APPLICATION OF ANALYTIC HIERARCHY PROCESS (AHP) TO PRIORITIZE CAUSES OF CLAIMS BASED ON THE EFFECT ON THE TIME AND COSTS OF INFRASTRUCTURAL PROJECTS IN THE FIELD OF IRAN OIL AND GAS

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ABSTRACT

As the approaches and implementation process of the projects are becoming more and more complicated, the possibility of encountering events that causes argument and claim among project beneficiaries increase. Nowadays, claims have become an indispensable part of the management projects. Since claims have pronounced effects on the project implementation and may raise question the project justification, the need for claims management is evident.

The first step in the optimization of claims management is to identify the causes of claims. However, in order to determine the most important ones, other claim management techniques including identifying, pursuing and solving the claims are required. For this purpose, the claims causing difficulties in the projects should be prioritized according to the different types of claims (time and cost claims). As such, Analytic Hierarchy Process (AHP) has been employed in this study. Therefore, pairwise comparison of these causes have been conducted based on their importance in the time and cost claims. Also comparison of the importance of time and cost has investigated in the industry for the purpose of determining the most important causes as well as its importance rate.

Since the importance of claim causes may vary from one project to another according to the changes of the importance of time and cost, sensitivity analysis have been implemented on the prioritizing. Sensitivity analysis identifies the critical claim causes in different projects (with different weights for time and cost claims) and prevents spending time and energy on low important issues.

Keywords: AHP, Claims Management, Time claim, Cost claim, Sensitivity Analysis.

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1- Introduction

Imposing negative attitude towards dealing with claims and disputes in a similar manner to the lack of attention to them can cause some difficulties in the project. There are different factors that lead to occur claims in the projects. The first step after identification of such factors is to determine their importance in claim arising. In this research, these factors have been compared and ranked and their effects on the time and cost claims have been investigated. Moreover, the most importance factors in the cost and time claims have been identified so as to properly manage claims.

Claims, disputes and project management

Since project managers are to be the first individuals to evaluate contract requirements, therefore, they are subject to claims, disputes and other relevant issues of the project [1]. Although each members of the project team may have their own goals and benefits, it is attempted that all activities are continually moving in the direction of project goals. [2], [3]. Therefore, Project Management Body of Knowledge (PMBOK) Standard presented claim management process in 2000.

Definition of claim

A claim is a demand for something due or believed to be due. Claims are a normal part of construction project performance. In the construction projects, the term "something" is usually assigned to the extra cost or extra time. Thus, two types of claims can be defined, namely time and cost claims.

Time claims

Time claims are claims in which a party asks for extending the contract period. This type of claim may be arisen by either party, namely client and contractor. For instance, contractor has not made its pledge within the specified time and accordingly this causes delay in the project implementation. On the other hand, client may have not met the contractor requirements resulting in increase in the contract period and contractor's costs.

Cost claims

Cost claims are claims in which a party has suffered loss a result of the acts of another party. For example, contractor may claim that due to the sanction, it was not capable to provide required equipment in accordance with specified prices; accordingly the contractor believes that the contract price should be increased. Also, client may claim that contractor has employed lower price equipment and consequently this should be considered in the project costs.

2- Delphi method

The Delphi method is a systematic, interactive forecasting method which relies on a panel of independent experts. The carefully selected experts answer questionnaires in two or more rounds. After each round, a facilitator provides an anonymous summary of the experts' forecasts from the previous round as well as the reasons they provided for their judgments [5]. The Delphi method is based on the dialectic approach. In other words, it is based on the thesis, antithesis and finally synthesis [6]. The Delphi process typically consists of two or more stages of data collection activities (such as questionnaire surveys), in which authoritative panel members are asked to indicate the significance of the listed items.

Delphi method procedure

The important issue in this process is to fully understand the aim of applying Delphi method by participants. Otherwise, we may face irrelevant answers. Participants should have sufficient information in the related field and be familiar with literature review. However, high expertise is not required. As mentioned before, the minimum number of members to obtain reliable results depends mainly on the

design. Therefore, even a group including four members may produce favorable performance. In addition, the answers can be manipulated by authorities to obtain desired results [8].

The Delphi procedure is illustrated in the following. Brainstorm occurs in the first iteration, then we may have confining in the second iteration; finally, exploration of ranking will be made in the next iteration. This procedure continues till obtaining favorable ranking [9]. The outcome of Delphi method is more than a theory. This theory is as valid as the participants' comment. These comments are summarized based on the statistical relations in lieu of majority and minority votes. Moreover, this method is subjected to criticism by some researches. They believe that Delphi method cannot be characterized as a scientific method and also there are some uncertainties about the reliability of the method [6].

