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Utilization of TOPSIS to Optimal Project Management for Maragheh City's Construction Projects

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ABSTRACT

In this study, by considering 10 large-scale construction projects in the Maragheh city, the effective factors in the design and implementation of these projects have been identified and the relationship between them and the optimal management is provided. For this purpose, multi-criteria decision making approach (MCDM) and TOPSIS model have been used. To evaluate the multivariates, the TOPSIS model was used, which can reduce the computational error to a minimum. Based on the results, 8 main effective criteria in construction projects in Maragheh have been identified, which have been considered interactively with 7 project management methods and have been evaluated by TOPSIS. Based on the results of evaluation by TOPSIS in terms of the indicators, the highest rank is related to the Imam-Hossein apartment Complex project. Al-Ghadir alley project is in the second place in this evaluation, which includes project management parameters. By prioritizing the implementation, it can be found that the development attitude in the city; It is the most important priority for the municipality and the employer. The methods of construction, operation, transfer, design and combined design and construction have placed into the first rank. This prioritization by these three methods does not mean that project management approaches are no longer present in these implementations, but rather that the impact factor of these methods is higher than other methods.

1. Introduction

The growth of urban population in Iran has been rapid in recent decades; this increasing trend was such that from 1335 to 1385 urban population increased from 6 million to 48 million and the number of cities in the country from 199 to 1026 cities. The trend of increasing urban population in the Iran will continue, so it is predicted that by 2020, about 80% of the population will live in cities (Asilian-Mahabadi et al., 2020). Such an increasing trend has led to the formation of highly unstable cities with problems such as increasing energy consumption, inadequate wastewater disposal, air pollution, noise and water, lack of open and public spaces, in some urban contexts, lack of urban infrastructure, Transportation and traffic problems, inadequacies in urban infrastructure, obvious differences between old and new urban structures, and the existence of welfare inequality among city dwellers and many other problems (Abedini et al., 2014). In this way, the deformation of the urban context is observed along with technological, economic, social and cultural changes

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(Eshgichaharbagh et al., 2015). All natural and man-made factors in the environment of the city are subject to continuous and smooth changes during the history and time of their lives. Among the necessities of human life and real urban life is change, the rate and speed of which varies (Abdel-Basset et al., 2020). In Iran, where construction projects, especially urban planning and mass construction projects are being implemented in large volumes, unfortunately due to the incompatibility of project management approaches with the implementation methods in different stages of construction and operation of projects sometimes take so long to put into operation (Madani et al., 2010). In addition to wasting national resources and social damage, they may ultimately make the project economically unjustifiable (Abedini et al., 2014). To the extent that the direct and indirect damage caused by the delay is sometimes many times the actual value of the project. So, it can be said that creating executive problems for construction projects is worth using the appropriate project management (Eshgichaharbagh et al., 2015).

One of the most important issues and problems in the construction projects management is not using new and coherent decision-making methods for strategic project management (Nikoobakht et al., 2016). Unfortunately, in most cases today, due to the special circumstances created, project management operations without expressing the factors involved in the priority and importance of project implementation are expressed only for time control with project cost management and to perform the task (Madani et al., 2010). This problem is referred to as "project management system inability" and has effects such as the formation of a vicious cycle that can lead to increased costs (Fewings and Henjewele, 2019).

Analytic Hierarchy Process (AHP) is a powerful approach that can respond to such situations and encompass all aspects of managerial and executive evaluations. The hierarchical analysis is one of the optimal decision making methods. This decision-making approach, by specifying the criteria and selecting the most important and sensitive criteria, attempts to determine a set of sub-criteria related to the orientation of the main criterion and the mechanization of that criterion for the project under review (Hashemizadeh and Ju, 2019). Approximately, AHP is represented as a matrix of pairwise comparisons, is the basis of all calculations related to the hierarchical analysis process. Any errors and inconsistencies in comparing and determining the importance between options and indicators will distort the final result of the calculations. The incompatibility rate is given below by how the compatibility matrix is calculated. This matrix indicates the interactivity of the actual criteria and conditions of the project, no matter how low the decision matrix is with the compatibility rate; the decision has been made with higher accuracy. The compatibility rate for decision matrices is less than 10% (Stojčić et al., 2019). In this study, using the advantages of multi-criteria decision making system (MCDM) and AHP process analysis in strategic management to evaluation, prioritization, and classification of effective criteria in the construction projects management implemented for the Maragheh city. In this regard, by considering the 10 main construction projects and adjacent urban conditions of projects in the Maragheh city, effective and influential environmental factors and parameters on the projects are identified These criteria are prioritized over urban projects using the TOPSIS model.

