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# Risks Evaluation of Sahand New Town 1226 Housing Project and Exploring Their Effects on Time and Cost of the Project

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## Abstract

**The main objective of this research is Risks Evaluation of Sahand New Town 1226 housing Project by means of Project Management Body of Knowledge (PMBOK) model in Iran. PMBOK presents a set of standards and guidelines for project management. After reviewing the literatures, 22 risk items have been identified. 19 risks were finalized under 5 factors of Administrative, environmental, economic and political and organizational using exploratory analysis. Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method under four criteria cost, time, quality and safety was used to select 2 work packages as the most important work packages. Consequently, the activities of the selected work packages were obtained via opinion's experts. Then, the risks were categorized into direct risks and indirect risks using semi-structural interview with experts. Results showed that financial risk was known as most important indirect threat and risk of delay in supply and mistakes in construction were the most important direct threat. Finally, the impact of risks on time and cost of the project were obtained as the follow: the project with 90% probability would finish with 29.39 months delay. Similarly, with 90% probability will have 4003.837IRR increase in cost.**

## Keywords

**Project Management, Project Risk Management, PMBOK Standard, TOPSIS Method**

## 1. Introduction

The increasing size and complexity of the construction projects have added risks to their execution. With the

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need for improved performance in construction project and increasing contractual obligations, the requirement of an effective risk management approach has never been more necessary [1].

The science of risk management was first theorized in the 16th century Renaissance. Since the 1990s, many risk management models have been proposed, all of which aim to increase success rates [2]. In general, all these models have the same principals and only differ in their execution steps [1]. Risk management is a means of dealing with uncertainty—identifying sources of uncertainty and the risks associated with them, and then managing those risks such that negative outcomes are minimized (or avoided altogether), and positive outcomes are capitalized upon. The need to manage uncertainty is inherent in most projects which require formal project management [3].

The history of risk management concept dates back to the Babylonian people in the 18th century BC. In the Code of Hammurabi it says that: if a constructor builds a house for someone and that building is not strong enough and collapses on the owner and kills him, the constructor should be penalized. Risk management has played an important role in construction design over the millenniums. The word risk comes from the Latin word resicum, meaning cut off that refers to a danger to boating or shipping [4].

The risk of a project always belongs to the future. It is an uncertain scenario or event that if occurred, it can affect at least one of the objectives of the project including: range, time, cost and quality. A risk can have one or more causes that if occurred, they can have one or few consequences. Moreover, a cause can be a need, Imposition, restriction or a condition that can create positive or negative results. For example, a cause can either be the need for an environmental permit for commencing the project or restricted number of staff for designing it, in the first example the environmental institute may give the permit late and delay the project and in the second example the project designing potential of limited staff numbers is considered risk factors. If any of the unprecedented causes occur, it might affect the cost, time or quality of the project. Risk causes can include environmental or organizational aspects of project such as; improper management, lack of integrated management systems, multiple projects or affiliation with foreign companies that are out of reach [5].

Considering the report of project manager of the Sahand new town, it consists of 4 phases, including: 460 units Sahandieh, 230 units Fereshteh, 270 units Rezvan and 266 units Nastaran. It started on January 16, 2010. The project was estimated to take 18 months. According to the project progress report prepared on January 7, 2012, the project should have been finished, though only 30% progress has been made. Due to the time delay and increases in the cost of the project, it was decided to identify project risks and estimate the impact of these risks on the time and cost of the project.

According to surveyed studies, most projects are completed with delay than the expected time and spending more budget than was predetermined with lower quality than estimated. This reduction of accuracy in prediction of objectives and lessening of efficiency is because of presence of risks and uncertainty in projects. Therefore, the need for recognition of risks its management in projects seems to be absolutely necessary [6].

## Literature Review

Risk is the probability of occurrence of uncertain events that can either have a positive or a negative effect. The difference between risk and uncertainty is that we can predict the probability and intensity of risk. Certainty is synonymous with the absence of doubt, and it is translated so in the dictionary. However, its opposite is uncertainty, which means doubt about the ability to predict the future. It is apparent that the word uncertainty, describes a state of mind and it is used when there is no certain outcomes predicted. In other words, uncertainty is used to describe events that the intensity and probability of their occurrence is unknown and unpredictable [7].