3-Analytical Hierarchy Process (AHP)

Decision making is one of the main characteristics of human being and every individual has to make several decisions within his life time. Contrary to some decisions, a number of them have significant importance. Decision making becomes more importance as the responsibility increases. The world is full of multi-criteria problems that should be solved. Therefore, some criteria should be employed so as to examine different decisions.

Since proper and in time decision making may have significant effect on the people's life, the necessity of a robust technique in this relation is completely evident. And as such, one of the most efficient methods is Analytical Hierarchy Process (AHP) proposed for the first time by Thomas L. Saaty in 1970. This method is based on the Pairwise comparisons and is capable to examine different conditions. Since AHP is simple and comprehensive, it is the subject of current research and development efforts [11].

AHP is a multicriteria decision-making method that uses a hierarchical structure to solve complicated, unstructured decision problems, especially in situations where there are important qualitative aspects that must be considered in conjunction with various measurable quantitative factors. The AHP is aimed at integrating different measures into a single overall score for ranking decision alternatives [12]. AHP has been applied in different fields such as management, engineering, industry, education, etc [13]. AHP also has widely been used in the engineering and construction management. As recent applications, it can be mentioned to procedure for multi-criteria selection of building assemblies [14], Decision support system for selecting the proper project delivery method [15], advanced automation or conventional construction process [16], multi-criteria assessment of the probability of winning in the competitive bidding process [17] and contractor pre-qualification model [18].

The widespread use of AHP may be assigned to its simplicity and flexibility. According to the literature review, it has been realized that AHP has been recently employed along with other methods like mathematical programming to consider not only quantitative and qualitative factors, but also limitations similar to real world [14]. Integrated AHP presents more promising and reliable results. Therefore, integrated AHP has been the focus of a significant amount of studies in recent years. The reason of integrating AHP with different tools may be assigned to the wide application and success in the decision making [14].

3-1-Evaluation of consistency and inconsistency of matrix

One of the main advantages of AHP is to control the consistency of decision. In other words, the rate of consistency after determination can be judged. A judgment is said to be compatible in which the importance of A and B is two times and three times of B and C, respectively, and consequently, the importance of A is six times of C [12]. Suppose an n × n matrix M, then the consistency index can be described as follows:

$$C.I = \frac{\lambda_{max} - n}{n - 1}$$

(1)

Where, λ_{max} is the largest eigen value of matrix M and n is the number row or columns.

The values of consistency index have been determined for matrix with different dimension and presented as random consistency index. Through using this index and index obtained from above equation, the rate of consistency index can be determined as follows [44]:

$$CR = \frac{C.I}{R.C.I}$$

(2)

Where, R.C.I is random consistency index listed in the following table.

Table 1. The values of random consistency index (R.C.I)

10	9	8	7	6	5	4	3	2	1	N
1.49	1.45	1.41	1.32	1.24	1.12	0.9	0.58	0	0	R.C.I

If CR is less or equal to 0.1, the rate of consistency the matrix is acceptable; otherwise, there is inconsistency in the matrix.

3-2- Analytical Hierarchy Process (AHP)

Time and cost are two of the most important factors in engineering projects. Due to the nature of claim arising and its effect on the time and cost, claims can be viewed from two different perspectives, namely cost and time claims.

The importance of cost is normally more than the time in a project. Hence, claims arising have different importance and priorities from the aspect of time and cost. And as such, Analytical Hierarchy Process (AHP) can be utilized to prioritize claims in accordance with time and cost.

The sources of claim arising have been identified using questionnaires and Delphi method. Then, the most important factors based on the occurrence probability in projects and effect on the claim arising has been determined. Thereafter, they were prioritized regarding pairwise comparison of time and cost claims. For this purpose, AHP as a tool of Group Decision Support System (GDSS) should be applied in the group decision making. The prioritization process includes subsequent steps:

- Formation of decision maker group
- Creating hierarchy process
- Performing pairwise comparison

3-3- Formation of decision maker group

Since decision making is a complicated process in organizations and companies, therefore, using other comments can be a very useful way of improving the result. Interference of irrelevant authorities makes some difficulties in this process. After identifying effective factors in the field of gas and oil, a decision maker group including experts was formed.

3-4- Creating hierarchy process

Analytical hierarchy process has been used as a subsidiary tool in decision making. Therefore, a proper analytical hierarchy process representing our goal should be created. For this purpose, experts' viewpoints have been employed. Then, ten of the most important sources of claim arising have been identified using questionnaires. Afterward, they were prioritized based on their effects on the arising of time and cost claims. The developed structure is illustrated in figure 1.