2. Project and Construction Managements

Project management is a process in order to maintain the project path, to achieve a balanced economic balance between the three factors of cost, time and quality, at the time of project implementation, which uses its own tools and techniques to accomplish this important task (Demirkesen and Ozorhon, 2017). In principle, the control is the exact and complete execution of the program developed for the project, so that when leaving the program, by identifying the causes and planning of the most economical activities, the project can be returned to the closest possible state to its original path (Owusu et al., 2019). Project control in this way uses three factors to determine the actual status of the project, compare the actual status with the program and consider corrective action. Lack of use of codified and coherent methods for project management is one of the most important issues and current problems of project management in the country (Ahmed, 2018). Unfortunately, in most cases in Iran, project management operations due to special circumstances are only presented in the form of time and cost control of projects and in the form of task assignment (Madani et al., 2010). This inefficiency is described by managers who do not believe in changing and using up-to-date knowledge and not recommending it for national collections and projects as "project management system inability" (Arditi et al., 2002). The result of this is the emergence of a vicious cycle through which we will see a lack of coherence in the processes and activities of project management and management of current projects in the Iran (Eshgichaharbagh et al., 2015).

Today, projects are more integrated and innovative than what has been seen in the past; requires the use of creative methods and techniques in the design, manufacture, testing and deployment of products and services (Ahmed, 2018). A manager can no longer prepare a proper schedule for a project just by completing one or two pre-prepared form templates. One of the ways to achieve more efficient results is to adopt newer and more effective methodologies for the

project and it can be said that today the application of bureaucratic approach to life cycle is limited to very simple projects that require very strict organization and control (Michael et al., 2018). According to the above, the importance of project management methods can be understood, so the study and identification of appropriate methods that lead to increased project success is of great importance (Denney et al., 2020).

To achieve the goal or purpose of a project, it is necessary to form the necessary organizational activities that include sufficient and appropriate resources and facilities for the implementation of the project (Ahmed, 2018). Management and control affairs are the correct and appropriate use of resources and facilities to carry out activities to achieve project goals (Atout, 2020). This final goal includes the outputs of the organization and the factors that the organization has been formed to achieve them and has carried out the necessary activities by using the inputs (Hashemizadeh and Ju, 2019). In order to have the necessary facilities to control the progress of work, and to compare the practical efficiency of the organization with what is planned, or explained in the framework of policies and guidelines, it is necessary to have appropriate information about the progress of work to management. This information can indicate factors such as manpower, practical dates of implementation of various stages of work and costs spent quality of work performed and other knowledge that can help management in deciding to implement the next stages of the project (Asilian-Mahabadi et al., 2020).

Project construction management is an organized system and resource management so that the project is completed with a clear vision, definite quality, definite time and definite cost price. The management of these systems is completely different and requires different technical methods, and this has been the reason for the development of project management science (Ahmed, 2018). The first issue in project management is to ensure that the project is defined with specific constraints. The second issue, which could be a more interesting discussion, is the optimization of resource allocation and the unification of data needed to achieve the predetermined goals of the project. A project is a series of well-defined activities that use resources (financial, human, materials, energy, opportunity, logistics and communications, etc.) to achieve predetermined goals (Chatterjee et al., 2018).

3. Study Location

Maragheh is one of the oldest cities in Iran. Maragheh is located next to the SafiChay River and is surrounded by the Gheshlagh and Ashan Mountains to the north and the Varjou Gardens to the south, the Sahand Mountains to the east and the fields to the west. There is not much accurate information about the situation of the city of Maragheh in the pre-Islamic period. Antonius is attacked and besieged for months. It is likely that the city of Maragheh today corresponds to the same Pharaohs (Faracia) of the first century B.C. and this city was the winter capital of Atropaten. During the Mongol conquest, Holako Khan made Maragheh the capital of his government, and some of the city's buildings were built in the style of Mongol architecture to this day. The streets of the city were limited to two streets, Khajeh Nasir and Ouhadi. The two streets perpendicular to each other divide the city into four parts that form four famous alleys. The former Pahlavi Street and Blouri Street, which were formed of three parallel streets located in the west of the city, are also considered as the primary thoroughfares of the city (Sehsoo Consulting Engineering, 2012).

