Identification of effective factors involved in reducing the time for building projects by AHP fuzzy method (Case study of Tehran Municipality projects)

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Abstract - Today, the time-consumingprojects, the desire for fast operation and increased competition in the market, haveincreased the employers' desire to reduce project time. Therefore, recognizing different approaches and techniques of time reduction is essential. The main objective of this research is to obtain an appropriate method for applying time reduction techniques in construction projects to make optimal use of these techniques. As a result, in this research, we tried to propose the most effective solutions for industry use by careful examination of the ways to reduce project time. This applied research consists of two stages of library studies and field survey, and then the combination conclusion of the library studies and field surveys. The fuzzy hierarchy method has been used to model and to identify the optimal solutions. In order to improve this research, a case study and interview with employers, consultants,and contractors of Tehran municipality projects were carried out to collect reliable answers. The statistical population of the research includes all the Tehran municipality projects. Then, the most effective strategies were identified by accurate and up-to-date fuzzy analyzes. The result shows that the economic and financial problems and bureaucracy of the offices are the underlying causes ofdelay inthe construction projects in the Tehran municipality.

Keywords: Building Projects, Tehran Municipality, Fuzzy Analysis.

1. Introduction

Today, one of the most important concerns of developing countries is the failure to reach the early plans. Many organizations are either out of date or when they enter the planning arena, they look at the plansin the form of a wallchart series. The most important application of these seriesisa team personality creation and bank contribution attraction. As a result, unwittingly, delayed projects increase direct and indirect costs and ultimately fall in bankruptcy. One of the industries that are heavily affected by this challenge in developing countries is the construction industry. So that one of the factors influencing economic growth and gross national product of each country is the construction industry (Agung, Wibowo, and Shah Nazari, 2012). Each project may be delayed during the operation. Time reduction techniques are used to offset these delays and return to the original timeline of the project. Since reducing the time of projects is vital for construction projects, extensive researches have been carried out in this field, which has resulted in different techniques for reducing time (Eldin, Neil N, 1996).

Delays in construction projects, rising costs and poor quality over the past years have been the most common problems in construction & engineering parts. Specifically, in the past 70 years, the increase in time and costs of large construction projects, including infrastructure projects, has become a global phenomenon, and according to the statistics, an average 28% has been added to the costs during project implementation. (Flyvbjerg, B., Holm, M.S., and Buhl, S, 2002). Within the scope of the project, all project deliverable items are specified. In principle, by specifying the scope of a project, it is determined which items should be presented at the end of the project and in what quality. According to the definition of Project Management Body of Knowledge (PMBOK), the deliverable items of a project are atangible and objective output of a work package that is measurable and verifiable, and doing part of the project is subject to completion and delivery. These items must be specified according to the needs of the project stakeholders before the beginning of the project. By defining the scope of change, it is avoided form changes because of changing requirements, since all deliverable items are identified at the beginning of the project, and these items must be delivered to the end of the project unless agreed upon by the project stakeholders and aware of the risks arising from changes in these items, these items change. (Sabzeparvar, M. 2012).

In each network, the route or paths that have the longest time are called a critical path, and activities on these pathways are called critical activities. So critical activities in a network are activities whose bulk flotation is zero. One of the reasons for the need to separate network activities from critical and non-critical activities is that it is possible for managers and authorities to focus on critical activities and try to reduce their time. In a network, in addition to critical activities with zero bulk flotation, there may be other activities, although they do not have zero bulk flotation, and therefore they are not defined as critical, but their bulk flotation is very low. Such activities are termed "semi-critical" planning (Mohammad Nejad, Hamid, Abdullah Nowrouzi and Sayyed Mohammad Lavasani, 2009). After reviewing the researches done in the second part of this study, the following factors were identified as the best ways to increase the manpower productivity and to reduce project time as follows:

- Provide timely access to the materials and resources needed
- Staff training
- Use of human resource motivation mechanisms (paychecks, rewards, music during work and extracurricular activities)
- Use more suitable tools and means (their availability, quality,and maintenance)
- Using the qualified people (having technical, perceptual, decision-making, executive and managerial skills and having sufficient experience)

Therefore, the main objective of the present study is to identify the factors and the most effective ones to reduce the time of building projects with the Analytic Hierarchy Process (AHP) fuzzy method in Tehran Municipality projects.

