sub-criteria of the model. Fuzzy ANP and fuzzy TOPSIS methods are used for the design the questionnaires, including its composition and overview, which was completed by using the table of linguistic variables. The validity level of the questionnaire and any questions posed therein was calculated by 10 experts in the statistical population, which on average was equal to 0.74, i.e. greater than the mean value of 0.5. After the calculation of Cronbach's alpha coefficient, the reliability level of the questionnaire was equal to 0.856, which is higher than the index value of 0.70. The data analysis is based on the integrated model of the research. Excel and SPSS software were used for the calculation and analysis.

7. Proposed Model

The proposed model for the optimum improvement projects selection problem, composed of fuzzy ANP and fuzzy TOPSIS methods, consists of four basic stages:

7.1 Identify the criteria and sub criteria to be used in the model.
7.2 Fuzzy ANP computations.
7.3 Evaluation of suitable improvement projects and determination of the final rank with fuzzy TOPSIS.

Schematic diagram of the proposed model for sniper selection is provided in Figure 2.

7.1 Identify the Criteria and Sub Criteria to be used in the Model

Self-assessment their strengths and weaknesses company calcimine excellence model is based on the excellence model criteria to identify and to improve and convert the weak points into strengths points, improvement projects are defined as shown in Table 2.

In this model criteria, the four perspectives of balanced scorecard and sub criteria required model Index are extracted from the balanced scorecard in company Calcimine number 15 on the sub criteria shown in Table 3.

The dependence between the criteria and sub criteria according to the group decision is stated in Table 4 and 5.

Scoring the questionnaire given linguistic variable table scale comparative is shown in Table 6.

7.2 Fuzzy ANP Computations

First Problem brings in a hierarchical structure. Schematic view of the structure shown in Figure 3.

First level: The purpose of the" optimal choice Improvement Project Excellence Model"

Second level: four perspectives of balanced scorecard

Third level: Balanced Scorecard Index.

Hierarchy super matrix optimal selection of projects improve the excellence model with three levels is given as follows:

So that,

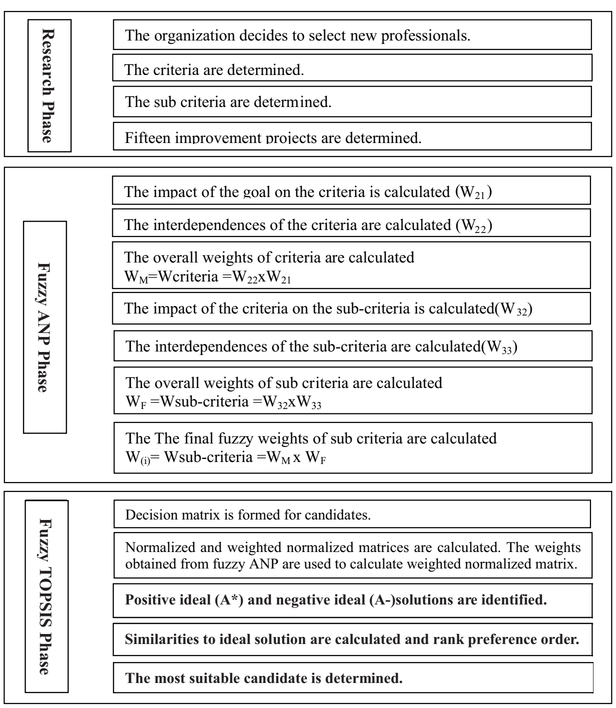

Figure 2. Proposed model.

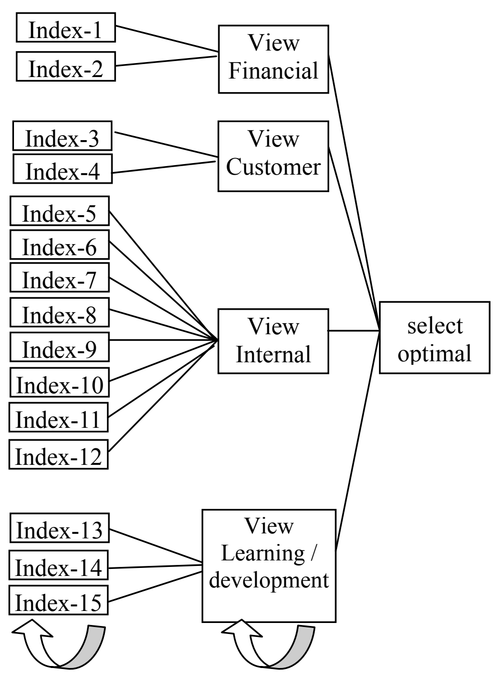

Figure 3. Schematic view of the hierarchical structure.

