Advanced Social Humanities and Management 1(2) 2014: 16-25
www.ashm-journal.com

Prioritizing Delay Causes in Construction Projects in Mazandaran Province (Iran) and Presenting Solutions for Improving it

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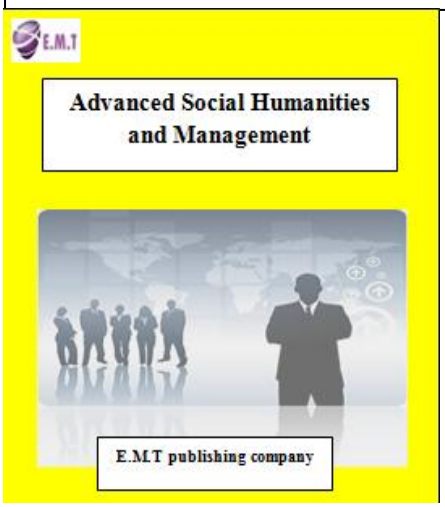


Abstract

Delays are an inevitable part of construction projects, and the evaluation of its effect on construction projects requires a reliable method for investigating delay causes and effects due to great complexities. In this study, we have investigated delay causes in the important projects in Mazandaran Province, prioritized factors by distributing questionnaires to construction specialists in construction projects and calculated their average weights. The effective criteria in prioritizing project elements were identified in the delays of three-factor construction projects by determining the main factors in delay. In this research, multi-criteria decision making methods of ANP & Topsis-Fuzzy were used to determine priority in project elements for creating delays in construction projects for the first time. After prioritizing, using multi-criteria decision making methods, the result showed that the employer is the main factor in creating delay in construction projects. Consequently, the main solution for decreasing the created delays in Iran is the proper prediction of credit allocation.

Keyword: construction project, mazandaran province, delay,multi criteria decision

1. Introduction

One of the main problems in project management is project time management or the required processes for gaining confidence in project completion on time [1]. Studying and referring to previous researches, one can see that enormous researches and investigations were done to identify the effective factors in creating delay in the implementation of construction projects [2]. As an Example in a well-done research done through surveys and the study of contactors and consultants in Jordan, employer or owner interference, inexperienced contactors, credit supply and payment difficulties, low labor productivity, delayed and slow decision makings, improper planning and problems related to sub-contractors were identified as the main factors in creating delay in performing construction projects. In this respect, having investigated employees, employers, consultants and contactors' opinions in Ghana, Yav Firmpong et al, stated that a) difficulties in monthly payment by organizations b) managerial weaknesses of contractors, c) supplying building materials, d) weak technical function, and e) the continuous increase of the primary price are the main reasons of creating delay in construction projects [3]. Emphasizing on the effects of Geographical variables during the implementation of projects and by collecting other groups' opinions in performing construction projects in Vietnam, Negoian Duy Long et al introduced five groups of a) incompetence of designers and contractors, b) changing the managers and weak prediction c) social and technical problems, d) land or constructions problems and e) improper techniques and tools as the main causes of creating delay in construction projects [4]. In another research for identifying the causes and effects of delay in construction projects in Malaysia, Morally Sambasivan and Yawoon Sunde identified the main factor in creating delay as 1) contractors' improper planning, 2) managerial weakness in the performance site 3) contractors' insufficient experience, 4) customer's credit weakness and

payment after project completion, 5) difficulties created with sub-contractors, 6) lack of building materials, 7) supplying labors 8) unavailability of equipment, 9) weak relationships among the groups involved in the project and 10) the mistakes made during construction operations [5]. By studying the effective factors in creating delay in performing 22 road projects in Nepal, organizational weaknesses, building materials suppliers' shortcomings and failure, governmental rules and regulations, and the presence of delay in transportation systems were announced as the main causes of creating delay [6]. In another research in Jordon, delay in construction projects were mainly recognized to be the result of designer's weakness, created changes by owners, climate, land and place circumstances, delay in transferences, economical situations and increase in quantity [7]. Through studying creating factors of delay in national construction projects in Saudi Arabia country, a positive relationship between contractors' technical grade and the frequency of delayed projects was confirmed [8]. The summary of previous studies is presented in

Table **1**.