Some Authors prefer to use risk and uncertainty interchangeably, for example, Kaplan and Garrick [8] define risk as uncertainty and damage. Chapman and Cooper [9] define it as an unpleasant concept of uncertainty. Another source has defined it as uncertain outcome of activities or manageable decisions [10].

Other authors however, have used definitions to segregate risk and uncertainty. Uncertainty in judgment can be caused by A) complexity of work or B) education level, confidence or experience; whereas, uncertainty in estimating parameters is caused by: 1) inaccessible and incomplete data or 2) estimates in Statistical Analysis methods [11].

Risk management is the systematic application of management policies, procedures and processes relating to the analysis and assessment of risk control. Risk management is the process of documenting the final decision and identifying and implementing measures that can be used to convey the risks to an acceptable level [12]. The Risk Management Project Management Institute has introduced risk as one of the nine original levels (general knowledge of project management) [13].

Purchasing Managers' Index (PMI) has described risk break-down as a managed hierarchy of project risks that are classified based on the type of risk. Based on PMBOK, risk breakdown structure sets a framework for risk estimation in a project. Risk breakdown structure is similar to the Work Breakdown Structure (WBS) and can have many benefits, as the resources divide risk to many compartments [14].

Risk breakdown structure was designed for classifying risks by software developers. The first level involves: project engineer, development, environment and program limitations. Second level involves: requirements, design, integration test, engineering specialties, development process, development system, management system, management methods, work environment, resources, contracts and program level [15]. A risk breakdown structure has been suggested for construction that includes these groups: environment, industry, customer and project. Second level includes: law, market, client, project management team, aims, budget, tactic, team and duty [16].

Risk breakdown structure is designed for international construction projects. The first level of the hierarchy is divided into two parts, project and project area. Project itself is divided into four subgroups that include: complexity, inaccessibility, ambiguity and limitations. Project area is divided into seven subgroups that include: weak international relations, Undesirable economic environment, weak attitude toward foreign companies, immature legal system, Social complexity and differences [17].

Hillson [18] believes that the high quality of risk breakdown structure allows it to be used in conjugation with any risk determination method to identify the risk. For example, risk determination workshop or brainstorming may use different elements of risk breakdown structure. Hillson also believes that risk breakdown structure can be used to generate a common tongue and technical terms to store the lessons learned and supports regular reports.

Kaming *et al*. [19] evaluated the factors affecting time and cost of construction projects. They used surveys filled by project managers in charge of skyscraper construction in Indonesia, and by using factor analysis technique the identified and classified these risks.

Mulholland and Christian [20] explained a systematic method for estimating risks associated with timing of the construction projects. Chapman [16] looked into implications such as: uncertainty, risk, threat, and opportunity. By analyzing models discussed until then, he discovered that most risk management models look at risk as a threat. Furthermore, they suggested increasing the importance of using opportunities in risk management models to increase its efficiency.

Roz and Michael [21] identified the tools used for different risk management processes. In this project gathering the tools was with guide to the Project Management Body of Knowledge method, by the America Project Management Institute. In this research, 100 tools were initially identified which were reduced to 38 tools with the help of experts.

Another paper looks at risk management by an analytic hierarchy process (AHP), which does analysis on a decision tree. Furthermore, this paper explains all proposed methods through the oil pipeline project across India [21].

Wang *et al*. [22] proposed a risk management model for international companies that have construction projects in developing countries. To certify their model, they studied the identification and risk Assessment of construction projects in China. Zou *et al*. [23] Using surveys the found the most important risks affecting construction projects in China and they published their findings by comparing their data to a similar model done in Australia.

Evaluating and analyzing risk factors in great construction projects, a nonparametric technique called the jackknife is used [5]. The results obtained from these methods in a project are compared with results obtained from other popular techniques on the same project [24]. A research has used reason's breakdown theory to propose a systematic method for studying direct and indirect effects of risk on patients [25]. Ergu *et al*. [26] used maximum threshold eigenvalues as a consistency index for ANP method in analysis of risk and decision. The mathematical threshold is equal to consistency Rate (CR).

Yeldiz *et al.* [27] devised a science based risk mapping tool that systematically determines risk related variables that increase costs in international markets. This tool uses ontology to link risk to increased costs and a vulnerability assessment method, so that we can predict possible risks linked to international construction projects.

Taylan *et al*. [28] have evaluated major risks of construction project using new analysis tools under uncertain conditions. They also tried to classify risks properly and increase their level to develop strategies and neutralize potential risk factors predicted.

