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# Finding a Probabilistic Approach to Develop a Fuzzy Expert System for the Assessment of Research Projects using ANP Approach

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**KEYWORDS**

Fuzzy expert system;
ANP;
Assessment of research project

**ABSTRACT**

*Nowadays, project selection is a vital decision in many organizations. Because competition among research projects in order to gain more budgets and to attain new scientific domain has increased. Due to multiple objectives and budgeting restrictions for academic research projects have led to the use of expert system for decision making by academic and research centers. The existing methods suffer from deficiencies such as solution time inefficiency, ineffective assessment process, and unclear definition of appropriate criteria. In this paper, a fuzzy expert system is developed and improved for decision making in allocating budgets to research projects, by using the analytic network process(ANP). This has led to fewer rules and regulation, faster and more accurate decision-making, fewer calculations, and less system complexity. The rules of the expert system exacted in C# environment, consider all of the conditions and factors affecting the system. We describe the results of proposed model to measure its advantages and compare to existing selection processes for 120 projects. We also discuss the potential of proposed expert system in supporting decision making. The implementation results show that this system is significantly valid in selecting high-priority projects with respect to the known criteria , decision making regarding the determination of the assessment factors, budget allocation, and providing the appropriate initiatives for the improvement of the low-priority projects.*



## 1. Introduction

The assessment and budget allocation of research projects, in other words, project selection is difficult to measure because of multiple interrelated criteria and quantitative and qualitative factors [1]. Lorie and Savage (1955) proposed a classical method for selecting projects that could be accepted or rejected on a number of available projects [2]. In the literature, there are several methods and tools for assessment and budget allocation of research projects. These methods include scoring models[3,4], Ranking model[5], mathematical models, checklist models, financial models, decision support system(DSS), decision theory models, consensus models, and portfolio models[6,7,8,9, 10,11,12,13]..

Even with a large number of proposed models, the assessment and budget allocation of research projects remains problematic so that few models have gained wide acceptance. Though computer-based models have certain desired features, the use is also not well accepted due to complex calculations and taking too

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much time [1, 14, 15]. Besides, none of these models have dealt with assessment and budget allocation simultaneously by considering both quantitative and qualitative criteria in the structure of a fuzzy expert system.

Fuzzy expert system as a subfield of artificial intelligence is an efficient tool for solving the problems often solved by certain number of experts. These systems utilize a set of rules and heuristic approaches to solve the problems. Thus, rule-based expert systems attempt to imitate expert people's behavior [4]. Developing country, in line with rapid growth and transformations of the global research activities, are looking for industrial development. Because of limited capital and resources, industrial development for these countries requires a proper selection of research projects. Using valid and suitable approaches based on scientific foundations, determined and appropriate criteria for budget allocation, resource allocation, and planning prevents non-profitable or unfeasible projects. [16].

In developing countries, regarding the general features and characteristics of these countries, issues, and obstacles that every country faces in practically evaluating its economic, scientific, technical, managerial, and social conditions, this context has not gained the attention, which it merits. However, regarding the limited financial resources, the best budget allocation in these countries is great and vital importance. The Empirical assessment of research projects in developing countries due to invalidity and lack of information and statistics are often incomplete or inefficient. Generally, there has been no long-standing analysis in accordance to technical assessment principles.

The number of previous studies which consider multiple interrelated criteria such as creation of science and technical knowledge, economic, financial and technical feasibility conformity with the development of science and technology, mission-oriented, available resource's and researcher and co-researcher's qualifications for assessment, selection, and budget allocation of research projects is relatively low[9,10,11,14,15]. In addition, there is no expert model to consider the interrelationships of these criteria in a fuzzy medium while using the fewest rules and regulations to assess. Therefore, in this paper, both quantitative and qualitative assessments of research projects is done simultaneously, i.e. financial, economic, technical, scientific factor, risk appetite, feasibility, technical, scientific and managerial competencies is evaluated at the same time. In addition, a fuzzy expert model, which is developed and improved by fuzzy ANP, provide for the assessment and decision-making in budget and loan allocation. The remainder of this paper is organized as follows: Section 2 provides some necessary literature review.

Section 3 describes the Research Methodology. Section 4 presents the proposed assessment and decision-making model that includes the use of ANP and designing a fuzzy expert system. The system development and implementation is explained in section5. The validity of the model is verified in section 6 using the real results. The last section is devoted to the Summary and Conclusion.

## 2. Review of Literature

Nowadays, universities and specially research centers are increasingly investing in assessment models and development of fuzzy expert systems. Calculation technique is one of the ways for universities to reduce the risks and probability of project failure, but external factors such as economic, scientific, or social factors and variables force them to review their decision-making methods.