Maragheh city with an area of 2185.65 km^2 occupies 48% of the total area of East-Azerbaijan province. West Azerbaijan and Malekan city and to the southeast with Charavimaq city, to the west with Bonab city and to the northwest with Osko and Ajabshir cities. Maragheh is located at an altitude of 1480 m above sea level.

Maragheh city is composed of two separate parts: 1) the northern part, which is the southern slopes of the Sahand heights, is mountainous and uneven. 2) the central and southern part of the city is plain and plain. Based on the latest divisions of the country, this city includes two parts with the names of Maragheh and Kharajoo and 158 villages (Asilian-Mahabadi et al., 2020). The existing altitudes have affected the climate change of the city and have moderated the climate of the city (prone to cold and semi-humid). The city of Maragheh in the northwestern half of the country is affected by the general characteristics of the climate of Azerbaijan. Fig. 1 is provided the location of the studied area.

4. Material and Methods

Decision making in the implementation and selection of implementation methods is a principle in the management of construction projects. This issue is also in the knowledge group in the field of main criteria and indicators involved in construction projects (Chatterjee et al., 2018). Therefore, while identifying and classifying project management criteria, project implementation methods based on comprehensive project management should be defined and then project specifications should be assessed with appropriate approaches and related project management methods. The multi-criteria decision making approach (MCDM) and TOPSIS model are more reliable procedures to provide accurate decisions regarding various criterion involved into the project managements.

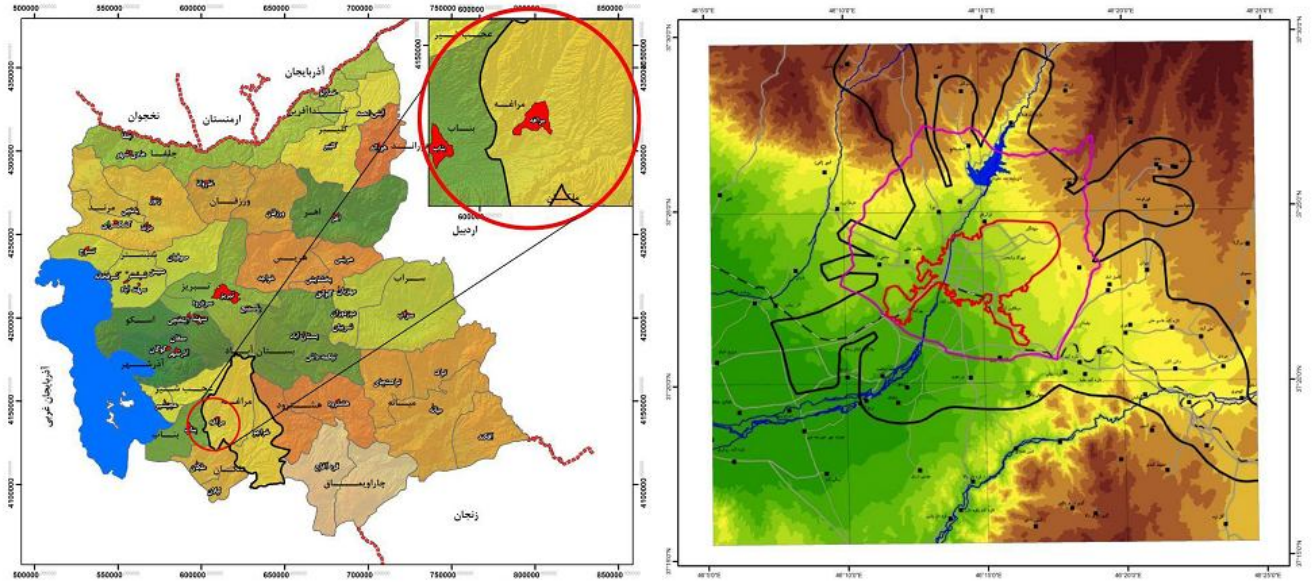

Figure 1. Location of the Maragheh city in East-Azerbaijan province

MCDM models due to the very high analytical ability in continuous optimal decisions are considered in this study. These models is divided into two groups concluded multi-attribute decision-making (MADM) and multi-objective decision making (MODM) models. MODM models are considered to optimize multiple goals simultaneously, and the scale for each goal may be different from the scale for the other goals. However, when the decision maker selects one of the several options that are evaluated with n indicators or ranks them, they are faced with MCDM models (Dayana et al., 2016). According to the subject under study, the decision-making problem in this study is a MADM. Normally, the option with the highest score is the best option to be selected. However, when discussing weighted scoring, the effectiveness of each sub-criteria and criteria are also classified based on the degree of importance (Xu et al., 2013).