Taklif *et al.* [29], utilized TOPSIS approach to quantify risk analysis in industrial investment projects. They designed a program in visual basic software to identify the project risk. Another research has been investigated to identify the risks of information and communication technology projects. In this research, FMEA and TOPSIS were used to identify and to evaluate of the projects. Final result of the study showed that there is a high correlation between FMEA and TOPSIS models [30].

## 2. Methodology

In a current research to identify and assess risks in construction projects of 1226 new houses in Sahand town, the PMBOK standard model was used. The research steps are illustrated in **Figure 1**. After literature review [1] [31]-[33], 22 risk items were identified. To identify the most important risks, exploratory factor analysis was used. This factor analysis along with Factor loadings and Operating Division are then assessed. The calculations of acquiring eigenvalues for classifying the 22 risk items into some factors which were done by SPSS software based on factor analysis on 22 risks (3 risks of 22 risks were excluded from further analyses); five factors were proven to be main factors. These five factors are labeled as:

1) Technical risk,
2) Administrative risk,
3) Environmental risk,
4) Economic and political risk,
5) Organizational risk.

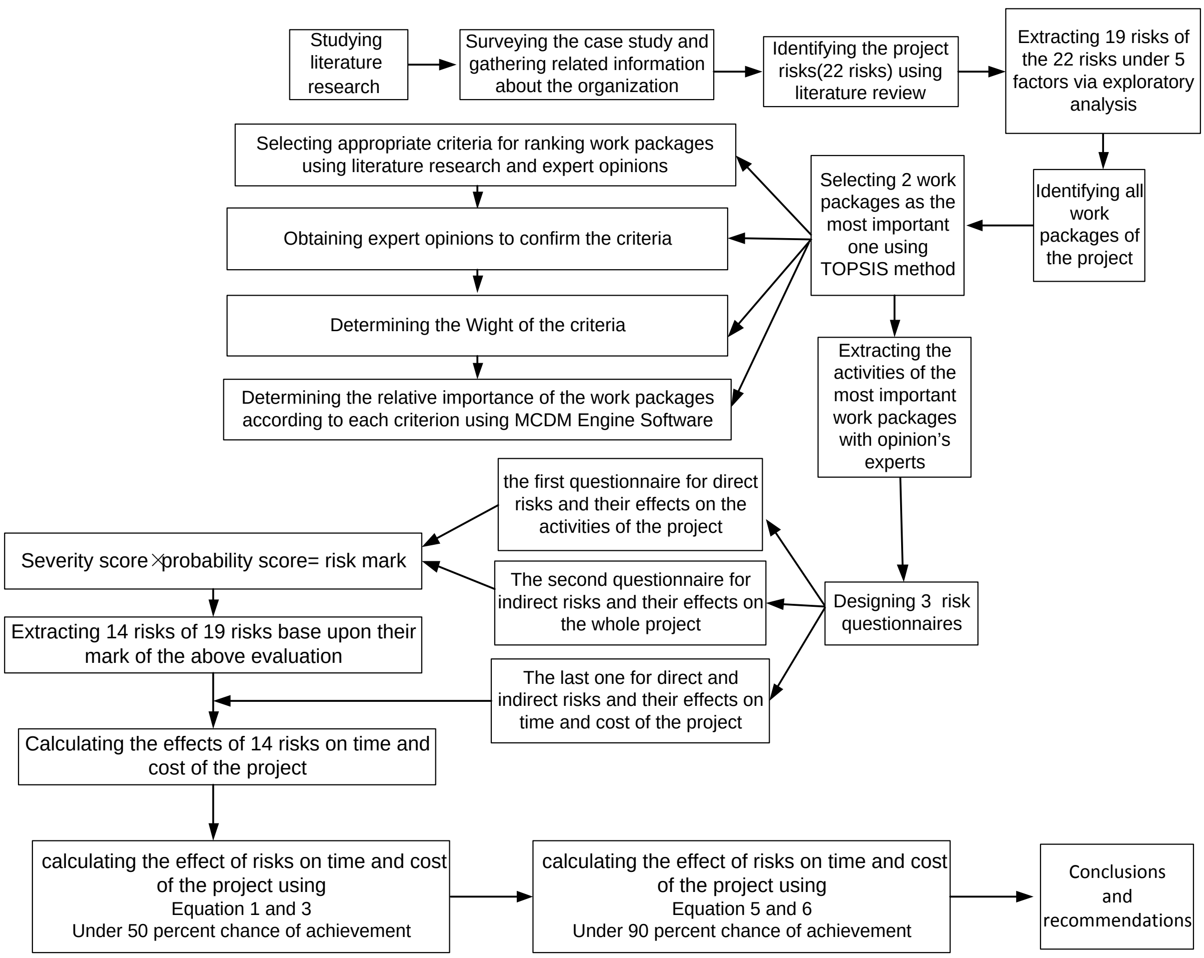


**Figure 1.** Steps to conduct research.

Based on **Table 1** and Factor loading coefficients, five main indexes have been identified and variables are shown in **Figure 2** respectively set based on factor loading.