Therefore, expert systems, artificial intelligence, and other knowledge tools with automatic decision-making lead to the improvement of project assessment processes and, consequently, reduce the risk level and provide better information, solutions and, decision-making options for managers. Some tools which have appeared in the literature include: AHP[17, 18, 19], Goal Programming (GP) [20], AHP & GP [21], fuzzy AHP[22], ANP and fuzzyANP[9,23,24,25], Quadratic linear0-1[26,27], quadratic 0-1[28], Nonlinear0-1[29,30], ANP &ZOGP[31]. So far, various mathematical models have been employed by researchers concerned with selection of projects. These models are sometimes single-objective like the mixed integer-programming model and sometimes multiple-objective [1,6,7,1129,32,33,34,35].

For example, there are a number of studies that present multi-criteria mathematical modeling in project selection problems by using 0–1 goal programming [30, 36,37,38]. In these cases, one may refer to such frequently used models as, revenue per one dollar method, payback period method, net present value method, net future value method, net annuity value method, and internal return rate method are very popular ones[33,39]. However, expert systems each embracing various criteria have much less often been in use. Bryant has proposed an assessment model and an expert system for budget allocation in the agriculture sector and then has validated and verified its performance [40]. Also Levy et al. has used five factors of Credit, Capacity, Capital, Collateral, and Character (5C) for the assessment of the applicant's specifications [41].

The expert system proposed by Bryant has been designed for combining the quantitative factors and qualitative factors such as skills, experience, and intelligence of budgeting experts. To develop this system, the shell expert system and Levy' criteria have been used. The major components of this knowledge base include banking financial resources, strategies, and banking policies such as market and economic conditions, experience, loan records, and risk management with economic and political considerations [40,41]. Kivijari et al., through a real life project in 1999, showed how an expert system could contribute to the improvement of an entire budget allocation management process. Budget allocation process was divided in to the following steps: identifying the budget allocation ideas, determining the homogenous budget allocation alternatives, choosing a budget allocation alternative and, finally, budget allocation implementation and control.

The proposed expert system is intended to use human judgment through appropriate computerized techniques at every step of the budget allocation process and at the same time, to process the objective and subjective data. This process includes the determination of performance indicators, identifying investment opportunities, and extracting high priority investment ideas [42].

The important point in designing of an expert system is the avoidance of complexity due to an increase the number of roles and the maintenance of system efficiency.

Using a tool like fuzzy ANP for the development and improvement of expert systems can lead to the reduction of roles and, hence, complexity and implementing time.

Because ANP is an extensive multi-purpose decision method, it has been used in solving many complex decision-making problems [25]. Several researchers made an effort to overcome the problem of project selection by using ANP approach. They showed that ANP could model not only dependency but also interdependency functions more appropriately and conveniently in comparison with other methods [9, 15, 21, 42, 43, 44, 45, 46].

Despite the mentioned advantages of this technique, it has some shortcomings in eliminating vagueness. Using fuzzy logic can be proper where there is no certainty and it helps to get a more realistic result. Some researchers have applied the fuzzy ANP based approach to solve complex decision-making problems [9,25,47,48].

In this paper, we integrate previous research findings and use a theoretical approach, which is based on fuzzy ANP, to develop and improve a fuzzy expert system for project selections.

## 3. The Research Methodology

In the management literature, each traditional task of a manager such as planning, organizing, control, resource allocation and monitoring is considered as a perspective of decision-making. Decision-making process is a function of critical factors such as objective, decision maker, time of decision-making and complexity of the decision variables [28]. For designing and implementing of the assessment and, decision-making model based on the criteria, factors and options, first the major criteria (primary and secondary) of the budget allocation assessment process are identified with the help of the experts and by means of questionnaires. Then, an ANP model is proposed for the analysis of the criteria and contributing the ultimate budget allocation decision-making. In the next step, the factors and parameters affecting the final decision-making are determined and introduced to the system. Then, an expert system is implemented using C#(C sharp) programming language, ANP model results, and the identified factors.

The next step is devoted to the validation of the fuzzy expert system where the validity of a number of research projects is investigated using the assessment model and the fuzzy expert system and the results are compared to the real results. Figure1 illustrates three major steps of proposed assessment model and fuzzy expert system.

Three steps have been defined as follows:

***Step 1***: Identification, classification and, assessment of the critical factors and criteria of research projects and calculation of priority:

- Interviewing 50 candidates including professors, managers and experts.
- Classification of the effective factors to three levels of "University (U)", "Faculty (Fa)" and "Group (G)" and preparing, project assessment questionnaires by using the experts opinon(50 candidates).
- Distributing the questionnaires among professors, managers, and expert in order to determine the weight and priority of factors and applying the required modifications such as adding new and similar factors and inter-category criteria movement to the form.
- Calculation of the weight average and standard deviation of the results and applying the required modifications to the questionnaire then calculation of coefficient of reliability by Cronbach's $\alpha$ (85%).
- Re-distributing the questionnaires among professors, managers, and experts in order to determine the weight and priority of the factors along with the earlier determined average and deviation of the previous results.
- Calculation of the weight average and standard deviation of new responses
- The final questionnaire is again offered to the professors, managers, and experts for the final weighting and prioritizing of the criteria along with the previous average and standard deviation.
- Calculation of the weight and priority of each criterion using the weight average (LOCAL)