1- Inflation and increase in the wage, price of materials and equipment
2- Conducting extra work without specified price in the contract

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3- Lack of proper budgeting in the implementation of project
4- Political and economical sanctions and consequently failing to provide foreign materials and equipment
5- Wrong estimate and arranging the contract based on unreal issues.
6- Increase in the costs equal to more 25 percent of contract price.
7- Lack of in time completion of the project
8- Contractor selection on the basis of only lower bid price and without considering the technical capabilities
9- Lack of in time announcement of contract, changes, confirmations and maps to the contractor
10- Changes in the price of foreign currencies

Figure 1. Pairwise comparison of sources of claim arising time and cost claims

3-5-Performing pairwise comparison

After creating hierarchy process for prioritization, pariwise matrix should be formed at each level. To do this, there are different methods as follows:

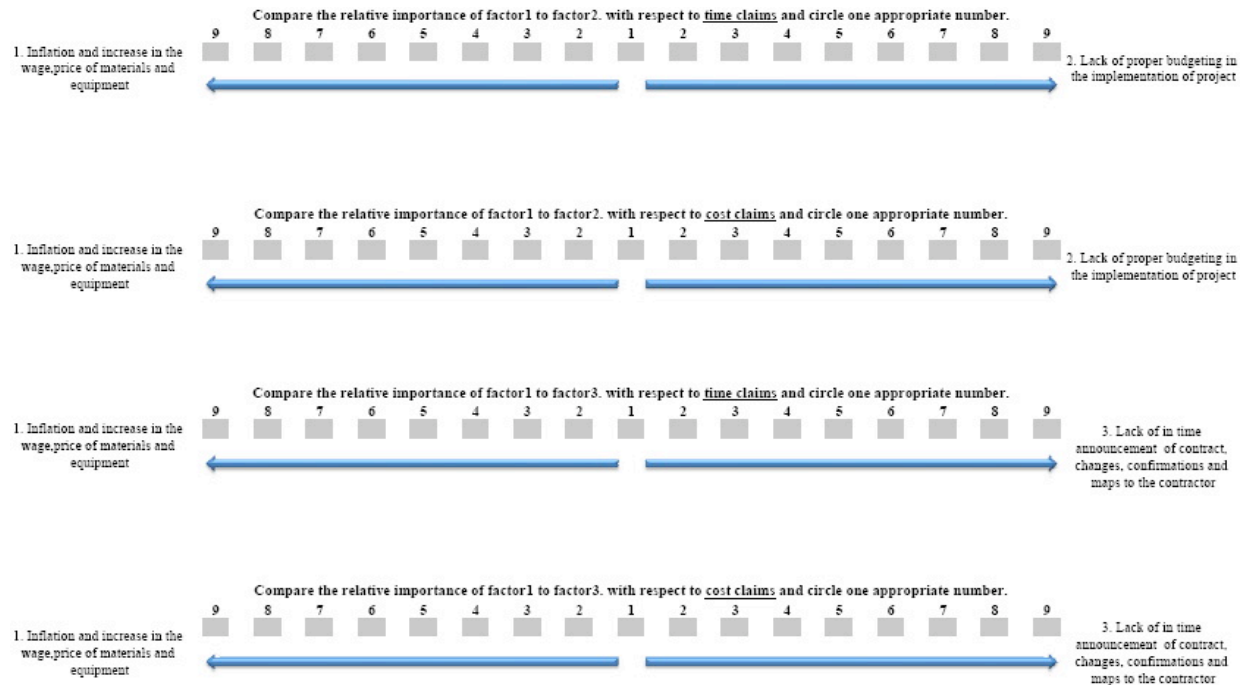1- Judgment with consensus

2- Individual judgment

Figure 2. The process of answering the questionnaires in the form of pairwise comparison

In this study, individual judgment has been used. For this purpose, some questionnaires have been developed for pairwise comparison between factors and seven project managers were asked to perform pairwise comparison in accordance with analytical hierarchy process. The process of answering the questionnaires is illustrated in figure 2. As shown, these factors have been compared with each other on the basis of their importance on the cost claims and the same trend was repeated for the time claims. In addition, time and cost claims have been compared to each other. For the sake of comparison, a number was selected in accordance with its importance.