After identifying hidden and latent variables, risk breakdown structure is formed; **Figure 2** shows risk of

**Table 1.** Rotated component matrix[a].

| | Component | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Mistakes of construction | 0.692 | 0.363 | 0.010 | −0.210 | −0.218 |
| Scope change | −0.003 | 0.589 | −0.006 | −0.153 | 0.280 |
| Military dereliction of duty | 0.535 | 0.051 | −0.280 | −0.244 | −0.196 |
| Events during execution | 0.910 | −0.029 | −0.157 | 0.104 | −0.207 |
| Delay in supply | 0.090 | 0.840 | 0.062 | −0.267 | −0.006 |
| Financial risk | 0.164 | 0.056 | −0.223 | 0.782 | −0.142 |
| Natural changes in climate | −0.212 | −0.059 | 0.645 | −0.059 | 0.284 |
| The lack of infrastructure in the region | −0.072 | −0.162 | 0.870 | 0.039 | −0.251 |
| Defective equipment | 0.120 | 0.913 | −0.155 | −0.220 | 0.033 |
| Abnormal changes in climate | 0.127 | −0.225 | 0.793 | −0.059 | −0.085 |
| Inflation risk | −0.251 | 0.138 | −0.274 | 0.893 | 0.007 |
| Lack of quality of materials | −0.010 | 0.903 | −0.163 | 0.080 | −0.259 |
| Rules and regulation changes | −0.217 | 0.109 | −0.193 | 0.925 | 0.024 |
| Economic and political sanction | 0.052 | −0.258 | 0.073 | 0.900 | −0.236 |
| Changes in government policies | −0.251 | −0.274 | 0.138 | 0.893 | 0.007 |
| inability of project owners | −0.268 | 0.029 | 0.040 | −0.149 | 0.893 |
| Negligence of consultants | 0.024 | 0.109 | −0.193 | −0.217 | 0.925 |
| Incompetence contractors | −0.251 | −0.274 | 0.007 | 0.138 | 0.893 |
| Technical and engineering changes | −0.241 | 0.676 | 0.008 | 0.138 | −0.273 |

[a]means that data are calculated based on 95% possibility in SPSS software.