***Step 2***: To design the assessment model, all of the criteria and effective factors have been divided into three levels of university, faculty and group in previous step. This hierarchy has been illustrated in figure2. The whole process of designing the assessment model and calculating the weight of every factor, criterion and option is as follows:

- Constructing ANP structure with respect to the identification and classification of the criteria and effective factors that exert influence on the assessment of research projects.
- Constructing the pair wise comparison matrices using the results obtained from the completed questionnaires by the professors, managers, and experts (LOCAL).
- Calculating each criterion's weight (priority) using the existing rules of ANP (GLOBAL).

***Step 3***: during the designing stage of the fuzzy expert system based on the decision-making rules, the following decisions have been taken for every research project for the budget allocation purpose:

- Responses to three principal questions regarding research projects by the group manager or head of the department
- Calculating each project's score using the obtained results from professors, managers and expert through the ANP assessment model
- Converting the scores to linguistic term of very poor, poor, fair, good, and excellent.
- Determining the required level of resources for research projects based on the type of the project.
- Making the decision whether to accept the project or to reject it according to the defined rules in the fuzzy expert system.
- Presenting reasons rejection or acceptance.

Providing improvement initiatives for research projects

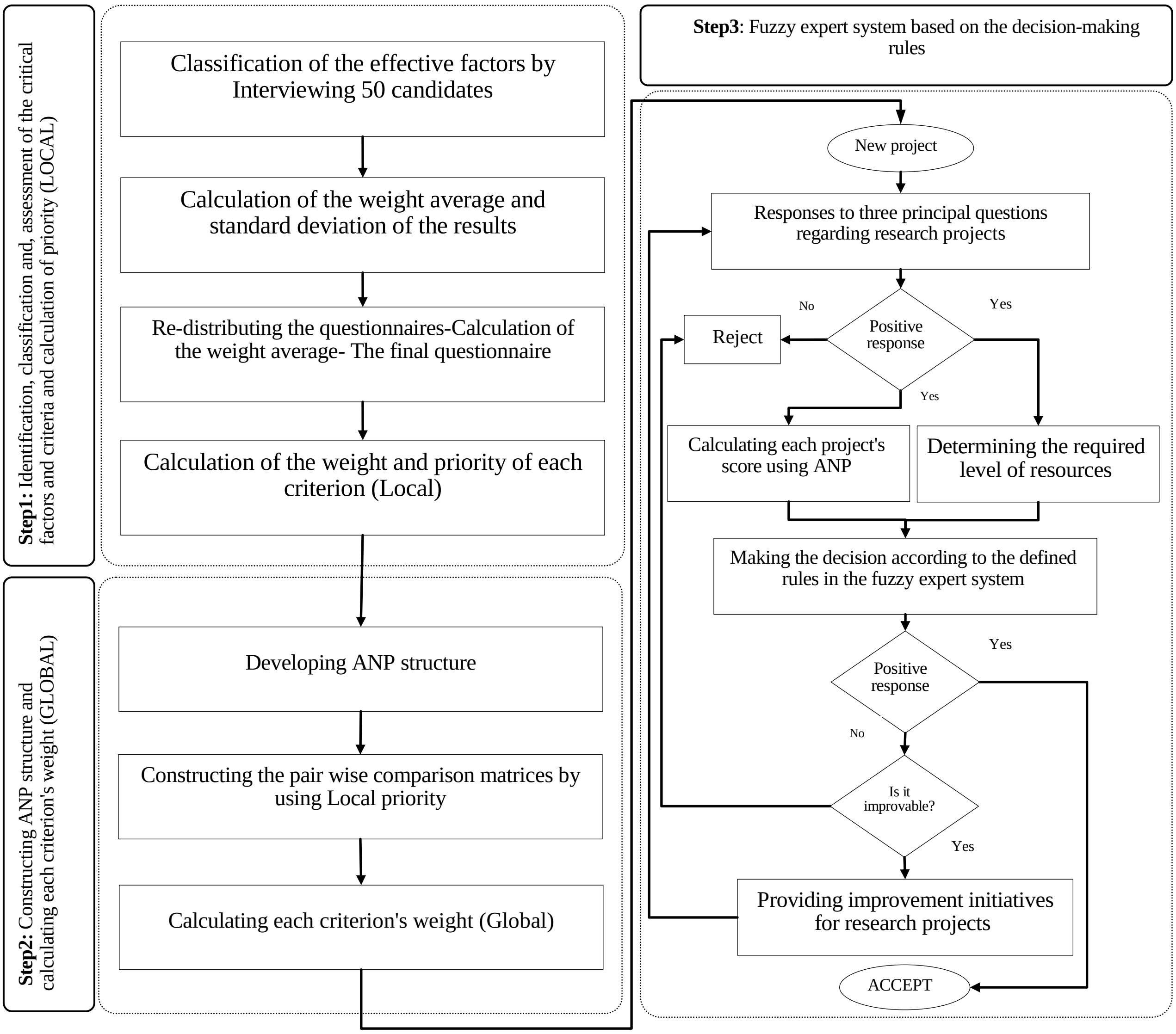


**Fig. 1. Overview of the assessment and decision-making model using ANP and fuzzy expert system**

## 4. Designing the Assessment and Decision-Making Model

### 4-1. Calculating of Each Criterion's Weights and Scores

In order to gain knowledge on the research projects assessment model, in the first step several interviews are conducted in which the candidates include professors, executive managers, and experts familiar with this context from several universities and research centers in Iran. By comparing the obtained information and the conducted studies in these universities and research centers to those of other countries, it was determined, that there is no comprehensive and complete model for the budget assessment and allocation for research projects. In the opinion of these professors, managers, and experts, lack of documented procedures is the major factor in the selection and adoption of disqualified projects.

In the second step of the research, the candidates were given two separately designed questionnaires for data collection. In the first questionnaire, all the criteria were divided into three layers based on the results of the interviews.

By this questionnaire, candidates were asked to determine its significance based on Likert scale. In addition, the experts were asked to add the factors, which were not mentioned in the questionnaire. In the second questionnaire, the newly added factors by the experts were distributed among the professors and managers to obtain a consensus on the factors. Finally, after determining the affecting factors and their importance, the secondary criteria and parameters for detection and assessment of each criterion were identified.

Based on the documents and the conducted interviews with the professors, managers, and experts, the factors affecting the research projects assessment process were classified as follows:

1- University (U) level assessment criteria including those of the available resources, collegial assessment results, and conformity with university strategies.