Table 2. Saaty's scale for AHP preference

Saaty's Scale for AHP preference		
Intensity for Importance	**Definition**	**Explanation**
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate Importance	Experience and judgment slightly favour one over another
5	Strong Importance	Experience and judgment strongly favour one over another
7	Very Strong Importance	Activity is strongly favoured and its dominance is demonstrated in practice
9	Absolute Importance	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Intermediate Importance	Used to represent compromise between the priorities listed above
Reciprocal of above non-zero numbers	If activity (i) has one of the above non-zero numbers assigned to it when compared with activity (j), then (j) has the reciprocal value when compared with (i)	

For the method of pairwise comparisons, the values 1 through 9 were used. If two factors have the same importance to the controller criterion, the number 1 will be assigned. On the other hand, if one factor has a significant importance to the other one, the number 9 will be used. In this study, it was concluded that cost claims are 5 times important than time claims.

91 pairwise comparisons have been made for each questionnaire. This high number of comparison may leads to produce inconsistency among comparison of experts that is natural.

After collecting the questionnaires, the compatibly of criteria has been investigated. The pairwise comparison matrix with inconsistency rate lower than 0.1was accepted. Among seven collected questionnaires, three of them were accepted. The obtained results from accepted questionnaires were referred to individuals and consequently the pairwise comparison matrix with maximum rate of 0.09 was obtained.

As it is cited in the tables, inconsistency rate was kept equal to 0.1. This indicated the logic judgment of individuals. It should be noted that the aim of this paper was not to conduct statistical study, but to propose a new method for prioritization of the resources of claim arising based on their effects on the time and cost claims. And as such, this study focuses on the field of oil and gas industry. Because the obtained relative weights are related to this field, applying the model in other fields require experts' comments.

General prioritization of effective factors in arising time and cost claims along with group weight, consistency rate and total weight are listed in the following tables.

Table 3. General priority of effective factors in arising cost claims

Claim group	Group weight	Factors	Consistency ratio	Weight in group	Global weight
Cost Claims	0.833	Inflation and increase in the wage, price of materials and equipment.	0.09	0.287	0.239
		Political and economical sanctions and consequently failing to provide foreign materials and equipment.		0.078	0.064
		Lack of proper budgeting in the implementation of project.		0.138	0.114
		Contractor selection on the basis of only lower bid price and without considering the technical capabilities.		0.036	0.029
		Wrong estimate and arranging the contract based on unreal issues.		0.105	0.087
		Lack of in time completion of the project.		0.021	0.017
		Lack of in time announcement of contract, changes, confirmations and maps to the contractor.		0.022	0.018
		Increase in the costs equal to more 25 percent of contract price.		0.062	0.051
		Conducting extra work without specified price in the contract.		0.277	0.189
		Changes in the price of foreign currencies.		0.025	0.02

Table 4. General priority of effective factors in arising time claims

Claim group	Group weight	Factor	Consistency ratio	Weight in group	Global weight
Time Claims	0.167	Inflation and increase in the wage, price of materials and equipment.	0.08	0.031	0.00517
		Political and economical sanctions and consequently failing to provide foreign materials and equipment.		0.251	0.0419
		Lack of proper budgeting in the implementation of project.		0.211	0.0352
		Contractor selection on the basis of only lower bid price and without considering the technical capabilities.		0.079	0.0131
		Wrong estimate and arranging the contract based on unreal issues.		0.057	0.0095
		Lack of in time completion of the project.		0.178	0.0297
		Lack of in time announcement of contract, changes, confirmations and maps to the contractor.		0.133	0.0222
		Increase in the costs equal to more 25 percent of contract price.		0.017	0.0028
		Conducting extra work without specified price in the contract.		0.028	0.00467
		Changes in the price of foreign currencies.		0.016	0.00267

3-6-General priority

Finally, general prioritization of effective factors in arising time and cost claims through considering the importance of time and cost claims is as follows:

Table 5. General priority of effective factors in arising time and cost claims

Factors	Overall priority
Inflation and increase in the wage, price of materials and equipment	0.244
Conducting extra work without specified price in the contract	0.194
Lack of proper budgeting in the implementation of project	0.151
Political and economical sanctions and consequently failing to provide foreign materials and equipment	0.106
Wrong estimate and arranging the contract based on unreal issues.	0.097
Increase in the costs equal to more 25 percent of contract price.	0.055
Lack of in time completion of the project	0.047
Contractor selection on the basis of only lower bid price and without considering the technical capabilities	0.043
Lack of in time announcement of contract, changes, confirmations and maps to the contractor	0.04
Changes in the price of foreign currencies	0.023