Table 1: A summary of previous studies

Case study country	**Year**	**Identification factors of creating delay in construction projects**
Saudi Arabia	1999	The Technical grade of contractor
Jordan	2000	Weakness in designing, Changes created by owner's climate, Land and place circumstances, Delay in delivery, Economical situations, Increase in quantity
Jordan	2002	Interference quantity of employer, Lack of experience of contractor, Difficulties in supplying credit, Low productivity of labor, Slow decision makings, weak planning, Sub- contractor
Nepal	2002	Organizational weaknesses, Short comings of building materials suppliers, Governmental rules, Presence of delay in transportation systems
Ghana	2003	Difficulties in monthly payment by organizations, Managerial weakness of contractor, Supply of building materials, Weak technical functions, Continuous increase of the primary price
Vietnam	2004	Incompetence of designers and contractor, Changing managers and weak forecasting, Social and technical problems, Land or construction problems, Improper techniques and equipment
Iran	2006	Payment for completed projects, Management of place for performing project, Approve of workplace map unpredictable circumstances of land terms, Insufficient experience of the contractor, Inefficiency of cost estimations, Lack of capable labors
Malaysia	2007	Improper planning of the contractor, Managerial weakness of the contractor in performance place, Insufficient experience of the contractor, Credit weakness of customer and payment after accomplishment, Difficulties of sub-contractors, Lack of building materials, Supply of labors, Unavailability of equipment, Relationship weakness among groups involved in a project, Errors of construction operations

One of the difficulties or problems that most projects, whether constructional or not, in different countries face is the lengthy period of performance and the multiplication of costs for completing the projects in relation with primary estimates [9].

Williams investigated the present methods of studying the effects of delay on the increase in time in huge projects, and mentioned some points about the insufficiency of present methods for analyzing delay in huge projects [10]. In other research, the original causes of delay in construction industry of Malaysia were studied and the importance of the significance and effect of each reason was investigated. Consequently, the cause and effect relationship between them was identified [11]. Castro et.al developed one method for dividing financial problems of project delay in PERT networks [12].

2. Methodology

2.1 The Network Analysis Process

Based on the Saaty's definition, the general model ANP is more general and complete than AHP. That permits the analysis of different problems by having the mutual relations between elements [13]. In order to calculate the weight of these classes of problems, he developed a method called Meta-matrix [14]. Mata matrix modulates the effect of the weights of the elements related to each other by considering a matrix and by involving all the options and elements. One advantage of this method refers to this point that ANP arranges not only the elements but also groups or bunches of elements in terms of priority [15]. The network analysis process ANP is just a math theory that provides the possibility of investigating different kinds of reactions and dependencies systematically. Why this method is successful in extracting adjudications goes back to applying math measurement operation for measuring relative scales.
Priorities are persuasive numerical bases that guide primary calculation operations in a meaningful way [16]. So, the power of ANP in using relative scales to control all reactions is bases on exact prediction decision-making.

The stages of ANP is stated as follows:

First step: The options and indexes are identified and a questionnaire is developed based on them.

Second step: We compare indexes in pairs, there for each index we compare between options in a couple. We do these comparisons for each option between indexes.

Third step: We normalize couple comparisons.

Forth step: We get calculus averages from each matrix normalized in couple comparisons (it is called relative weights).

Fifth step: In this step we constitute the matrix of relative weights that is called primitive meta-matrix or non-weight meta-matrix.

Sixth step: This meta-matrix is squared by Markov's chains method as many times as lines tend to constant numbers. In this matrix, an option with most terminal weight is the best one.

2.2 The Topsis - Fuzzy Method

Considering that Topsis is a well-known method for problems of classic MCDM, it is used for solving FMCDM problems. Some researchers' [17] defuzzy rates and fuzzy weights in conclusive values while defuzzifcation causes loss of some information. Chen, Liang, Raj and Kumar [18, 19, and 20] assumed that Topsis should be generalized in Fuzzy environment. These methods can decrease lack of Fuzzy information but some problems were seen in their work. In this article, the rates and weights of the criteria in problems are expressed by linguistic variables and then by developing the Topsis method, we solve the problem of choosing a proper option for the decision-making problem. On the basis of Topsis concepts in multi-criteria decision making problems, we have defined the solution for Fuzzy ideal and non-ideal. Then, we calculate the distance between two Fuzzy numbers according to the Fuzzy numbers ranking approach. The distance between each option and the Fuzzy ideal and non-ideal solution are calculated by this method. Consequently, we calculate the neighboring coefficient index of each option for four different values of α (0.25, 0.5, 0.75, 1) to identify options ranking on this basis. Higher values of neighboring coefficient mean more neighboring to Fuzzy ideal solution and farther from Fuzzy non-ideal solution.