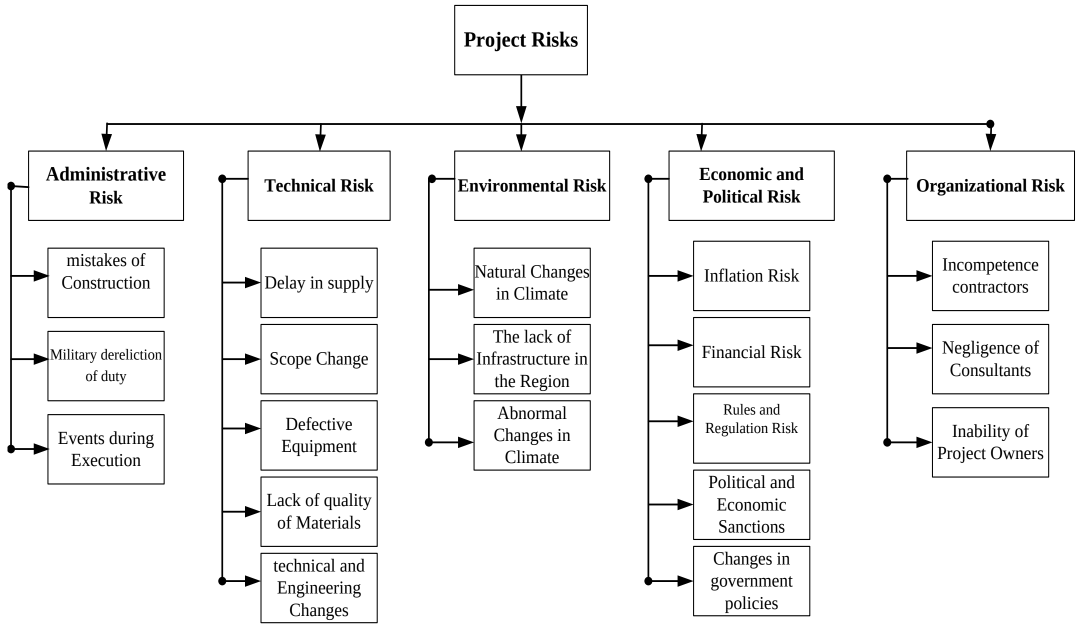


**Figure 2.** Risk breakdown structure of the project.

project failure in construction projects of 1226 new houses in Sahand town. Then, four of the most important work packages are identified using TOPSIS method as: cost, time, safety and quality. The work package is a subset of a project that can be assigned to a specific part for execution in this paper it is assumed that these packages are independent of each other and the calculations are done using MCDM engine software. To identify the most important risks in the construction project of 1226 buildings of Sahand new city, the experts divided the risks into two groups of direct and indirect risks. Direct risks are risks that their probability and their direct effect can be measured on important work packages. The probability and effect of indirect risks however can be measured on the whole of project. Furthermore, using the surveys that are designed for this very reason, probability and intensity of each risk is obtained and the most important risks are identified. Finally the output of SPSS software for all 19 risks is shown in **Table 1**.

The model used in this research is PMBOK and it is made of five steps:

1) Risk management planning: process of defining how to conduct risk management activities of the project.

2) Risk identification: The process of determining and recording the risks affecting the project. The study aims to identify the risks, a questionnaire was distributed among experts project. The use of exploratory factor analysis, latent variables were identified project risks identified.

3) Qualitative Risk Analysis process: of prioritizing risks for further analysis to assess and combine probability and effect. In this study, in order to prioritize risks, according to the experts, the project risks are divided into two categories: direct and indirect risks. The likelihood and impact of direct and indirect risks have been obtained in two separate questionnaires.

4) Quantitative Risk Analysis: Numerical analysis of the impact of identified risks to the overall objectives of the project. In this study, with the use of expert opinion, the effect of the most important risks on the cost and period of the project is obtained.

5) Risk Response Planning: The process of examining options to enhance opportunities and reduce threats to project objectives. The project will then identify the most important risks and calculating the effect of risk on the cost and period of the project using matrix response to the risks, according to expert Opinion obtained [5].

Using exploratory factor analysis, hidden variables were identified. After identifying hidden and latent variables, we establish the risk breakdown structure of our project. **Figure 2** shows Risk Breakdown Structure of 1226 units in Sahand New Town project. As you can see in the figure, 19 risks are under five indicators. The first level of the hierarchy consists of one component, the project risks. The rest of project risks are divided into five sub-categories, which include Administrative Risk, Technical Risk, Environmental Risk, Economic and Political Risk and Organizational risk. In the third level of risk, each indicator is shown.

The most important work packages are shown in **Table 2**.

It is the experts' suggestion that In order to provide a suitable solution to respond to the risks effectively, we should identify the risks corresponding to the most important activities. Since the activities of this project were enormous, we were unable to investigate all of them. For this reason, we initially identified the most important work packages then we extracted their activities.

In order to determine the most important working packages, ten dual comparative questionnaires were issued to the senior managers and top project engineers. "TOPSIS "software is employed to prioritize the work packages with higher degree of importance. According to the experts' opinion, the top five work packages are selected for dual comparative purpose. The work packages listed in order are as follows:

1) Foundation and structure work,

2) Workshop equipment,

3) Performing lean concrete,

4) Installing elevator guide rail,

5) Plaster and white wash.

These work packages are prioritized based upon four criteria listed below:

1) Time, 2) Cost, 3) Safety, 4) Quality.