MCDM models is that provides an effective framework for evaluation using several criteria by being able to rank and select a number of options or alternatives from the solutions and options of this approach for comparison. Among these methods, the ideal solution-based prioritization technique by TOPSIS prepares a very suitable solution for modeling problems with quantitative as well as qualitative criteria which will have progress, decision-making, evaluation, etc. (Saaty et al., 2000). This method was first introduced by Hwang and Yoon (1981) and was used to rank and compare different options and select the best option and determine the distances between the options and their grouping. Over time, this technique has been modified and perfected. TOPSIS is a MCDM-based that is considering the distance of an option (A1) from the ideal point, its distance from the negative ideal point is also considered. This means that the selected option should have the shortest distance from the ideal solution and also the farthest distance from the negative ideal solution (Chatterjee et al., 2018). The underlying reality of this technique is as follows (Fig. 1):

- The desirability of each indicator should be uniformly increasing or decreasing,
- The distance of an option from the positive ideal or the negative ideal may be calculated as the Euclidean distance (from the quadratic power) or as the sum of the absolute value of the linear distances (known as block distances), which is the exchange rate and the substitution rate.

The basis of the TOPSIS technique has a stronger theoretical basis on multi-criteria decision-making method. So that in this technique many problems of methods such as numerical taxonomy are solved. The theoretical basis of this technique is based on first determining the positive ideals (most efficient state) and negative ideals (most inefficient state) for each of the indicators and then the distance of each option from obtain positive and negative ideals (Saaty, 2000). The selected option is the one that has the shortest distance from the positive ideals and the highest distance from the negative ideals. The design of this technique is such that the type of indicators can be included in the model in terms of having a positive or negative impact on the decision-making goal, as well as the weights (parametric weighting) and the degree of importance of each indicator in the model. In order to use

the TOPSIS technique to rank and select the best option from the available options, it is necessary to go through steps including forming a decision matrix, weighting the indicators, quantifying the decision matrix, and forming a scale matrix. Find the weighted unbalanced matrix, find the positive and negative ideals, find the distance of each index from the ideal answers for each option, and determine the relative proximity of each option to the ideal answer and rank went in order (Dayana et al., 2016). The last step of the TOPSIS technique is to rank the options ahead and determine the best option. To do this, it is enough to compare the relative distances of each option obtained by the above steps and from large to small (Saaty, 2000). In this case, each of the options that has the largest relative distance compared to the other options will get the highest rank. As a result, the matrix can be implemented by TOPSIS technique, as mentioned below (Saaty and Peniwati, 2007):

Step 1: First, an evaluation matrix containing m alternatives forms n criteria. Considering the point of interaction of each criterion alternative (x_{ij}), the base matrix can be defined as m × n (x_{ij}).

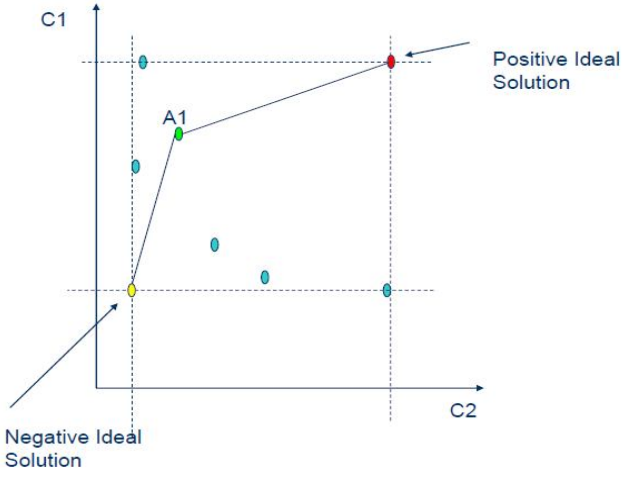

Figure 1. Geometric definition of characteristic analysis by TOPSIS (Saaty and Peniwati, 2007)