Table 2. Improvement projects Excellence Model

Criteria	cod	improvement projects
Leadership	P1	Power house establishment 25 MW in Complex Dandi
Policy& Strategy	P2	Creating management dashboards in line with the 5-year strategic Plan
	P3	Designing comprehensive human resource System
People	P4	Establishment international standard of education ((ISO 10015))
	P5	Establishment knowledge management system and application software «Share Point»
	P6	Establishment ERP system
Partnerships& Resources	P7	Create a comprehensive marketing information system in the field of commerce
	P8	Establishment system customer relationship management (CRM)
	P9	Industrialize project production Nickel and Cadmium
Processes	P10	New phase of 5000 tons on factory Dandy
	P11	INTEC Project

Table 3. Criteria and sub criteria to be used in the model

Sub criteria (Index)		Criteria (View)	
Index	**Cod**	**View**	**Cod**
Ratio Reduction of operational costs	F1	Financial	M1
Rate Income	F2		
Rate Lead Zinc ingot	F3	Customer	M2
Rate of zinc grade in zinc concentrate	F4		
stock the amount of mineral soil	F5	Internal processes	M3
Lead Extraction Efficiency	F6		
zinc Extraction Efficiency	F7		
Zinc concentrate Extraction Efficiency Until zinc Sheet	F8		
Melting efficiency	F9		
Number of customer complaints	F10		
Number of Incidents	F11		
Deviation of environmental standards	F12		
Number of offers accepted	F13	Learning and development	M4
Person-Hours of training	F14		
Effectiveness of training	F15		

Table 4. Interdependences between criteria

Dependent criteria	Depending on
M1	M4- M3 - M2
M2	M4 - M3
M3	M4- M2 - M1
M4	M3- M2 - M1

W_{21} is a vector that represents the impact of the goal on the criteria,

W_{22} is a vector that represents impact of the interdependences among criteria,

W_{32} is a vector that represents the impact of the criteria on the sub criteria,

W_{33} is a vector that represents impact of the interdependences among sub criteria,

In the method, information from the questionnaires 1 and using the logarithmic least squares method Fuzzy weight matrix W_{21} calculation is shown in the Table 7.

In order to obtain the fuzzy dependence criteria using information questionnaire 2 and logarithmic least squares method fuzzy weight matrix W_{22} calculation is shown in the Table 8.

According to the results obtained for the criteria model, the fuzzy weight matrix W_M ($W_M = C_{riteria} = W_{21} * W_{22}$) obtained are shown in Table 9.

The ANP method, information from the questionnaires 3 and using the logarithmic least squares method fuzzy weight matrix W_{32} calculation is shown in the Table 10.

In order to obtain the fuzzy dependence sub criteria using information questionnaire 4 and logarithmic least squares method fuzzy weight matrix W_{33} calculation is shown in the Table 11.

According to the results obtained for the sub criteria model, the fuzzy weight matrix W_F ($W_F = W_{sub\text{-}criteria} = W_{32} {}^{*} W_{33}$) obtained are shown in Table 12.

Then, a fuzzy ANP method to calculate the final fuzzy weights matrix $W_{(i)}$ ($W_{(i)} = W_M {}^{*} W_F$) is calculated for sub criteria as shown in Table 13.

This phase is known essentially as the fuzzy ANP phase essentially.

7.3 Evaluation of Suitable Improvement Projects and Determination of the Final Rank with Fuzzy TOPSIS

The second phase of the study, which is called the fuzzy TOPSIS phase, starts establishing fuzzy evaluations of the improvement projects (P1,P2,...,P11) with respect to the sub criteria by using triangular fuzzy numbers again. This is a decision matrix for ranking improvement projects the performance ratings of the improvement projects according to the sub criteria. After constructing the decision matrix, a normalized decision matrix is calculated decision matrix of using information questionnaire 5 is shown in Table 14.

Then the weighted normalized fuzzy decision matrix is calculated. Weights which are used to calculate weighted normalized fuzzy decision matrix are derived from the FANP. The weighted normalized value V_{ij} calculated by using Eq (8). Table 15 is the weighted normalized decision matrix.