The stages of Topsis-Fuzzy method:

Step1 - Organization of a decision making team and then determining options and their evaluation criteria

Step2 - Determination of the importance of the criteria by each decision-maker by using pre-defined linguistic variables.

Step3 - Determination of the rates of the options according to each criterion by using predefined linguistic variables.

Step4 - Organization of Fuzzy decision-making matrix

Step5 – Organization of normalized Fuzzy decision-making matrix

Step6 - Organization of weighty normal Fuzzy decision-making matrix

Step 7 - Determination of Fuzzy ideal limit and solving Fuzzy non-ideal.

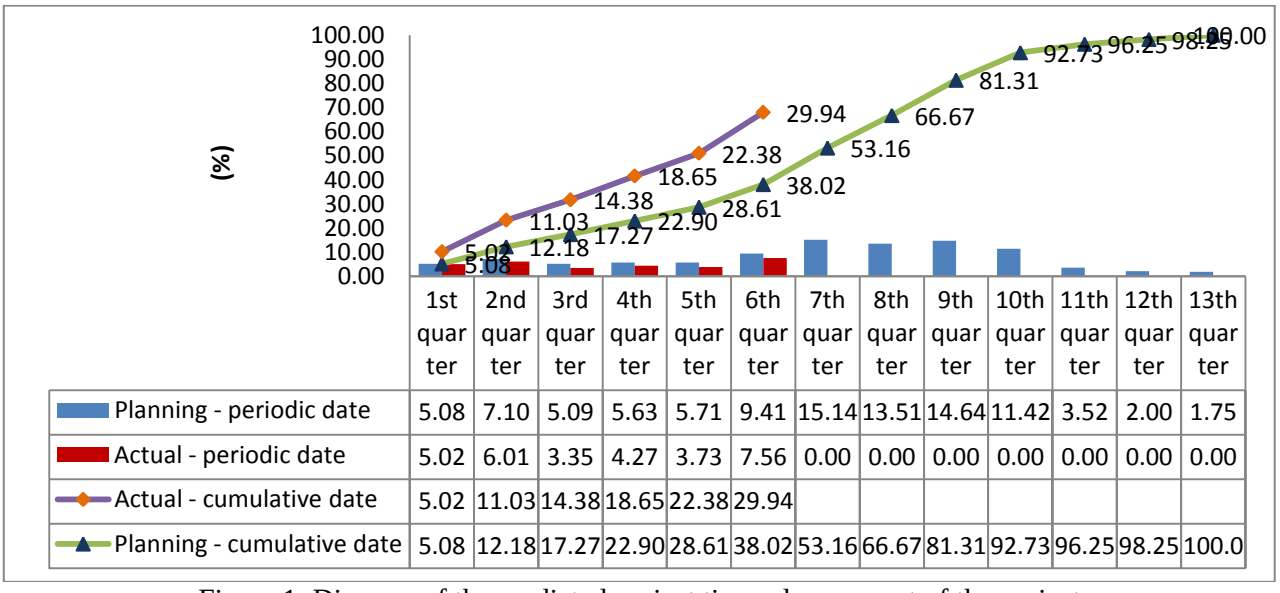
Step8 - Calculation of the distance between each option and Fuzzy ideal solution and Fuzzy non-ideal solution for each certain α

Step9- Calculation of the neighboring coefficient index of each option for each certain α

Step 10 - Ranking the options according to the calculated neighboring coefficient index in the previous step

3. Results and discussion

In this research, some projects were investigated in terms of delay point of view in project time. One of the investigated projects is Haraz Dam that was evaluated by using MSP software as the predicted time period of performing the project was estimated to be 1249 days. The estimation of the actual physical advancement in the project according to the work schedule was presented chapter by chapter. By dividing the actual amount of well-done work on the total amount of work and the calculations of that, Figure 1 was resulted. According to Figure 1 and time calculations, the actual cumulative physical advancement is less than the planned cumulative physical advancement.