2. Research background

In a paper in 2006, De Bakheng and Myintpresent a case study on the implementation of the Korsch's hypothesis in a cement factoryand demonstrate that the use of the Babo Suresh model could have a surprising effect on cost reduction. They achieved cognitive results by plotting 64 activities in a cement factory and solving the problem with LINGO software. Their results were achieved by classifying levels of quality into four levels of categories with equal points in terms of time and quality. The result of this work is the ability to make a more straightforward decision on any of the qualitative levels.

In 2000, Tavares [64] also presented a review article on the application of operation research in the optimal balance between the three factors of project quality, time and cost that divided each of the three domains and identified three key elements (criteria, resources,and activities) in the project management field. A project is considered as three main perspectives; criteria (including project length, resource utilization, resource leveling, current value with consideration of other investments) that can be considered as definitive or uncertain. The second is an activity that examines aspects of length, precursor, prerequisite, and mode. The third is the resources that are examinedas financial flows, capacity, and consumption.

In a paper published in 2014, Van Faho and Jinova Hay [65] presented a cost-quality balance model for building projects with a resource allocation approach, although in terms of mathematical relationships, it facilitates time-consuming work in the projects, but in practice, especially in civil engineering projects that are operating at a large field, it is simply not possible, or that it is not easy to estimate the time of an activity that has highly complex in terms of execution. For this purpose, the two authors have used genetic algorithm method for solving the model related totheir three-storey building, which consists of only 20 activities.

Thomas et al. (1999) reviewed three projects in order to quantify the various material and climate effects on constructionefficiency. Theydetermined the best delivery method by using regression analysis. The best way to deliver the materials was to install steel structures directly from the truck. Also, the results of this study showed that the repositioning of materials would result in a 9% reduction in labor productivity. In 2000, Thomas and Sanvido investigated the impact of project performers and suppliers on labor productivity by comparing their daily productivity with Baseline Productivity and reported workers' productivity reduction by 16.6% to 56.8% in three different projects.

Allmon et al. in 2000 stated that the manufacturing industry hadwitnessed a lot of technological changes between 1970 and 1998. The power and strength of the tools, their complexity,and their output energy had increased. These advances affect the workforce productivity in different ways. In order to specify the exact effect, it requires full attention and control of the other factors that are associated with these changes.

In 2001, Goodrum examined how changes in equipment technology affect productivity. In this study, 200 different activities from different information sources were examined. The technical and technological factors of the equipment include their control level, the amount of human energy used, the speed of information processing and their performance range.

In 1982, Olson sought to examine the impact of management, planning,and communication on the basis of past studies and industry knowledge and experiences. The results of this study showed that unsuccessful management would cause fatigue and reduce labor productivity, and result in lower productivity rates.

In 1981, Danladi and Horner built a regression model of labor rates and quality indicators (the ratio of management working hours to useful working hours of workers and the ratio of management working hours to total worker working hours), based on the documentation and records of the three manufacturing industry projects. It is concluded that at a lower level of management control, labor productivity increases with increased management control. The results of these studies have shown that there is a desirable level of management control in which the overall cost level of construction is minimized, and also an increase beyond the desired level in management control causes interference in the work cycle and decreases effectiveness.

Diekmann and Heinz in 2001 examined the impact of planning and buffer strategy on the efficiency of skilled plumbing and electrical installation workers. Initial data were collected from 20 power plants through a questionnaire. The labor productivity rate was calculated from the ratio of actual working hours to planned working hours and adjusted to reflect 5 project characteristics such as the project location, type of project, project implementation system, manpower and total working hours of the workers. The regression model was developed to evaluate buffer design, buffer materials, buffer supplies, and buffer planning on labor productivity.

To the extent that more activity is done, less time is needed to redo it, which refers to the learning curve. Therefore, the productivity of workforces is improved by repeating activities (Touran et al, 1988). Scarpa and Gates in 1972 used the findings of the past studies to study the effects of learning curves and experience on construction activities simultaneously. Increasing the productivity that results from the learning curve is related to the characteristics and records of the individuals. In contrast, the experience curve depends more on the type of activity and function rather than the personal characteristics of the workforce. Therefore, when the activity is repeated for a short period of time, the experience curve is affected and its useful effect is reduced.