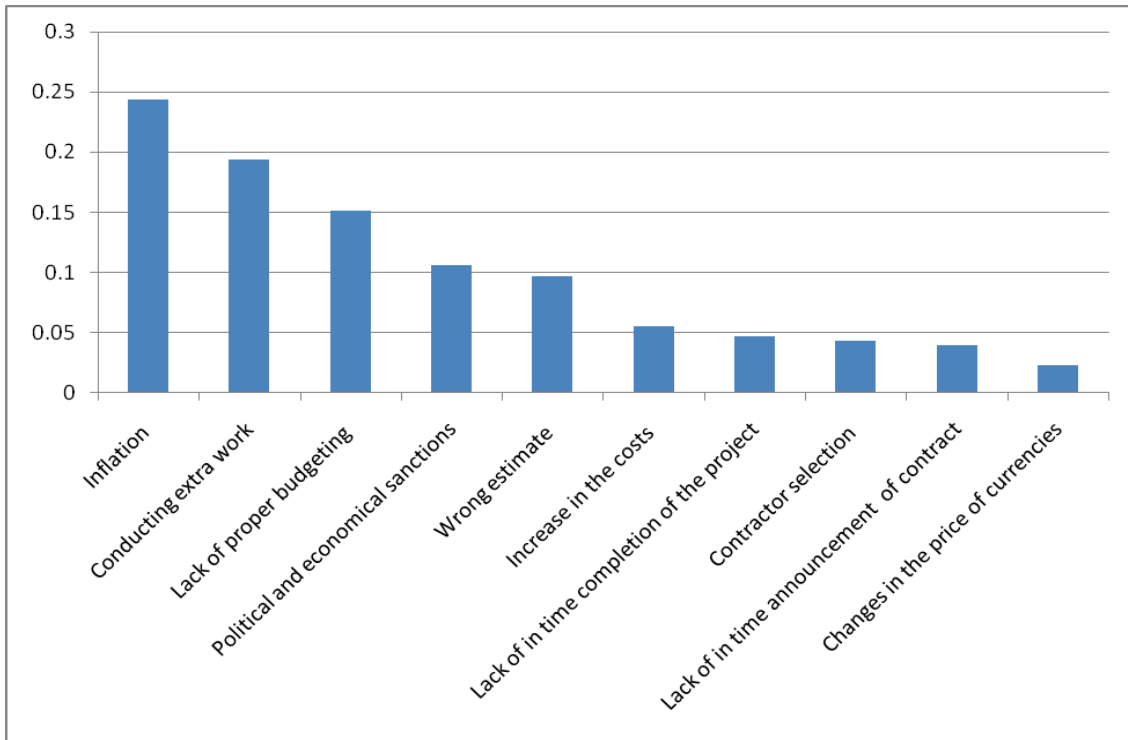With the aim of better comparison, chart 3 is presented.

Figure 3. The chart of general priority of effective factors in arising time and cost claims

First, the correspondent weights were derived from questionnaire on the basis of time and cost claims. However, in order to determine general priority, a comparison made between time and cost claims should be considered. In the following figures, the role of time and cost claims in the general priority is illustrated.
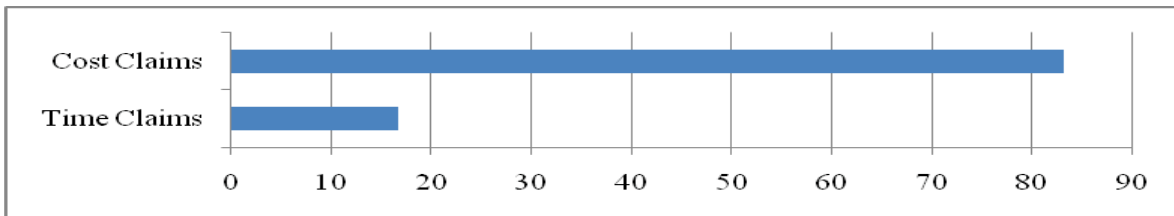