	1st quarter	2nd quarter	3rd quarter	4th quarter	5th quarter	6th quarter	7th quarter	8th quarter	9th quarter	10th quarter	11th quarter	12th quarter	13th quarter
Planning - periodic date	5.08	7.10	5.09	5.63	5.71	9.41	15.14	13.51	14.64	11.42	3.52	2.00	1.75
Actual - periodic date	5.02	6.01	3.35	4.27	3.73	7.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Actual - cumulative date	5.02	11.03	14.38	18.65	22.38	29.94							
Planning - cumulative date	5.08	12.18	17.27	22.90	28.61	38.02	53.16	66.67	81.31	92.73	96.25	98.25	100.0

Figure 1: Diagram of the predicted project time advancement of the project

3.1 controlling indexes

The indexes that are introduced here are for controlling program advancement and project price and for measuring deviations from the predicted schedules and will be given to managers. These indexes cause creating a common language among endorsees in the project and standardizing the project control process [21].
The scheduling performance index (SPI), which is sometimes used for forecasting project completion date, compares the completed work with the scheduled one.

$$SPI = \frac{BCWP}{BCWS} \quad (1)$$

If SPI is less than 1, the project is behind the schedule and if the corrective reaction is not imposed, the project will be completed with delay. In this research, the control index was investigated for some projects as the samples and the results are presented in

Table 2.

Table 2: The investigation of the control indexes of different projects in Mazandaran Province

Studied project	Contract period	Control index
Class-section in different areas in Ghaemshahr Square	12 months	73/80
Second (Cable) Bridge over Tajan River - Sari	25 months	86/60
Ghaemshahr-Behshahr-Pole Sefid cross-section	24 months	90/36
Haraz Dam in Amol	30 months	76/00

As it was found by investigating the above projects, most construction projects are behind the predicted time in terms of scheduling. In this research, the causes of these delays and the solutions for improving them were presented. After widespread investigations on different researches and interviewing many specialists of construction projects, 11 factors were selected as the main factors of delay in contraction projects and were averaged by the opinions of 100 people involved in construction projects.

Table 3: Prioritizing delay causes in construction projects in Mazandaran province

Number	criteria	mean	Criterion deviation
1	Lack of doing financial commitments of project bases	10/92	4/93
2	Incomplete primitive studies or errors, problems and lack of plans	10/35	4/09
3	Management weakness and non-coordination between project bases	9/65	4/02
4	Principles of improper project control and non proper period of contract	8/56	3/87
5	New works order and other unpredictable factors	7/78	4/03
6	Lack of experience and efficiency of contractors and subcontractors	7/60	2/98
7	Lack of materials and equipment	7/39	3/61
8	Weak supervision	7/17	2/97
9	Insufficient and damaged maps	6/47	3/57
10	Improper climate situation	6/34	4/00
11	Lack of contractor personnel	6/17	4/27

Consequently, to find which factors of project has the greatest roles in the delay of construction projects, we have selected five criteria among the main ones in Table 3 as the criteria for multi-criteria decision-making and the employer, contractor and consultant as the options of multi-criteria decision making structure that will all consequently form the following structure.

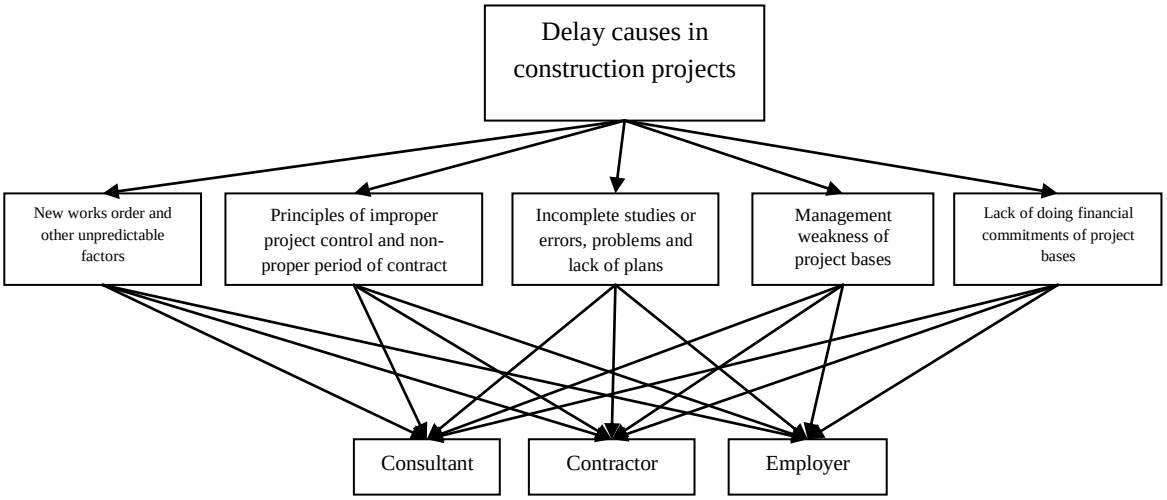


Figure2 : The hierarchical structure of project bases

4.1 Model solving by ANP method

In this method, proposed to complete the AHP method by Saaty, the primary stages were the same as the AHP method. The criteria were compared with each other in pairs by distributing questionnaires to specialist; the results of each criterion are shown in

Table 4 as follows.