Touran, in 1988, examined the effect of work repetition on formatting activities. This research showed that labor productivity increased by 25% and 40%, respectively, in the form of peripheral beams and the formatting of the elevator wall. The reason for this is that the formatting is a continuous and repetitive activity carried out by a particular working group.

Changes in change orders affect labor productivity indirectly. Usually, changing the agenda disrupts the project implementation and causes problems that generally relate to factors such asresources availability, the relationship between working groups and rework, and leads to a deficiency in the learning curve.

In 1987, Leonard developed a model for estimating the effect of changes based on work groups, the percentage change in the agenda and a number of other key reasons.

In 1994, Thomas and Napolitan reported a 30% efficiency reduction due to changes in their construction activities, but some of these changes showed that they did not reduce efficiency. The data were collected daily from 3 industrial projects. The key variable was related to reducing the efficiency at the time of construction changes. These studies also showed that there is a very strong dependence between changes in construction, rework, and interruptions at work (for example, lack of materials, lack of tools and equipment and busy work).

3. Research methodology

In this research, according to the nature of the subject, a descriptive research method has been used which will be further discussed. Descriptive research includes collecting information to test hypotheses or answer questions about the current state of the subject under study. The purpose of this research is to describe systematically the identification of factors and their most effective choice on time reduction of building projects using the AHP fuzzy method. In order to increase the accuracy of the analytical method in this study, fuzzy logic was used. In fact, a hierarchical analysis method is combined with fuzzy logic. The statistical population of the research includes all Tehran municipality projects.

In this research, two library study and field study methods are used to collect the required data. The data gathering tool in this research is survey method (questionnaire, semi-organized interview) and library and field documents. The questionnaire used in this research consists of two main sections which the first part includes demographic questions such as age, gender, education level, and etc. The second part relates to the questions of the research variables, which has been designed with a five-pointLikert spectrum scale. The designed questionnaire was completed by 44 people. The 5% error level of the sample size/volume was 39.5707463246 with Cochran's method. The observed skewness value is 0.156 and is in the range of (-2, 2). In other words, the questionnaire is normal and the distribution is symmetric. Its kurtosis value is 0.694 and is in the range of (-2, 2). This indicates that the variable distribution has a normal elongation, and the questionnaire has passed the normal test successfully. To determine the reliability of subscales, this questionnaire was used to calculate the Cronbach's alpha coefficient. Cronbach's alpha was shown, and a value of 0.992 was obtained for it, which was 0.993 after standardization.

One of the remarkable points in this study is the case study of Tehran Municipality projects. The Tehran City Council, by presenting a 12-month monitoring-report on capital asset procurement projects of 2015Tehran Municipality, said that the total number of the projects were 2446 projects. Design and planning, contractor delays, financial issues, and executive issues have been due to delays in the timely implementation of projects. According to a report by the Tehran City Council, experts encountered 75% improvement in projects after project visits, and the rate of project backwardness in the regions was 25%. The comparison table between the operational status of capital construction projects in 2011, 2012, 2013, and 2014 in Tehran Municipality was about 28.9%, 17%, 10%, 18%, and 28%behind schedule, respectively. 31% of the projects were public tendered in 1994, 6% were limited tendered, 12% were quoted, 39% were assigned (assigning to private and state-owned companies), and 10% were implemented through affiliates and companies. In general, 44 respondents answered tothe questionnaire. Of the respondents, 27 persons have a bachelor's degree, 10 persons and 7 persons have theundergraduate and doctoral degrees, respectively. The average age of respondents is 55 years. Ninepersons are female and 35 persons are male.

4. Results

The first level of the hierarchy is the main criteria. We also convert paired comparisons into fuzzy triangles. The first questionnaire examines the priority of each main criterion by paired comparisonsof themain criterias based on the goal. Therefore, we must compare the criteriason a two-way basis.

We consider the criteria C1 to C6 and the criteria A1 to A4, respectively. The paired matrix of options is based on criteria C1 in Table 2. In this matrix, the inconsistency of 0.097 is acceptable and there is no need to revise judgments. In this table, there are one to 6 technical and technological, job, construction, economic, financial, administrative, organizational, social and cultural criterias, which have the highest weight in terms of economic and financial criterias and the lowest weight in terms of social and cultural criterias.