Moreover positive-ideal (A^*) and negative-ideal (A^-) solutions are identified. The fuzzy positive-ideal solution (FPIS, A^*) and the fuzzy negative-ideal solution (FNIS, A^-) are calculated using Eqs.(9) and (10). The distance of each alternative from A^* and A^- is computed by using Eqs. (11) and (12). Fuzzy preferences are normalized positive triangular fuzzy numbers, so we can define the fuzzy positive-ideal solution (FPIS, A^*) and the fuzzy negative-ideal solution (FNIS, A^-). In the final step, similarities to the ideal solution are calculated and ranked in preference orders. Then, an alternative with maximum CC^* j is chose or alternatives according to CC^* j are ranked in descending order. Table 16 summarizes the results. Eq. (13) is used to calculate distances to ideal solutions. According to the last step, the best alternative for the optimal improvement projects selection problem is determined as P7.

Fuzzy TOPSIS final result ranking improvement projects is the optimal improvement projects proposed model research.

Table 5. Interdependences between sub criteria

Dependent sub criteria	Depending on
F1	F6 - F7 - F8 – F9
F2	F3 - F4 - F10
F3	F8 - F9
F4	F6 - F7
F5	F2
F6	F7 - F14 - F15
F7	F6 - F14 - F15
F8	F4 - F14 - F15
F9	F8 - F14 - F15
F10	F3 - F4
F11	----------
F12	-------------
F13	F14 - F15
F14	F11 - F13 - F15
F15	F11 - F13 - F14

Table 6. Comparison scale

Linguistic scale for importance	Linguistic scale for performance	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Equal importance	Very poor	1, 1, 1	1, 1, 1
Weak importance (of one over the other)	Poor	2, 3, 4	1/4, 1/3, 1/2
Strong importance	Fair	4, 5, 6	1/6, 1/5, 1/4
Demonstrated importance over the other	Good	6, 7, 8	1/8, 1/7, 1/6
Absolute importance	Very good	8, 9, 10	1/10, 1/9, 1/8

Table 7. Matrix fuzzy weights W_{21}

	fuzzy weights W_{21}		
	L	M	U
M1	0.73	0.81	0.90
M2	0.78	0.86	0.96
M3	0.26	0.29	0.34
M4	0.11	0.12	0.13

Table 9. Matrix fuzzy weights W_M for criteria

	fuzzy weights W_M		
	L	M	U
M1	0.77	0.86	0.97
M2	0.93	1.05	1.19
M3	0.61	0.72	0.85
M4	0.18	0.20	0.24

Table 8. Matrix fuzzy weights W_{22}

	M4			M3			M2			M1		
	L	M	U	L	M	U	L	M	U	U	M	L
M1	0.11	0.12	0.13	0.11	0.12	0.13	0	0	0	**1**	**1**	**1**
M2	0.04	0.04	0.05	0.05	0.05	0.06	**1**	**1**	**1**	0.22	0.20	0.18
M3	0.01	0.02	0.02	**1**	**1**	**1**	0.35	0.38	0.41	0.13	0.12	0.10
M4	**1**	**1**	**1**	0.01	0.01	0.01	0.06	0.06	0.07	0.04	0.04	0.03

Table 10. Matrix fuzzy weights W_{32}

	fuzzy weights W_{32}		
	L	M	U
F1	0.24	0.27	0.31
F2	0.86	1.00	1.14
F3	0.30	0.34	0.39
F4	0.32	0.36	0.41
F5	0.42	0.49	0.56
F6	0.22	0.25	0.29
F7	0.25	0.29	0.33
F8	0.34	0.39	0.44
F9	0.61	0.61	0.57
F10	0.09	0.10	0.12
F11	0.07	0.08	0.10
F12	0.07	0.08	0.10
F13	0.06	0.06	0.07
F14	0.04	0.05	0.06
F15	0.05	0.05	0.06