Table 4: Comparing option according to the criterion of not doing fiscal commitments of project bases

Lack of doing financial commitments of project bases	**Employer**	**consultant**	**Contractor**	**weight**
Employer	1	9	7	0.78
Consultant	1/9	1	1/3	0.07
Contractor	1/7	3	1	0.15

After comparing each criterion's in a couple we will compare criterions relative to each other according to options. That is the difference of AHP method with ANP. A result of comparing relative to each other was shown according to employer criteria in

Table **5**.

Table 5: Comparing criterion to each other according to employer option

Employer	Lack of doing financial commitments of project bases	Management weakness of project bases	Incomplete studies or errors, problems and lack of plans	Principles of improper project control and non-proper period of contract	New works order and other unpredictable factors	weight
Lack of doing financial commitments of project bases	1	7	9	9	5	0.60
Management weakness of project bases	1/7	1	3	3	1/3	0.10
Incomplete studies or errors, problems and lack of plans	1/9	1/3	1	1/2	1/3	0.05
Principles of improper project control and non-proper period of contract	1/9	1/3	2	1	1/5	0.05
New works order and other unpredictable factors	1/5	3	3	5	1	0.20

After doing these coupling comparisons, super-matrix or Meta-matrix is formed. This matrix should be multiplied by itself many times or should be squared in order to have a tendency to a number in a row of lines. A matrix line indicates the perfection weight of factors. That was presented in

Table **6**.

Table 6: Constitution of super matrix

Employer	Lack of doing financial commitments of project bases	Management weakness of project bases	Incomplete studies or errors, problems and lack of plans	Principles of improper project control and non-proper period of contract	New works order and other unpredictable factors	Employer	Consultant	Contractor
Lack of doing financial commitments of project bases	0	0	0	0	0	0.60	0.06	0.07
Management weakness of project bases	0	0	0	0	0	0.10	0.06	0.06
Incomplete studies or errors, problems and lack of plans	0	0	0	0	0	0.05	0.58	0.69
Principles of improper project control and non-proper period of contract	0	0	0	0	0	0.05	0.15	0.09
New works order and other unpredictable factors	0	0	0	0	0	0.20	0.15	0.09
Employer	0.78	0.28	0.07	0.15	0.65	0	0	0
Consultant	0.07	0.07	0.78	0.07	0.07	0	0	0
Contractor	0.15	0.65	0.15	0.78	0.28	0	0	0

For using ANP method, super Decisions software was used. The results were found as Figure 3.

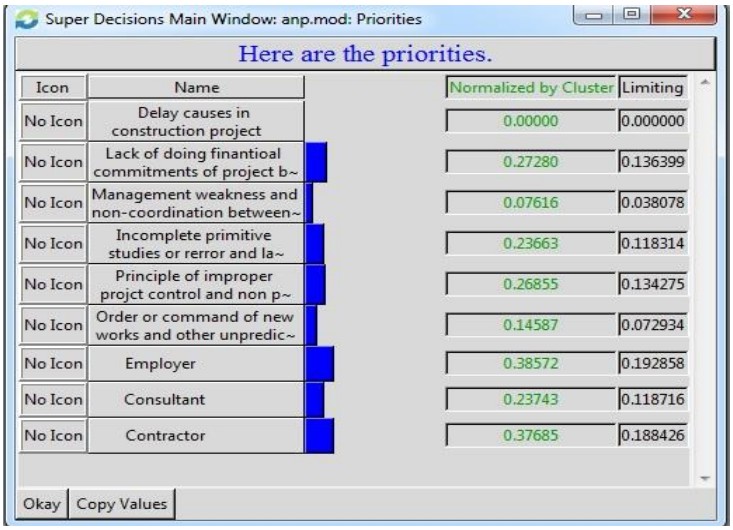


Figure 3: Prioritizing options by Super Decisions software

Results obtained from the ANP method indicate that the employer is the main factor and the contractor and consultant are the next priorities.

4.2 Solving the model by Topsis-Fuzzy

After investigating the model by ANP method, the case study model was evaluated by Topsis Fuzzy method and some samples of tables were presented as follows. Results gotten from upper, medium and lower bound weight were shown in the Table 7 respectively (L, C1, C2, U).