2- Faculty (Fa) level assessment criteria including those of technical feasibility, group assessment criteria and economic and financial feasibility criteria.
3- Group (G) level assessment criteria including empirical criteria, applied criteria and researcher's and co researcher's specifications.

In order to collect the opinions of the professors, managers, and experts on the influence of each primary and secondary criterion in the research project assessments, a questionnaire was designed. This questionnaire contains a comparison table for the primary criteria at university, faculty, and group levels and five other tables for the comparison of the secondary criteria including technical feasibility, economic and financial feasibility, theoretical criteria, empirical criteria and researcher's and co researcher's specifications. In these tables, the impact of each criterion on the success of a research project is determined as very poor, poor, fair, good and excellent. Of 150 questionnaires distributed among the universities and research centers, 121 questionnaires were completed. The result was calculated as the weighted average significance given to each criterion in the collected responses. The criteria and their subcategories are presented in figure2.

### 4-2. Using the Fuzzy ANP for the Assessment

Our world is a plenty of multi-criteria problems, which often make us face decision-making problems. For example, in macro decision-making contexts such as allocating the state budget, experts follow different objectives and intend to obtain optimum results. In some cases, the result of the decision-making process is so important that any error may lead to irretrievable consequences. Therefore, it is necessary to use appropriate technique or techniques for optimum choosing and selection of the projects. One of the most complete of these is ANP technique first developed by Saaty in 1980 [28]. This process is one the most comprehensive systems ever developed for multi-criteria decision-making because this technique enables us to formulate the problem as a network and to consider different quantitative and qualitative criteria.

This technique provides various options for decision-making and sensitivity analysis on the criteria and sub-criteria. Additionally, it is based on a pair wise comparison, which facilitates judgment on the level of consistency or inconsistency of the decision and possesses a solid a theoretical basis (for more details see 28).

ANP represents a graphical demonstration of a complicated real life problem where the ultimate goal is the problem and in the lower levels objectives are the criteria, sub-criteria, and other options. According to the determined factors in the previous sections, ANP is illustrated as figure2. Assessment and selection of research projects is the ultimate objective. At the first level, project's main objective, at the second level, departmental assessment criteria, and at the third level, group's assessment criteria are determined.

ANP is as follows:

**Step 1**: Different criteria are identified and defined based on the objectives and decision-makers, opinions

**Step 2**: Decision-makers have to determine various values for the pair wise comparison matrix ($W = a_j$) which is a ($n \times n$) matrix. Elements of this matrix represent the weight ratios of *i* and *j* elements ($W_i / W_j$).

We use the pair wise comparison criteria to better understanding a pair of criteria at the same time as specifying weights to individual criteria in their collection. In this paper, $a_{ij}$ is represented as a linguistic term.