Figure 4. Importance chart of time and cost claims according to experts' viewpoint
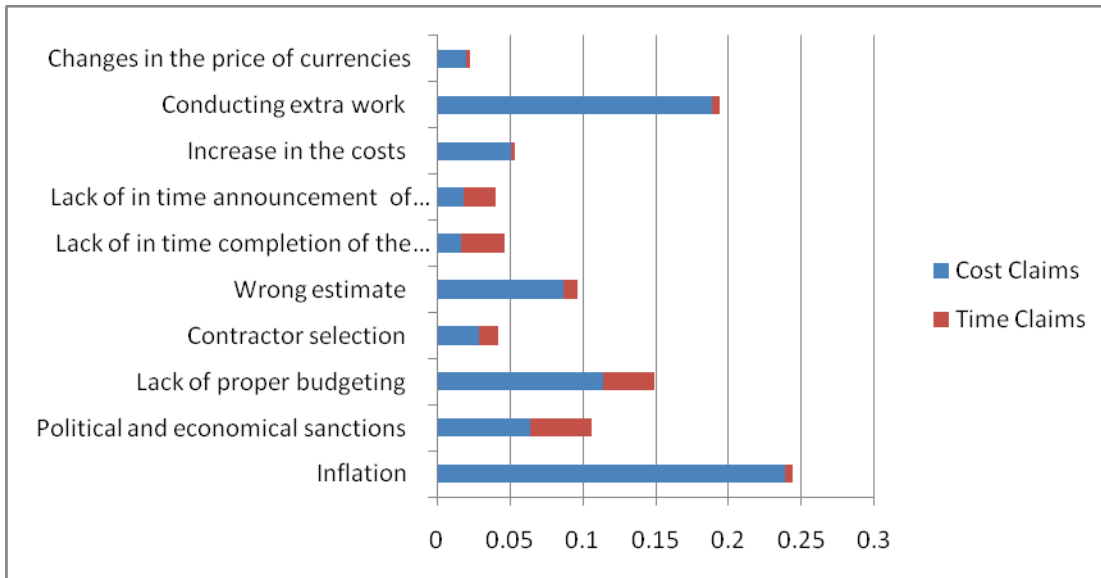
Figure 5. Importance chart of recourses of claim arising according to their importance on the time and cost claims

As can be seen clearly, changes in the importance of time and cost claims may lead to some changes in the quantity values and consequently ranking. In order to conducting a comprehensive study, these changes should be considered.

4- Sensitivity analysis

As sated previously, relative weights of each factor have prioritized using pairwise comparison in the field of gas and oil industry. Experts emphasized more on importance for cost claims. Therefore, in order to apply the model to the other fields, it is required to conduct sensitivity analysis.

Sensitivity analysis is used to determine how "sensitive" a model is to changes in the value of the parameters of the model and to changes in the structure of the model. In the sensitivity analysis was conducted by changing the importance of time and cost claims and then observing the results.

In order to prioritize of sources of claim arising in the field of gas and oil industry, the importance of cost claims was assumed by far higher than time claims. Then different cases were considered for conducting sensitivity analysis. At first, the importance of cost and time claims was assumed to be 100 and 0 percent, respectively. Then, these values assumed to be 95 and 5 percent. This trend continued till the importance of cost and time claims were 0 and 100 percent, respectively.

As it shown in the charts, as the importance of cost claims increases in a project, the role of "inflation and increase in the wage and price of equipment and machinery" becomes more critical in arising claims and vice versa. This is because the above mentioned factor may lead to increase the project costs. On the other hand, when the time claims are more important, "political and economical sanctions and failing to provide foreign equipment and materials" becomes a more important reason to arise claim. This factor may cause some delay in the implementation of project and consequently the role of time claims become more important in the project.

The most important reasons to arise cost claims are as follows:
1- Inflation and increase in the wage, price of materials and equipment

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2- Conducting extra work without specified price in the contract
3- Lack of proper budgeting in the implementation of project
And the most important reasons to arise time claims include:
1- Political and economical sanctions and consequently failing to provide foreign materials and equipment
2- Lack of proper budgeting in the implementation of project
3- Lack of in time completion of the project