Table 1. Paired comparison between criterias

	Technical and technological	Job status	Construction		Economic and financial	Administrative and organizational		Social and cultural weight
Technical and technological	(1,1,1)	(1,3,5)	(1/7,1/5,1/3)		(1/7,1/5,1/3)	(1/7,1/5,1/3)	(3,5,7)	0.098
Job status		(1,1,1)	(1/7,1/5,1/3)		(1/7,1/5,1/3)	(1/5,1/3,1)	(1,3,5)	0.072
Construction		(1,1,1)	(1/7,1/5,1/3)	(1,3,5)	(3,5,7)	0.25		
Economic and financial			(1,1,1)	(1,3,5)	(3,5,7)	0.34		
Administrative and organizational				(1,1,1)	(3,5,7)	0.23		
Social and cultural					(1,1,1)	0		

Table 2 shows the paired scale valueof the options based on the C1 criteria. In this matrix, the inconsistency of 0.092 is acceptable and there is no need to revise judgments. In this table, there are one to four criterias for insufficient studies and local information on land and work conditions, design mismatch and design information in the correct estimation of cost, time and resources, limited access to materials and building materials, non-standard materials. It is required that the highest weight belongs to the design mismatch criteria and the design information for the correct cost estimating and the lowest weight criteriabelongs to the non-standard materials.

Table 2. Paired scale matrix based on C1 criteria

	A1	A2	A3	A4	weight
A1	(1,1,1)	(1,3,5)	(1,3,5)	(5,7,9)	0.39
A2		(1,1,1)	(3,5,7)	(5,7,9)	0.47
A3			(1,1,1)	(1,3,5)	0.12
A4				(1,1,1)	0

The paired scale matrix of the options is based on criteria C2 in Table 3. In this matrix, the inconsistency of 0.094 is acceptable and there is no need to revise judgments. Table 3 shows the paired scale value of the options based on the C2 criteria. In this table, there are one to four criterias for resource shortages (land, materials, and labor), lack of technical personnel expertise in sensitive technical and workshop systems, commitment to do things that the executor or the employer or control system does not have the records of doing the same, and work in the border, deprived or warfare areas due to the presence of the explosives and the subsequent risks pose the fact that the highest weight belongs to the shortage criteria of the technical personnel expertise in sensitive technical and workshop systems and the lowest weight criteriabelongs to the border,deprived or warfare areas due to the presence of explosives and the subsequent risks posed by them.

Table 3. Paired scale matrix based on C2 criteria

	A1	A2	A3	A4	weight
A1	(1,1,1)	(1/5,1/3,1)	(1/5,1/3,1)	(1,3,5)	0.24
A2		(1,1,1)	(1,3,5)	(3,5,7)	0.30
A3			(1,1,1)	(1,3,5)	0.24
A4				(1,1,1)	0.20

The paired scale matrix of the options is based on the C3 criteria in Table 4. In this matrix, the inconsistency of 0.097 is acceptable and there is no need to revise judgments. Table 4 shows the paired scale value of the options based on the C3 criteria. In this table, one to fourefficiency criterias and low efficiency show the lack of knowledge and expertise of the contractor, working with unprofessional employers, and prolonging the execution time and completion of projects for rational and unreasonable reasons. The highest weight criteria belongs to the lack of knowledge and expertise of the contractor and the lowest weight criteria belongs to the prolongation of the execution time and completion of projects for rational and unreasonable reasons.

Table 4. Paired scale matrix based on C3 criteria

	A1	A2	A3	A4	weight
A1	(1,1,1)	(1,3,5)	(3,5,7)	(1,3,5)	0.14
A2		(1,1,1)	(1,3,5)	(1,3,5)	0.4
A3			(1,1,1)	(1,3,5)	0.2
A4				(1,1,1)	0.16

The paired scale matrix of the options is based on the C4 criteria in Table 5. In this matrix, the inconsistency of 0.091 is acceptable and there is no need to revise judgments. Table 5 shows the paired scale value of the options based on the C4 criteria. In this table, one to fourare criterias for non-cooperation of the financial institutions in the payment facilities, carrying out tasks without adjustment in regions with high and unpredictable inflation, fluctuations in material prices and housing due to the economic conditions of the country, region and the world and inflation without having a scale for costs and analyzing the cost atproject completion. The highest weight belongs to non-cooperation of the financial institutions in the payment facilities,and the lowest weight belongs to inflation without having a scale for costs and analyzing the cost at project completion.