It is assumed that these criteria are not correlated and regarded independently from one another. Also, the calculations are run by MCDM engine software. As per experts' opinion, the most important work packages for the urban development project consisting 1226 units of the new City of Sahand, are as follows:

1) Plaster and white wash,

2) Foundation and structure work,

3) Installing elevator guide rail,

**Table 2.** The most important work packages of the project.

| Start Project | 1 |
|---|---|
| Workshop equipment | 2 |
| Excavation | 3 |
| Revetment | 4 |
| Performing lean concrete | 5 |
| Foundation and structure work | 6 |
| Roof insulation | 7 |
| Door frame Slope roof | 8 |
| Run drains | 9 |
| Plaster and white wash | 10 |
| Performing electrical facilities | 11 |
| Concrete flooring and Stained concrete work | 12 |
| Bath room insulation | 13 |
| Floor ceramic and tile work | 14 |
| Installing elevator guide rail | 15 |
| Outlook painting | 16 |
| Installing windows | 17 |
| Performing the pipes and electrical installation | 18 |
| Performing fire sprinklers | 19 |
| Gas piping | 20 |
| Masonry of area and stares | 21 |
| Installing elevator | 22 |
| Performing non-structural ceiling | 23 |
| Installing fence and metal doors | 24 |
| Installation of wooden doors | 25 |
| Internal painting | 26 |
| Dismantling workshop | 27 |
| Finish | 28 |

4) Workshop equipment,
5) Performing lean concrete.

## 2.1. The Most Important Packages Main Tasks

To discover direct risks, having determined the main work packages, their entailing tasks are determined. These tasks are obtained from the direct suggestion of the project manager.

Work packages tasks" Plaster and white wash" and "Foundation and structure work" has shown in **Table 3** and **Table 4** respectively.

## 2.2. Calculating the Possibility of Occurrence and Severity of Direct Risks

In this project, eight direct risks are identified for Foundation and structure work and nine risks for Plaster and white wash. Some questionnaires are drawn up with regard to the work packages including tasks and the direct risks involved. These questionnaires were issued to 53 members of staff and managing department of the 1226-unit project in the new City of Sahand; fifty replies were received, the result of which is illustrated in **Table 5** and **Table 6**.

## 2.3. Calculating Possibility of Occurrence and Indirect Risks Severity

The indirect risks are those whose probability and effects can be calculated on the whole project. These risks are recognized and announced by experts. A Questionnaire has been composed to allow calculating the probability

**Table 3.** Work package tasks of plaster and white wash.

| Plan control and extra angel prevention | 1 |
|---|---|
| Carcass implementation (plumbing and perpendicular investigations) | 2 |
| Cement and perpendicular controls | 3 |

**Table 4.** Work package tasks of foundation and structure work.

| Performing lean concrete | 1 |
|---|---|
| Armature installation | 2 |
| Rebar framing | 3 |
| Concrete extrusion | 4 |
| Rebar framing | 5 |
| Implementation of axis of columns | 6 |
| Concrete work | 7 |
| Concrete preparation and curing | 8 |
| open the extrusion | 9 |

**Table 5.** Calculating the possibility of occurrence and severity of direct risks (plaster and white wash) [21].

| Risk Mark | severity | Possibility of occurrence | | Risk |
|---|---|---|---|---|
| 4 | 2 | 2 | Delay in supply | Technical |
| 3 | 2 | 1.5 | Defective equipment | |
| 5 | 2.5 | 2 | Lack of quality of Materials | |
| 10.67 | 4 | 2.67 | Technical and engineering changes | Administrative |
| 13 | 4.33 | 3 | Mistakes in construction | |
| 9.78 | 3.67 | 2.67 | Military dereliction of duty | |
| 12 | 4 | 3 | Events during Execution | |
| 1 | 1 | 1 | Natural changes in climate | Environmental |
| 4 | 2 | 2 | Abnormal changes in climate | |

**Table 6.** Calculating the possibility of occurrence and severity of direct risks (foundation and structure work) [21].

| Risk mark | severity | Possibility of occurrence | | Risk |
|---|---|---|---|---|
| 5.19 | 3.33 | 1.56 | Mistakes in construction | Administrative |
| 5.73 | 3.22 | 1.78 | Military dereliction of duty | |
| 3.98 | 2.56 | 1.56 | Events during Execution | |
| 1.49 | 1.22 | 1.22 | Natural changes in climate | Environmental |
| 2.1 | 1.89 | 1.11 | Abnormal changes in climate | |
| 6.44 | 3.22 | 2 | Delay in supply | Technical |
| 5.46 | 2.89 | 1.89 | Defective Equipment | |
| 6.33 | 3 | 2.11 | Lack of quality of Materials | |

and severity of these risks. Questionnaires were issued to 53 experts, fifty of whom filled it out and submitted it. The results are shown in **Table 7**.