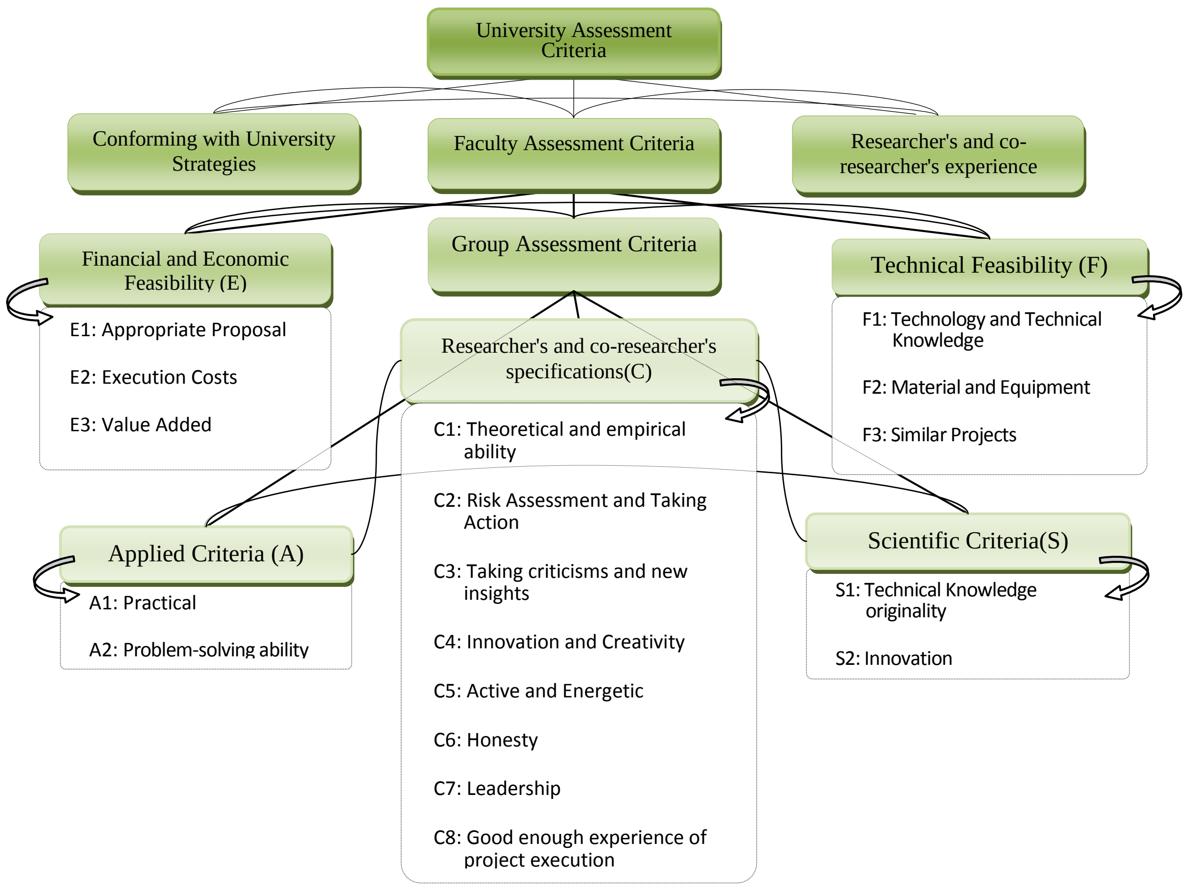


**Fig. 2. Analytic network process**

$a_{ij} = (1,1,1)$ When criteria *i* and *j* have the same priority.

$a_{ij} = (1,2,3)$ When criteria *i* is relatively more important than *j*.

$a_{ij} = (3,4,5)$ When criteria *i* is more important than *j*.

$a_{ij} = (5,6,7)$ When criteria *i* is much more important than *j*.

$a_{ij} = (7,8,9)$ When criteria *i* is greatly more important than *j*.

**Step 3**: Comparison of the covariance among the primary criteria using the pair wise comparison matrix

**Step 4:** Comparison of the covariance among the secondary criteria using the pair wise comparison matrix

**Step 5**: Calculating the primary criterion in order to determine the acceptance weights for every research project.

**4-3. Calculating the Relative Weights (Prioritizing)**

After constructing ANP, the relative weights of the criteria must be defined for all levels. In fact, the criteria must be compared pair wise. Judgments about the pair wise comparisons combine logical thinking with a sense of experience. Mathematical sequencing of ANP calculations is an effective way to obtain multiple objectives. In order to calculate these weights, a pair wise comparison matrix must be constructed for different network levels with the cooperation of a group of experts. Calculations made up to the second level as Local and Global weights are illustrated in figure 3 as a weighting tree. When the relative weights (Local) have been determined, a cross-division of the local weights has led to pair wise comparison matrix, and then the final weights (Global) for every primary and secondary criterion are calculated by using ANP principles.

**4-4. Calculating of Each Criterion's Weights and Scores**

In this step, professors are asked to assess the research project according to the results obtained from the proposal, market research, and the information from previous experiences. Each criterion is evaluated on a five-point scale. Then, faculty and university authorities are asked to evaluate and score the results. For example, group professors determine the executive ability of the researcher as excellent, good, fair, poor and very poor. Table1 illustrates the relative weights of fuzzy options. The set of fuzzy values provided in Table1 is represented in figure4. Since at least five experts assess each project, the calculation of final values is conducted by the arithmetic average of the experts' opinions.