Step 2: To quantify and scale the matrix, a decision is made to scale the norm used. To compute the weighted unbalanced matrix (V), the unbalanced decision matrix is multiplied by the base matrix.

$$V_{prim} = N \times (x_{ij})_{m \times n} \tag{1}$$

To do this, the decision matrix must first be converted to a scaleless softened matrix. Then, after normalizing the matrix, the following equations are used:

$$R = (r_{ij})_{m \times n} \tag{2}$$

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^{m} x_{kj}^2}} \qquad i = 1,2,3,....,m \;\; ; \;\; j = 1,2,3,.....,n \tag{3}$$

Step 3: The normalized weighted matrix must be determined from the scaleless decision matrices. To compile the matrix, the decision is made as follows:

$$t_{ij} = r_{ij} \cdot w_j \qquad i = 1,2,3,...,m \;\; ; \;\; j = 1,2,3,....,n \tag{4}$$

$$w_j = \frac{W_j}{\sum_{k=1}^{n} W_k} \qquad j = 1,2,3,....,n \tag{5}$$

$$\sum_{k=1}^{m} w_i = 1 \qquad i = 1,2,3,...,m \tag{6}$$

where, W in these Eqs. is the weight diagonal matrix defined for the input of the algorithm. This matrix is defined as:

$$W = \{w_1, w_2, w_3, ..., w_i\} \tag{7}$$

$$V = N \times W_{n \times n} = \begin{bmatrix} V_{11} & ... & V_{1n} \\ V_{21} & ... & V_{2n} \\ \vdots & \ddots & \vdots \\ V_{m1} & ... & V_{mn} \end{bmatrix} \tag{8}$$

Step 4: After weighing and specifying the elements of the matrices and the decision, the positive ideal solution and the negative ideal solution are determined. In this regard, the vector of the best values of each index matrix V equals the positive ideal solution (A_b) or the best alternative and the vector of the worst values of each matrix V equals the solution of the negative ideal (A_w) or the worst alternative. Thus, the "optimal option" for positive indices is the largest value assigned to that index for various options in the weighted unmatched matrix, and the smallest value is assigned to negative indices. This negative relationship is reversed when determining the ideal ideal solution. Therefore, it can be stated that (Saaty and Peniwati, 2007):

$$A_b = \{\langle \min[t_{ij} | \, i = 1,2,3,....,m] \, | \, j \in J_- \rangle, \langle \max[t_{ij} | \, i = 1,2,3,....,m] \, | \, j \in J_+ \rangle\} \equiv \{t_{bi} | \;\; j = 1,2,3,...,n\} \tag{9}$$

$$A_w = \{\langle \max[t_{ij} | \, i = 1,2,3,....,m] \, | \, j \in J_- \rangle, \langle \min[t_{ij} | \, i = 1,2,3,....,m] \, | \, j \in J_+ \rangle\} \equiv \{t_{wi} | \;\; j = 1,2,3,...,n\} \tag{10}$$

In these Eqs., the criteria are introduced as positive and negative impact coefficients.

Step 5: After calculating the alternatives, it is necessary to calculate the separation distance of the index from the index i and the ideal alternative conditions (worst and best). The following equations can be used to estimate separation distances:

$$d_{ib} = \sqrt{\sum_{j=1}^{n} (t_{ij} - t_{bj})^2}, \qquad i = 1,2,3,...,m \tag{11}$$

$$d_{iw} = \sqrt{\sum_{j=1}^{n} (t_{ij} - t_{wj})^2}, \quad i = 1,2,3,...,m \tag{12}$$

where, d_{iw} and dib are the norm distance from the target alternative i for the worst and best case.

Step 6: In this step, the similarity coefficient to the worst case is calculated using separation distances. This coefficient is also defined as the relative proximity of the index (Dayana et al., 2016). It is done as follows:

$$CL_i \ or \ S_i = \frac{d_{iw}}{(d_{iw} + d_{ib})}; \quad 0 \le S_{iw} \le 1 \ ; \quad i = 1,2,3,...,m \tag{13}$$

where, the best conditions for S_i or CL_i equal to 1 selected alternative and the worst conditions for 0 selected alternatives are included.

Step 7: After estimating the relative proximity coefficient for all indicators, all criteria are ranked and categorized in order of priority. This ranking leads to the identification of the best option to choose from. In this study, TOPSIS technique has been used to solve the research problem.