In the following figures, horizontal axis represents time and cost claims and the vertical axis shows the importance rate of claims. The perpendicular line to the horizontal axis implies the experts' viewpoints. The importance rate of each factor can be obtained from intersection of this line with the mentioned factor.
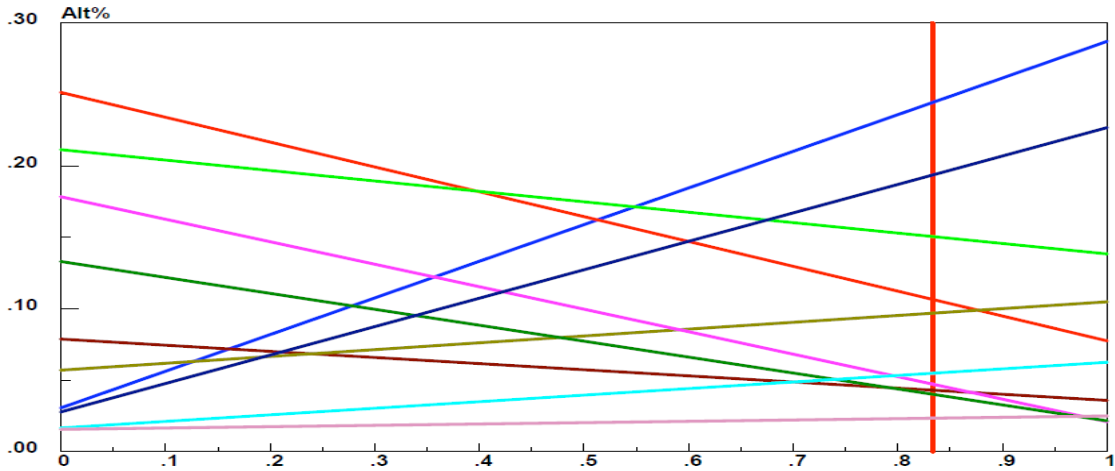
Figure 6. The chart of change in the prioritization of sources of claim arising with different importance of cost claims in the project
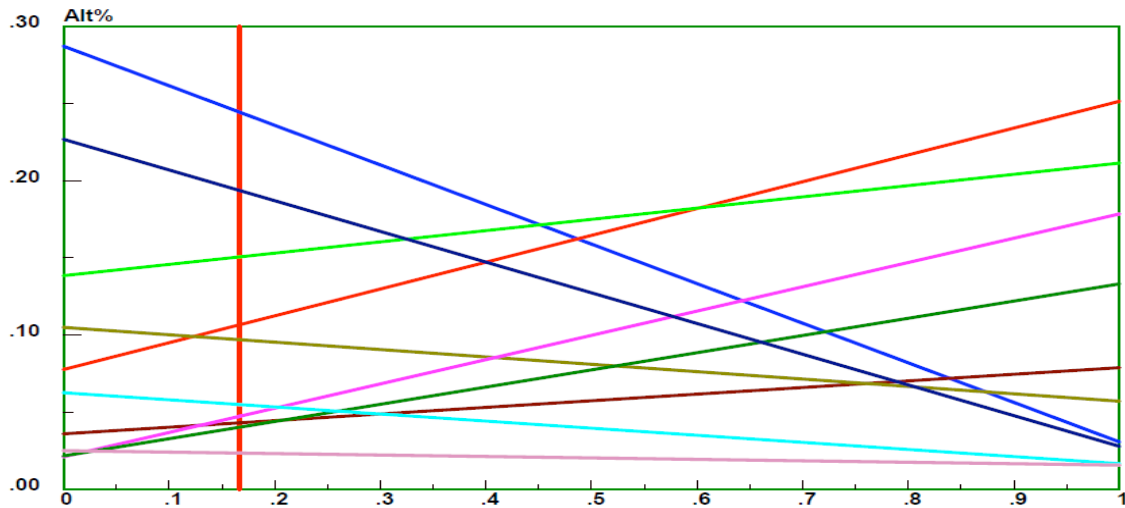
Figure 7. The chart of change in the prioritization of sources of claim arising with different importance of time claims in the project

In the following table, the correspondent factor with color of each line is presented.

Table 6. Correspondent factor with color of each line

████	Political and economical sanctions and consequently failing to provide foreign materials and equipment.
████	Lack of proper budgeting in the implementation of project.
████	Lack of in time completion of the project.
████	Lack of in time announcement of contract, changes, confirmations and maps to the contractor.
████	Contractor selection on the basis of only lower bid price and without considering the technical capabilities.
████	Wrong estimate and arranging the contract based on unreal issues.
████	Inflation and increase in the wage, price of materials and equipment.
████	Conducting extra work without specified price in the contract.
████	Increase in the costs equal to more 25 percent of contract price.
████	Changes in the price of foreign currencies.