## 2.4. Identifying the Most Important Risks in the Project

After multiplying the possibility of occurrence by severity of risk yields the risk mark. The risk with the higher mark assumes a higher priority [34]. **Table 8** lists each of the obtained marks.

**Table 7.** Calculating the possibility of occurrence and severity of indirect risks [21].

| Risk mark | severity | Possibility of occurrence | Risk |
|---|---|---|---|
| 6 | 2 | 3 | **Inflation** |
| 16 | 4 | 4 | **Financial** |
| 10 | 5 | 2 | **Rules and Regulation changes** |
| 6 | 2 | 3 | **Economic and Political Sanction** |
| 9 | 3 | 3 | **Changes in government policies** |
| 10 | 5 | 2 | **Incompetence contractors** |
| 10 | 5 | 2 | **inability of Project Owners** |
| 8 | 4 | 2 | **Negligence of Consultants** |
| 3 | 3 | 1 | **Scope change** |
| 6 | 3 | 2 | **Design and Engineering Changes** |
| 12 | 4 | 3 | **The lack of Infrastructure in the Region** |

**Table 8.** Calculating risks mark.

| Risk mark | Risk | Work package | Type of risk |
|---|---|---|---|
| 16 | Financial | - | **Indirect** |
| 12 | The lack of Infrastructure in the Region | - | **Indirect** |
| 10 | Incompetence contractors | - | **Indirect** |
| 10 | Inability of Project Owners | - | **Indirect** |
| 10 | Rules and Regulation changes | - | **Indirect** |
| 6.44 | Delay in supply | Foundation and structure work | **direct** |
| 6.33 | Lack of quality of Materials | Foundation and structure work | **direct** |
| 5.73 | Military dereliction of duty | Foundation and structure work | **direct** |
| 5.46 | Defective equipment | Foundation and structure work | **direct** |
| 5.19 | Mistakes in construction | Foundation and structure work | **direct** |
| 13 | Mistakes in construction | Plaster and white wash | **direct** |
| 12 | Events during Execution | Plaster and white wash | **direct** |
| 10.67 | Technical and engineering changes | Plaster and white wash | **direct** |
| 9.78 | Military dereliction of duty | Plaster and white wash | **direct** |

## 3. Results Analysis

The study aims to find important risks associated with the project and to estimate the effect of these risks on time and cost of the project. All the important risks have illustrated in **Table 8** and risks with higher than average probability and severity were selected for further studies. The severity of each of the risks, considering their effects on time and cost of the project, was independently achieved from the experts' opinion. In order to integrate the whole effect of the risks on time and cost of the project, we need to use the following equations. **Tables 4-7** shows the probability and severity of the most important risks in the project. The results below, in an attempt to calculate the increase in cost and time anticipated with the corresponding standard deviations are calculated by the following formulas: Here, $X$ is considered to be a discrete stochastic variable. The $r^{th}$ instant when $X$ varies around zero, we will have:

$$\mu_r = E\left(X^r\right) = \sum_X X^r p\left(X\right) \tag{1}$$

And if $X$ is a continuous variable, we will have:

$$\mu_r = E\left(X^r\right) = \int_{-\infty}^{+\infty} X^r f\left(x\right) \mathrm{d}x \tag{2}$$

The first moment of $X$, which is around zero, is called the average and is denoted by $\mu$. Hence, the r$^{th}$ central moment of $X$ or the r$^{th}$ moment around the average of $X$ is determined by the following equation:

$$\mu_r = E(X-\mu)^r \, p(x) \tag{3}$$

If $X$ is continuous, we will have:

$$\mu_r = E(X-\mu)^r = \int_{-\infty}^{+\infty} (X-\mu)^r f(x)\mathrm{d}x \tag{4}$$

The second central moment is known as the variance of the stochastic variable [21].

$$\mu_2 = E(X-\mu)^2 \tag{5}$$

- Therefore, from the data in **Table 9** and Equations (1)-(3), the following statistical parameters are acquired.
- The anticipated extension of the project duration = 27.8 months.
- The standard deviation = 1.21 months.
- The designated duration to complete the project = 18 months.
- The anticipated increase on the cost = $106,828.
- The standard deviation = 205.3 million Rials.
- The designated expenditure for the project = $701,0876.