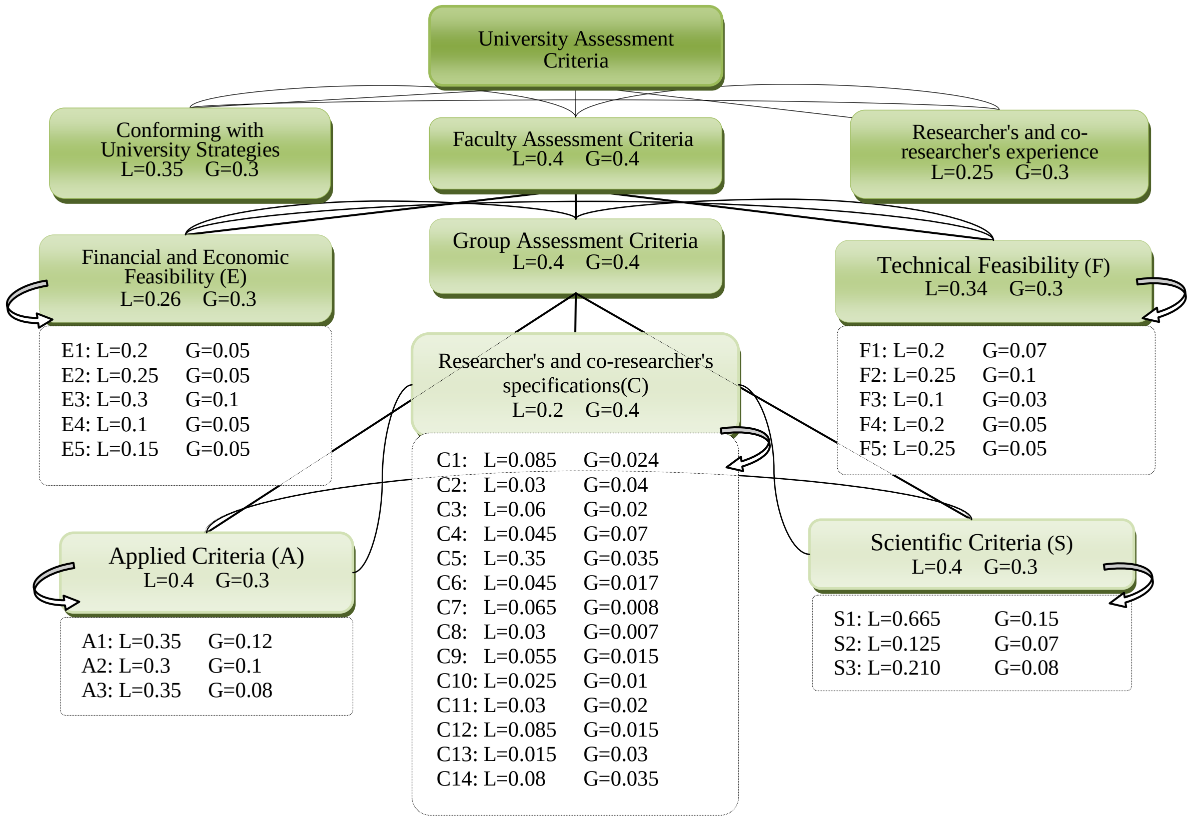


**Fig. 3. Relative and final weights of the primary and secondary criteria**

**Tab. 1. Fuzzy options weights**

| Linguistic terms | Weight | Abbreviation |
|---|---|---|
| Excellent | (0.75,1,1) | E |
| Good | (0.5,0.75,1) | G |
| Fair | (0.25,0.5,0.75) | F |
| Poor | (0,0.25,0.5) | P |
| Very Poor | (0,0,0.25) | VP |

In order to calculate the final weight, the chosen options for the final level criteria have to be evaluated by the assessor the assessor's score is calculated by the sum of the products of the cumulative weight of individual criteria multiplied by their weights. For example, in the case of scientific criteria, if the expert scores knowledge generation, innovation, and technical information generation criteria as excellent, fair and poor respectively, the total score of the project in the scientific criteria section is calculated as follow.