Table 11. Matrix fuzzy weights W_{33}

	F1			F2			…..	F14			F15		
	L	M	U	L	M	U		L	M	U	L	M	U
F1	0	0	0	0	0	0		0	0	0	0	0	0
F2	0	0	0	0	0	0		0	0	0	0	0	0
F3	0	0	0	0	0	0		0.27	0.30	0.33	0	0	0
F4	0	0	0	0	0	0		0.33	0.36	0.40	0	0	0
F5	0	0	0	0	0	0		0	0	0	0	0	0
F6	0	0	0	0	0	0		0	0	0	0.22	0.24	0.26
F7	0	0	0	0	0	0		0	0	0	0.08	0.09	0.10
F8	0	0	0	0	0	0	…………	0	0	0	0.62	0.68	0.74
F9	0	0	0	0	0	0		0	0	0	0.14	0.15	0.16
F10	0	0	0	0	0	0		0.07	0.08	0.09	0	0	0
F11	0.19	0.21	0.23	0.32	0.35	0.38		0	0	0	0	0	0
F12	0	0	0	0	0	0		0	0	0	0	0	0
F13	0.10	0.10	0.11	0.13	0.13	0.15		0	0	0	0	0	0
F14	0.05	0.05	0.05	0	0	0		0	0	0	0	0	0
F15	0	0	0	0.38	0.40	0.43		0	0	0	0	0	0

Table12. Matrix fuzzy weights W_F for sub criteria

	fuzzy weights W_F		
	L	M	U
F1	0.30	0.34	0.39
F2	0.72	0.83	0.95
F3	0.57	0.68	0.82
F4	0.62	0.74	0.89
F5	0.30	0.34	0.39
F6	0.51	0.59	0.70
F7	0.39	0.45	0.53
F8	1.37	1.54	1.68
F9	0.41	0.46	0.53
F10	0.37	0.42	0.49
F11	0.33	0.37	0.43
F12	0.30	0.34	0.39
F13	0.31	0.36	0.41
F14	0.41	0.46	0.53
F15	0.52	0.59	0.67

Table 13. Matrix fuzzy weights W_i for sub criteria

	fuzzy weights W_i		
	L	M	U
F1	0.23	0.30	0.38
F2	0.56	0.72	0.92
F3	0.53	0.72	0.97
F4	0.57	0.77	1.06
F5	0.19	0.25	0.34
F6	0.31	0.43	0.60
F7	0.24	0.33	0.45
F8	0.84	1.11	1.43
F9	0.25	0.33	0.45
F10	0.22	0.30	0.42
F11	0.20	0.27	0.37
F12	0.19	0.25	0.34
F13	0.06	0.07	0.10
F14	0.07	0.09	0.13
F15	0.09	0.12	0.16

Table 14. Fuzzy decision matrix for improvement projects

	F1			F2			....	F14			F15		
	L	M	U	L	M	U		L	M	U	L	M	U
P1	1.23	1.39	1.52	1.35	1.61	1.82	....	3.78	4.78	5.75	3.91	4.99	6.04
P2	3.35	4.24	5.10	3.49	4.40	5.27		4.75	5.81	6.85	4.90	5.95	6.98
P3	5.35	6.40	7.36	5.38	6.41	7.33		3.61	4.42	5.21	3.83	4.90	5.94
P4	6.86	7.87	8.88	6.90	7.91	8.93		2.61	3.38	4.11	3.62	4.45	5.24
P5	4.23	5.28	6.32	3.73	4.77	5.80		2.36	3.08	3.76	3.10	4.01	4.88
P6	3.18	4.18	5.14	3.26	4.25	5.21		4.16	5.21	6.24	4.69	5.70	6.72
P7	1.94	2.56	3.13	1.94	2.56	3.13		4.06	5.00	5.89	2.21	2.83	3.40
P8	2.43	2.43	2.90	1.78	2.22	2.61		3.82	4.74	5.62	2.24	2.75	3.21
P9	1.70	2.19	2.62	1.59	2.00	2.36		6.65	7.67	8.69	3.49	4.32	5.12
P10	1.87	2.49	3.06	1.91	2.58	3.20		6.33	7.38	8.41	3.08	3.86	4.59
P11	1.78	2.40	2.97	1.82	2.49	3.11		6.49	7.96	8.97	4.30	5.21	6.08