A 50 percent chance does not keep any manager satisfied. The purpose of a more-realistic time-duration is realized by using a statistical model described by Yeo [35]. Therefore, the extended period of the project considering the initial planning is obtained by the following mathematical expressions:

$$Z = [X_t - \mu]/\sigma \tag{6}$$

$X_t$: The increased period of the project,

$\mu$: The anticipated increase in the period of the project (27.8 months),

$\sigma$: The period standard deviation (1.21),

$Z$: Value of the normal distribution diagram versus the probability (90% confidence level: 1.29).

Consequently, a project with 90 percent probability will have a delay with 29.36 months. Similarly, with a 90 percent probability, the project with undergo a $114,395 increased expense.

## 4. Conclusions

In this project, in order to identify the most significant risks initially questionnaires were distributed among ex-

**Table 9.** The possibility of occurrence and severity of the most important risks in the project.

| Risk mark | Effect on cost (million Rials) | Effect on time (month) | Probability | Risk | Work packages | Type of risk |
|---|---|---|---|---|---|---|
| 16 | 77.1 | 4 | 0.8 | Financial | - | **Indirect** |
| 12 | 86.66 | 2 | 0.6 | The lack of infrastructure in the region | - | **Indirect** |
| 10 | 27.33 | 4 | 0.4 | Incompetence contractors | - | **Indirect** |
| 10 | 38.4 | 5 | 0.4 | Inability of project owners | - | **Indirect** |
| 10 | 24.3 | 2 | 0.4 | Rules and regulation changes | - | **Indirect** |
| 6.44 | 42.2 | 3 | 0.4 | Delay in supply | Foundation and structure work | **Direct** |
| 6.33 | 29.7 | 2 | 4.22 | Lack of quality of materials | Foundation and structure work | **Direct** |
| 5.73 | 26.21 | 4 | 0.356 | Military dereliction of duty | Foundation and structure work | **Direct** |
| 5.46 | 23.2 | 2 | 0.378 | Defective equipment | Foundation and structure work | **Direct** |
| 5.19 | 36.33 | 1.5 | 0.312 | Mistakes in construction | Foundation and structure work | **Direct** |
| 13 | 24 | 4 | 0.6 | Mistakes of construction | Foundation and structure work | **Direct** |
| 12 | 22 | 1 | 0.6 | Events during execution | Foundation and structure work | **Direct** |
| 10.67 | 21 | 3 | 0.534 | Technical and engineering changes | Foundation and structure work | **Direct** |
| 9.78 | 25.7 | 4 | 0.534 | Military dereliction of duty | Foundation and structure work | **Direct** |

perts. Afterwards, using exploratory factor analysis, the project risks were determined and hidden parameters were known. Then, Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method was used to identify the most important work packages with respect to risk. The next step involved the risks breakdown structure involved and categorizing into direct and indirect risks. Taking the experts' opinion into consideration, it is possible to calculate the direct risks' probability and effects on the entailing tasks of the most important work packages. Since the two work packages of "Plaster and white wash" and "Foundation and structure work " were selected as the most important packages of the project, the probability and the effects of the direct risks on the entailing tasks of the most important work packages were calculated. Additionally, the indirect risks were defined as the risks whose effects were considered globally on the whole project. Having identified the most important risks involved in the project, the top list of risks with higher than average probability and severity were chosen for further analysis and studying. The severity of each of the risks was evaluated based upon the effect they will have on the project's period and cost of completion and was acquired from the experts' statements. Considering the probability of 90 percent and the effect of each of the risks on the time duration and cost of the project, the project will be accomplished with 29.36 moths delay and about 4003.837 million Rials increased cost.

Based on the findings and opinions of experts regarding the financial risks, it is recommended that the time of loan being received match with the time of purchase, appropriate purchase contracts, using the overall discounts and using of alternative materials. For the lack of infrastructure in the region, it is recommended coordination with municipalities is set up for infrastructure and technology transfer. Due to inability of Project Owners it is recommended that appropriate contracts with reputable companies be made. For Defective equipment, it is suggested to make contracts with several suppliers in different places. For Lack of quality of Materials, it is recommended to add quality control department at the technical office and use high quality materials. For mistakes in construction, it is recommended to Careful monitoring of employers, the workshop supervisors and project engineers. For the Events during Execution, it is recommended to Compliance with building and safety regulations.

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