As it is cited in the above figures, the factor of "Lack of proper budgeting in the implementation of project" was among the most important factors in all cases considered. This indicated the importance of above-mentioned factor in different projects with different importance rate of time and cost claims. Accordingly, giving more attention to this factor may plays a valuable role in decrease in the claim arising. The factor "changes in the price of foreign currencies" is characterized as the least important factor among 10 factors. Prioritization of factors may be obtained through plotting a perpendicular line to the charts 6 and 1. Figure 8 illustrate the priority of factors. The right and left hand axis show the score of factors and importance of criteria.
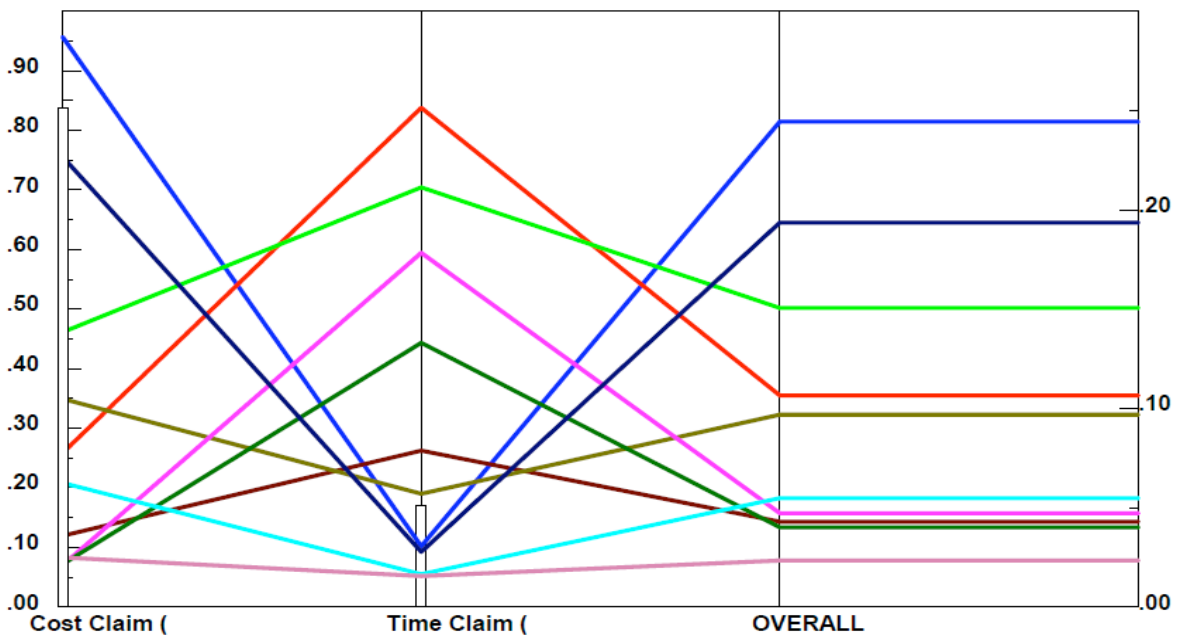

Figure 8. Illustration of sensitivity analysis of sources of claim arising

Definition of each line and the correspondent color in chart 8 is similar to previous chart and table. In the above figure, prioritization of factors based on the time and cost claims, ranking of factors and changes in the importance of claims in different projects are illustrated. As shown, the importance of cost claims decreases as the importance of time claims increases. Therefore, importance of factors such as "inflation and increase in the wage, price of materials and equipment" and "conducting extra work without specified price in the contract " decrease and in the opposite trend, the importance of "Political and economical sanctions and consequently failing to provide foreign materials and equipment" increases. As can be seen clearly, "lack of proper budgeting in the implementation of project" has always high importance in the time and cost changes.

5-Conclusion

In references, claim is defined as a demand for something due or believed to be due. Claims are a normal part of construction project performance. In the construction projects, the term "something" is usually assigned to extra cost or extra time. Thus, two types of claims can be defined, namely, time and cost claims. However, the differences between these two claims have not been much addressed. In view of this, an attempt is made in the present study to evaluate the most important reasons in the claim arising. For this purpose, analytical hierarchy process has been used based on its wide applicability and reliability. Regarding the effects of these factors on the cost and time claims, they have been evaluated using pairwise comparison. Altogether, 91 questionnaires have been prepared and identify the most important factors. Then, they were prioritized in accordance with their effects on the claims. The consistency rate less than 0.1 indicated the accuracy of the prioritization. These factors in prioritization order are as follows:

1- Inflation and increase in the wage, price of materials and equipment
2- Conducting extra work without specified price in the contract
3- Lack of proper budgeting in the implementation of project
4- Political and economical sanctions and consequently failing to provide foreign materials and equipment
5- Wrong estimate and arranging the contract based on unreal issues.
6- Increase in the costs equal to more 25 percent of contract price.
7- Lack of in time completion of the project
8- Contractor selection on the basis of only lower bid price and without considering the technical capabilities
9- Lack of in time announcement of contract, changes, confirmations and maps to the contractor
10- Changes in the foreign currencies

Regarding the fact that this prioritization has been made in accordance with expert's viewpoints and the importance of time and cost claim, therefore, sensitivity analysis has been carried out on the proposed prioritization. This is because the importance of claims varies from one project to another according to the circumstances and this analysis enables project managers to make the best decision.

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