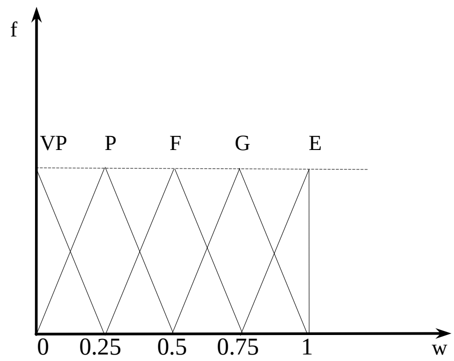


**Fig. 4. Set of fuzzy numbers**

$$P_{SOG} = (W_E.W_{S1}) + (W_F.W_{S2}) + (W_P.W_{S3}) \qquad (1)$$

$$P_{SOG} = (0.75,1,1)(0.15) + (0.25,0.5,0.75)(0.07) + (0,0.25,0.5)(0.08) = (0.13,0.21,0.24)$$

$$P_{STG} = (W_E)(W_{S1} + W_{S2} + W_{S3}) = (0.75,1,1)(0.15 + 0.07 + 0.08) = (0.23,0.3,0.3)$$

$$Accept(s) = \frac{P_{SOG}}{P_{STG}} = \frac{(0.13,0.21,0.24)}{(0.23,0.3,0.3)} = (0.57,0.7,0.8) \qquad (2)$$

Similarly, this calculation is generalized to all levels and the total score of the project is obtained and the project acceptance is calculated by dividing the given score by the total score (0.75, 1, 1) which is the project score when the project is assessed as Excellent.

### 4-5. Determining the Final Assessment Score

The assessment result of the ANP fuzzy model is the most determining factor in deciding how to allocate budgets.

Executives take decisions using the result. The final result, which is a fuzzy number, must be converted to a verbal expression. Therefore, the system expresses the experts' assessment result of each project as excellent, good, fair, poor, or very poor. The process of converting the scores in to expression s undergoes three stages as follows:

1- Determining the difference between project's fuzzy scores and the fuzzy values obtained from each linguistic term by Eq.3.

$$d(A,B)=\frac{1}{4}[(a_1-b_1)+(a_2-b_2)+(a_3-b_3)] \quad (3)$$

2- Matching the project's fuzzy score and the verbal expressions by Eq.4

$$u=Min\{(A_i,E),(A_i,G),(A_i,F),(A_i,P),(A_i,V)\} \quad (4)$$

Determining the decision-making rules.

$$\begin{array}{llll}
\text{Rule 1:} & \text{if } u=(A_i,E) & \text{then} & \text{Assessment}=\text{Exclent} \\
\text{Rule 2:} & \text{if } u=(A_i,G) & \text{then} & \text{Assessment}=\text{Good} \\
\text{Rule 3:} & \text{if } u=(A_i,F) & \text{then} & \text{Assessment}=\text{Fair} \\
\text{Rule 4:} & \text{if } u=(A_i,P) & \text{then} & \text{Assessment}=\text{Poor} \\
\text{Rule 5:} & \text{if } u=(A_i,V) & \text{then} & \text{Assessment}=\text{Very Poor}
\end{array}$$

### 4-6. Knowledge base and Inference motor

In this section, the final decision on the budget allocation for research projects is made after the assessment of the expert system. This decision is made based on the following factors:

1- The results obtained from ANP
2- Available resources (The availability of the resources is defined for the system as Table2 and a monetary unit.)

Existing rules of the expert system:

**Tab. 2. Availability of the resources**

| Very Poor(VP) | Poor(P) | Fair(F) | Good(G) | Excellent(E) |
|---|---|---|---|---|
| (5,10,15) | (10,15,20) | (15,20,25) | (20,25,30) | (25,30,35) |

The knowledge base of an expert system is a set of decision-making rules and, therefore, one of the major problems of rule-based expert systems is the numerousness rules required for decision-making. In this study, the number of the rules has dramatically reduced due to the application of ANP. It has occurred in a manner that while more than 5000 rules where required for the expert system prior to the application of ANP with respect to the total number of the identified criteria; it was reduced to 50 rules by applying ANP. Regardless of other factors, some of the principal rules affecting the final decision are as follows:

$$\begin{array}{llll}
\text{Rule 11:} & \text{if Strategy}=(\text{VP or P}) & \text{then} & \text{Reject} \\
\text{Rule 12:} & \text{if Resource}=(\text{VP or P}) & \text{then} & \text{Reject G, F, P, VP} \\
\text{Rule 13:} & \text{if Resource}=(\text{F}) & \text{then} & \text{Reject F, P, VP} \\
\text{Rule 14:} & \text{if Assessment(U, Fa, G)}=(\text{VP or P}) & \text{then} & \text{Reject} \\
\text{Rule 15:} & \text{if Experience}=(\text{VP or P}) & \text{then} & \text{Reject} \\
\text{Rule 16:} & \text{if AssessmentE}=(\text{VP or P}) & \text{then} & \text{Reject} \\
\text{Rule 17:} & \text{if AssessmentF}=(\text{VP or P}) & \text{then} & \text{Reject} \\
\text{Rule 18:} & \text{if AssessmentC}=(\text{VP or P}) & \text{then} & \text{Reject} \\
\text{Rule 19:} & \text{if AssessmentS}=(\text{VP or P}) & \text{then} & \text{Reject} \\
\text{Rule 20:} & \text{if AssessmentA}=(\text{VP or P}) & \text{then} & \text{Reject}
\end{array}$$

In this system, first, the research projects that are disqualified for execution are rejected based on the expert system rules and, then, decision-making is done for the rest of the projects as follows:

1- If the proposed project is Excellent, then it is accepted.
2- If the proposed project is good, then it is accepted based on terms.