Table 5. Paired scale matrix based on C4 criteria

	A1	A2	A3	A4	weight
A1	(1,1,1)	(5,7,9)	(3,5,7)	(3,5,7)	0.68
A2		(1,1,1)	(1/7,1/5,1/3)	(1,3,5)	0
A3			(1,1,1)	(1,3,5)	0.23
A4				(1,1,1)	0.07

The paired scale matrix of the options is based on the C5 criteria in Table 6. In this matrix, the inconsistency of 0.095 is acceptable and there is no need to revise judgments. Table 6 shows the paired scale value of the options based on the C5 criteria. In this table, there are one to 4 inappropriate and inefficient management standards for administrative bureaucracy, structural, managerial changes, and the probability of changes in programs and targets, the inconsistency of agencies and organizations affecting the implementation of construction projects, the weakness of the laws, and tailored interest of above organizations.The highest weight belongs to the inconsistency of agencies and organizations affecting the implementation of construction projects and the lowest weight belongs tostructural, managerial changes, and the probability of changes in programs and targets.

Table 6. Paired scale matrix based on C5 criteria

	A1	A2	A3	A4	weight
A1	(1,1,1)	(1/5,1/3,1)	(1/7,1/5,1/3)	(3,5,7)	0.23
A2		(1,1,1)	(1/7,1/5,1/3)	(1,3,5)	0.07
A3			(1,1,1)	(5,7,9)	0.5
A4				(1,1,1)	0.2

The paired scale matrix of the options is based on C6 criteria in Table 7. In this matrix, the inconsistency of 0.091 is acceptable and there is no need to revise judgments. Table 7 shows the paired scale value of the options based on the C6 criteria. In this table, there are one to fourcriteriaswhich showthe inappropriate working and technical culture of executives and skillfuls, lack of attention to cultural issues and social norms in building design, population growth, migration and non-standard construction in marginal areas and weaknessof culture in use ofthe building.The highest weight belongs to inappropriate working and technical culture of executives and skillfuls, the lowest weight belongs topopulation growth, migration and non-standard construction in marginal areas and weakness of culture.

Table 7. Paired scale matrix based on C6 criteria

	A1	A2	A3	A4	weight
A1	(1,1,1)	(1/5,1/3,1)	(3,5,7)	(3,5,7)	0.37
A2		(1,1,1)	(1,3,5)	(1,3,5)	0.24
A3			(1,1,1)	(1,3,5)	0.18
A4				(1,1,1)	0.18

The weight of each option based on the criteria is given in Table 8. Table 8 shows the weight of each option based on the criteria. In this table, there are one to four solutions for cost estimation, procurement of essential equipment, performing local environmental studies, providing the required safety and forces, pursuing the necessary bureaucracy in the respective organ in terms of a hierarchical manner and suspended project.

Table 8. The weight of each option based on criteria

	C1	C2	C3	C4	C5	C6	score
B1	0.39	0.24	0.30	0.68	0.23	0.37	0.41
B2	0.47	0.30	0.24	0	0.07	0.24	0.12
B3	0.12	0.24	0.2	0.23	0.68	0.18	0.31
B4	0	0.20	0.24	0.07	0	0.18	0.09

Conclusion

According to the schedule, one of the major goals is project implementation. There are often many problems in performing projects and many studies have been done for this achievement. However, many of the common and planned schedules are long and may not meet the employer's demands regarding the project delivery time, which would lead to the loss of many competitive opportunities. As a result, today the use of the solutions to reduce the time of projects has become a major concernfor project managers. So, in this research, comprehensive solutions for reducing the time of projects and, finally, ranking them according to the different criteria are carried out. Based on Fuzzy AHP ranking, the solution is as follows:

- B1> B3> B2> B4
- ✓ Cost estimation, procurement of necessary equipment
- ✓ Pursuing the essential bureaucracy in the corresponding organs in terms of a hierarchical manner
- ✓ Performing the local environmental studies, providing the required safety and forces
- ✓ Project suspension

The first two solutions are 71% and the last two solutions are 29% that represents the focus of problems on the first two solutions. The result shows that the economic and financial problems and bureaucracy of the offices are the underlying cause of the delay inconstruction projects in the Tehran municipality.

Recommendations

• Use methods to reduce project time, such as HSE.

• Managing metropolitan construction projects with modern Case-Based Reasoning (CBR) intelligent systems.

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