Table 7: Comparing different options by Topsis Fuzzy method by using criteria of not doing fiscal commitments of project bases

Lack of doing financial commitments of project bases	**Employer**				**consultant**				**Contractor**			
	L	**C1**	**C2**	**U**	**L**	**C1**	**C2**	**U**	**L**	**C1**	**C2**	**U**
Employer	0.50	0.80	1.20	1.50	8.50	8.80	9.20	9.50	6.50	6.80	7.20	7.50
Consultant	0.10	0.11	0.11	0.12	0.50	0.80	1.20	1.50	0.29	0.31	0.36	0.40
Contractor	0.13	0.14	0.15	0.15	2.50	2.80	3.20	3.50	0.50	0.80	1.20	1.50

Table 8: Calculating mean weight in upper, medium and lower bound

Mean weight	**AVE_L**	**AVE_{C2}**	**AVE_{C2}**	**AVE_U**
Employer	5.17	5.47	5.87	6.17
Consultant	0.29	0.41	0.56	0.68
Contractor	1.04	1.25	1.52	1.72

Table 9 indicates that in the Topsis-Fuzzy method, like the ANP method; prioritizing by four different parameters of α, affirm each other with a very low approximation of results as the employer, contractor and consultant have the biggest roles in creating delays respectively.

Table 9: Prioritizing option by different value of α

CCI	***α***			
	0.25	**0.50**	**0.75**	**1.00**
Employer	0.5634	0.5634	0.5633	0.5632
Consultant	0.2405	0.2404	0.2404	0.2403

Contractor	0.3628	0.3628	0.3628	0.3628

5. Presenting concepts for improving delays

After widespread investigations for solutions of delays improvement and studying different articles and studying specialist ideas, some solutions were considered for improving the causes of delays in construction projects. The concepts of creating delays were prioritized by distributing questionnaires to decrease delays in construction project by considering very important factors in construction projects or even bringing it to zero. In the Table 10, several main factors in decreasing delays were prioritized.

Table 10: Priority of proper concepts for decrease of delays in construction projects

Number	Criteria	mean	Criteria deviation
1	Prediction and credit allocation	17.00	4.59
2	Selecting proper contractor	16.39	2.13
3	Ownership of project land before performance	16.17	4.57
4	Selecting proper consultant	14.83	4.20
5	Collecting proper information about project	14.35	3.86
6	Correct management	12.91	4.66
7	Designing and correct punctual supervision	12.56	4.01
8	Using planning and project control methods	12.17	4.82
9	Creating coordination between project bases and responsible people in the province and county	11.17	4.38
10	Proper planning of resources	10.39	4.05
11	Proper planning of resources	9.74	6.34
12	Application of technologies and new machinery in performance	8.82	4.99
13	Using value engineering	8.35	4.29
14	Creating competitive atmosphere between project bases of different contractors for conclusion of treaty	8.13	5.15
15	Creating encouragement and punishment policy of project bases and different contractors of project	8.08	5.33
16	Changing the kind of project contract	7.74	4.91
17	Identification of risks and risks management	7.60	4.52
18	Changing the way of performing project	7.35	3.77
19	Proper decisions in claims between the consultant and contractor	7.13	4.68
20	Other cases	1.41	0.91

As it was clear from the results in the table, forecasting and credit allocation, selecting proper contractor and ownership of the project land before performance are shown as the main factors for improving delays in construction projects.

6. Conclusion

From the investigations on different projects of Mazandaran province, it was clear that there are still many problems in the design and performance of these projects that cause creating delay in construction projects. The construction industry in Iran is actually suffering from these problems. As it was shown in

Table 2, most projects in Mazandaran province are behind the scheduled time. In addition, after investigating the causes of creating delay, it was clear that not doing fiscal commitments was the main factor and incomplete studies and weak management were the next priorities in creating delays. Then by using multi-criteria decision making methods, as two methods of Topsis-Fuzzy & ANP were used in this study, the results gotten from these two methods affirmed each other and identified employer as the main factor of creating delay in construction projects among bases responsible for a project. The contractor and consultant were the next priorities. At the end, after investigating the main solutions that cause decrease of delay in construction projects, forecasting and proper credit allocation are the main solutions and selecting proper contractor and ownership of project land before performance are the next priorities that decrease delay. By considering the mentioned solutions in this study, we can prevent from creating delays in construction projects.

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