5. Results and Discussions

Table 1 shows the information related to the identified and effective criteria in construction projects in Maragheh. On the other hand, in order to prepare the TOPSIS model for 10 construction projects in the city of Maragheh, the structural implementation of the analysis process is required hierarchically. For this purpose, first the effective factors are identified and then the amount of factor coverage is determined by each of the project management methods. According to the classifications presented in Table 1, it can be said that the framework for construction management projects is a comprehensive issue and needs to take into account the various specializations involved in It is an urban issue. In this regard, first taking into account the factors involved in construction management issues, different levels of evaluation should be defined and then using project management methods that have full coverage of evaluation parameters, levels of approach to urban project management should be provided. As the slightest defect in this field causes the inefficiency of the evaluation framework. In this study, considering this framework provided for construction projects in urban areas, Maragheh city projects have been classified. In order to prepare hierarchical decision models and matrices by descriptive-survey approach; The MCDM approach with TOPSIS is used for the final measurement and preparation of the final hierarchical matrix. The results of the evaluation for the estimated criteria is presented in Figs. 2 to 5 have been identified separately for construction projects, the specifications of which are given in Table 1.

Table 1. Effective criteria in managing Maragheh urban construction management projects

No.	Evaluation criteria	Project management method
1	Planning quality	Safe deposit method, Traditional way, Execution management method (based on salary), Execution management method (risk sharing), Design and construction (turnkey), Design and construction (combined), Construction- operation-transfer
2	Qualification of the project consultant	Safe deposit method, Traditional way, Execution management method (based on salary), Execution management method (risk sharing), Design and construction (turnkey), Design and construction (combined), Construction- operation-transfer
3	Scientific support	Safe deposit method, Traditional way, Execution management method (based on salary), Execution management method (risk sharing), Design and construction (turnkey), Design and construction (combined), Construction- operation-transfer
4	Proposed design quality	Safe deposit method, Traditional way, Execution management method (based on salary), Execution management method (risk sharing), Design and construction (turnkey), Design and construction (combined), Construction- operation-transfer
5	Project management competence	Safe deposit method, Traditional way, Execution management method (based on salary), Execution management method (risk sharing), Design and construction (turnkey), Design and construction (combined), Construction- operation-transfer
6	Legal interaction	Safe deposit method, Traditional way, Execution management method (based on salary), Execution management method (risk sharing), Design and construction (turnkey), Design and construction (combined), Construction- operation-transfer
7	Qualification of the project contractor	Safe deposit method, Traditional way, Execution management method (based on salary), Execution management method (risk sharing), Design and construction (turnkey), Design and construction (combined), Construction- operation-transfer
8	Economic and financial power	Safe deposit method, Traditional way, Execution management method (based on salary), Execution management method (risk sharing), Design and construction (turnkey), Design and construction (combined), Construction- operation-transfer

According to the results of the evaluation, it can be stated that the most important factors influencing the evaluation are related to the prioritization of criteria, respectively, including the competence of the project contractor, planning quality, quality of the proposed project, project management competence, legal interaction.