Table 15. The weighted normalized fuzzy decision matrix

	F1			F2			....	F14			F15		
	L	M	U	L	M	U		L	M	U	L	M	U
P1	0.02	0.02	0.03	0.01	0.02	0.03		0.30	0.43	0.59	0.19	0.25	0.33
P2	0.05	0.06	0.09	0.04	0.05	0.08		0.38	0.52	0.70	0.23	0.30	0.38
P3	0.07	0.10	0.14	0.06	0.08	0.11		0.39	0.40	0.54	0.18	0.24	0.32
P4	0.09	0.12	0.16	0.07	0.09	0.13		0.21	030	0.42	0.17	0.22	0.29
P5	0.06	0.08	0.12	0.04	0.06	0.08		0.19	0.28	0.39	0.15	0.20	0.27
P6	0.04	0.06	0.09	0.03	0.05	0.08	....	0.33	0.47	0.64	0.22	0.28	0.37
P7	0.03	0.04	0.06	0.02	0.03	0.05		0.33	0.45	0.61	0.11	0.14	0.19
P8	0.03	0.04	0.05	0.02	0.03	0.04		0.31	0.43	0.58	0.11	0.14	0.18
P9	0.02	0.03	0.05	0.02	0.02	0.03		0.53	0.69	0.89	0.17	0.22	0.28
P10	0.03	0.04	0.06	0.02	0.03	0.05		0.51	0.66	0.86	0.15	0.19	0.25
P11	0.02	0.04	0.05	0.02	0.03	0.04		0.56	0.72	0.92	0.20	0.26	0.33

8. Discussions and Conclusions

In this study, the model for the optimal selection of the improvement projects of the organizational excellence was a combination of fuzzy multi-criteria decision-making methods: fuzzy ANP and fuzzy TOPSIS. A major concern of the organization is that the improvement projects of the organizational excellence model are compatible with the strategic vision and long-term goals of the organization. Therefore, the criteria and sub-criteria used in the selection of improvement projects in the fuzzy multi-criteria decision model are the perspectives and the indicators of the four perspectives of the balanced scorecard. In addition, the fuzzy logic was used in this study, because it is used by decision-makers to make the more accurate and more flexible assessment process to describe the uncertainty in decision making. In other words, it can be very useful for uncertainty conditions in case of using language preferences. The proposed model was conducted as a case study in the Calcimin Co. The company's improvement projects, which were 11 in the number, were extracted from the perspective of the excellence team in the company using a self-assessment process according to the criteria and sub-criteria of the

Table 16. Final results of the fuzzy TOPSIS method

Priority	projects code	improvement projects	Dj^+	Dj^-	CCj
1	P7	Create a comprehensive marketing information system in the field of commerce	0.58	0.26	0.38
2	P2	Creating management dashboards in line with the 5-year strategic Plan	0.74	0.41	0.36
3	P10	New phase of 5000 tons on factory Dandy	0.82	0.39	0.35
4	P8	Establishment system customer relationship management (CRM)	0.71	0.32	0.34
5	P6	Establishment ERP system	0.62	0.31	0.34
6	P5	Establishment knowledge management system and application software «Share Point»	0.78	0.39	0.33
7	P3	Designing comprehensive human resource System	0.41	0.25	0.32
8	P4	Establishment international standard of education ((ISO 10015))	0.59	0.30	0.31
9	P1	Power house establishment 25 MW in Complex Dandi	0.54	0.33	0.31
10	P11	INTEC Project	0.53	0.28	0.30
11	P9	Industrialize project production Nickel and Cadmium	0.55	0.24	0.30

excellence model. Then, to determine the criteria of fuzzy multi-criteria decision model, 15 indicators (sub-criteria) were introduced using the balanced scorecard. According to the research processes, the fuzzy ANP method was used to weight the sub-criteria of the model and to prioritize and select among 11 improvement projects of the company using fuzzy TOPSIS method. The final arranged improvement projects are the optimal improvement projects, among which the improvement project of "Creating Management Dashboards in line with the 5-year Strategic Plan" was selected as the optimal improvement project that had the highest priority for implementation.

This model has a systematic fit with the defined procedures and known inputs. The criteria and sub-criteria, which have been used as a basis to evaluate projects in this model, were extracted from the balanced scorecard that has high integration and high interaction with the decision maker. Since the weights of criteria and sub-criteria are calculated from the experts' opinions, the weights obtained are more realistic and are more acceptable to decision makers. In addition, since these weights are not fixed and may vary from one organization to another organization, the calculation method is of higher validity.

Although the proposed model in this study uses two fuzzy multi-criteria decision-making methods (i.e. fuzzy ANP and fuzzy TOPSIS), the fuzzy ANP method is suggested to be used instead of the fuzzy AHP method for weighting criteria and sub-criteria. The other methods can be fuzzy multi-criteria decision: fuzzy ELECTRE combined with fuzzy ANP and fuzzy TOPSIS methods used to ranking improvement projects better.

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