The terms of the budget allocation for these projects is to increase the certainty of the project situation or reduce the university/research center risk. Some measures may be taken in line with it as to increase the accuracy of the progress reports and to decrease the university share of investments.

3- If the proposed project is fair, then it is prioritized as the second level for the budget allocation.

The terms of the budget allocation to these projects is to support the promotion of the conditions set by the university to the first level. The expert system proposes prioritized solutions and initiatives by comparing these projects with ideal project conditions.

## 5. System Development and Implementation

This system is implemented in C# programming environment through three steps illustrated as figure5.

In the first Step, The head of the group or the center is asked three questions:

- Does the project comply with university conditions and restrictions?
- Do the researcher and co-researchers have qualifications and permission for the implementation?
- Does the proposal of the project provide the initial and legal terms for the budget allocation?

If the answers to all three questions are positive, the system grants access to the second step. Otherwise, a rejection notice is issued.

In the second step, the professors/managers/experts are asked 37 questions. After choosing the appropriate option for each criterion, the system calculates the final fuzzy score and the project acceptance percentage based on the chosen options and fuzzy ANP rules. Then it goes to the decision-making step.

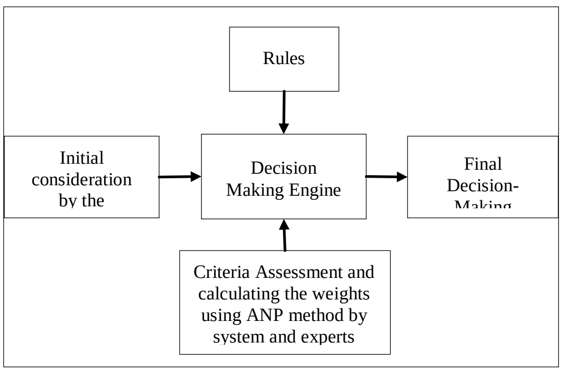


**Fig. 5. system implementation steps**

In the third step, the final decision is made by the inference motor based on the existing rules of the knowledge base. The output of the system includes the final decision-making result, advantages and disadvantages of the research project, and the university terms for the improvement of the second type projects.

## 6. System Validation

Validation of the expert system is an important part of the system development effort in order to ensure the correct performance and consistent results. The validation method mentioned here is to use real data and generated data. The system has been put to test by comparing the real world results and the previous opinions of the assessors with the obtained results from the system for 120 projects. The generated input data for each project were obtained from the assessors of those projects. A comparison the results obtained from the expert system and the real assessments show a success level of 95%. In case of 120 evaluated projects, the assessment results for 114 projects were consistent with real life results. The detail of system validation is described as follow.

| **The method for validity** | **Number of projects** | **Number of accepted project by annual assessment** | **Number of rejected project by annual assessment** | **Number of accepted project by proposed expert system** | **Number of rejected project by annual assessment** |
|---|---|---|---|---|---|
| **Using historical data** | 120 | 52 | 68 | 48 | 72 |
| **Error %** | The result of 4 project which assess by Proposed expert system is not matched by real result therefore the error % is 114/120=5% | | | | |

## 6. Summary and Conclusion

In this study, an assessment model and an expert system were developed through the identification of principal criteria and factors that affect the success of a project. The affecting criteria comprise 37 items classified in three levels. These criteria include information such as researcher's and co researcher's specifications, technical feasibility criteria, financial and economic criteria applied criteria, and scientific criteria.

In order to determine the priority and influence of each criterion on decision-making and assessment, ANP method has been used with respect to the five criteria. The results show that from assessors' points of view the affecting factors in the assessment have the priority sequence of scientific, applied, financial, managerial and technical. The second part of the proposed model is devoted to the final decision-making on the budget allocation. Although the process of assessment and identifying the criteria is very important and influencing in the loan process, other parameters also exert influence on the final decision including research's experience, available resource, and conformity with university strategies. The final decision regarding the budget allocation is made considering the status of the criteria and the assessment results. Various conditions resulting from these factors are dealt with and implemented under this rule-based fuzzy expert system. The validation of the model shows that if valid data are fed into the system, it will yield acceptable results. Usage this method includes such advantages as reduction in the number of rules, increase in calculation speed and accuracy, reduction in decision-making time, intra-category project prioritization, reduction in system complexity, and considering multiple objectives.

### 6-1. Limitations and Suggestions for Future Research

In the course of this study, an important limitation was identified in the proposed model. Although the ANP model is useful and capable of dealing with finding priority of factors, the gathering decision maker's opinions by questioners. Therefore the other tools like artificial neural network can be utilized to decreases time setup.

## 7. Acknowledgement

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