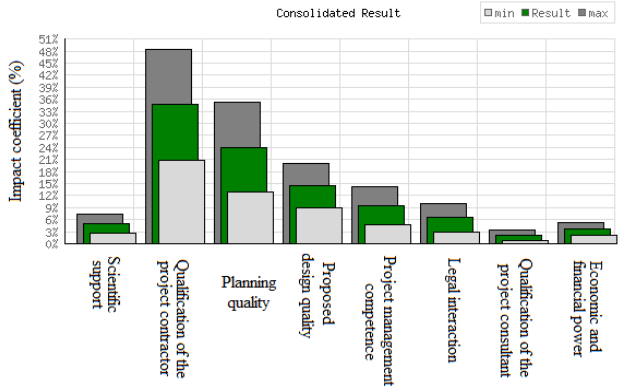

Figure 2. The parametric variation of TOPSIS model for evaluation criteria

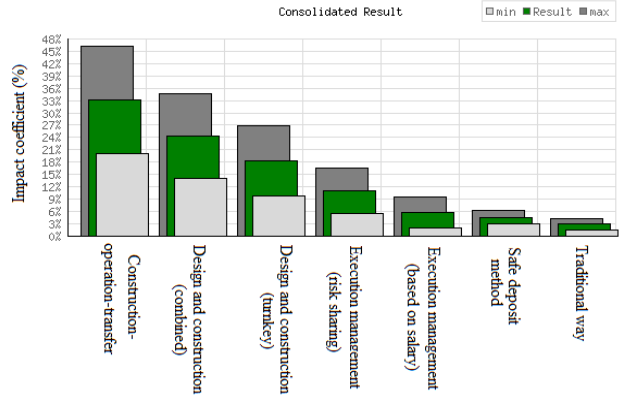

Figure 3. The management method variation estimated by TOPSIS

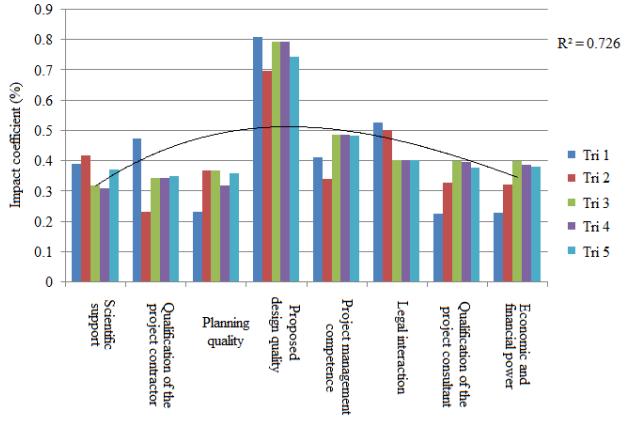

Figure 4. Tri stages in TOPSIS to estimate the evaluation criteria

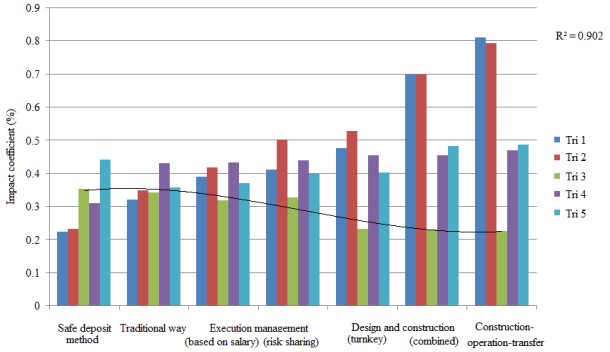

Figure 5. Tri stages in TOPSIS to estimate the optimal management method

Scientific support, economic and financial strength and competence of the project consultant, among which the project contractor competency factor has the most impact and the project consultant competency factor has the least impact.

6. Conclusion

The role of decision making systems in improving evaluation operations as well as providing appropriate methods for qualitative and quantitative improvement of project management plans and programs has led to these systems being widely used in evaluating the factors involved in the design. Construction projects, project risk forecasting, improvement in operations and their operation. Among these, multi-factor decision-making approaches such as multi-criteria decision-making system (MCDM) and TOPSIS approach have achieved significant success due to more data coverage. Taking advantage of this advantage, the present study has tried to provide a model for a multifaceted study of the existing conditions for 10 construction projects implemented in the urban area of Maragheh.

A) Based on the results of evaluation by descriptive-survey approach, 8 effective factors in construction projects such as planning quality, scientific support, project contractor competence, project consultant competence, project management competence, quality of the proposed plan, legal interaction, economic power and Finance has been extracted with 7 project management methods including traditional method, implementation management method (based on wages), implementation management method (risk sharing), design and construction method (turnkey), security method, design and construction method (design and Co-construction), operation, transfer; Attempts have been made to examine the logical relationship between evaluation factors (measurement criteria) and project management methods interactively.

B) Based on the results of standard evaluation by AHP and TOPSIS in terms of the indicators involved, the highest sensitivity is related to the project of Imam Hossein Town Apartment Complex in terms of priority and importance of management indicators. Al-Ghadir alley apartment project is in the second place in this evaluation, which includes project management parameters. This ranking for other projects is specified and specified in the order. By prioritizing the implementation, it can be found that the development attitude in the city; It is the most important priority for the municipality and the employer.

C) Based on the results of the evaluations, a logical relationship can be established between the effective factors in the management of construction projects (8 factors) and project management methods (7 methods). This relationship has been implemented by validation analysis at 5 levels and the overall correlation coefficient for the analysis has been prepared, which indicates the validity of the model. The calculated correlation coefficients for the top of the model are estimated to be above 0.7, which indicates the validity and reliability of the model.

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