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# Study of the Application of Risk Management in the Operation and Maintenance of Power Plant Projects

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***Abstract:*** *Management of various industrial, manufacturing, service and financial units in the modern world has been facing a variety of challenges. With its fast and stunning development, the competitive world has posed challenge to managers and made decision making more difficult every day. In this regard, parameters and components which goes with uncertainty and change in a period make it difficult and decision making at stake. Prediction of such parameters, the effect they exert on the whole work or project in question, will eventually lead to a good recognition of the general process of the project in question, making risks and potential threats unfold. As a result, managers will be able to take a decision by a good vision and recognition, reducing unpredicted and unintended consequences as much as possible. One of the methods used in this regard is risk management, which is known as an important part of project management and control. Risk management has evolved over time and its systematic method has provided managers with a definite path so that they reduce potential threats to a minimum and reach project goals by the least possible deviations. In this paper, subsequent to an introduction of fundamental concepts of risk, risk management, an account of risk management, methods and its techniques are presented. In the end, following a discussion on how it is practically used in projects in a real and practical sample, risk management and its application are implemented and essential investigations are undertaken into its effects.*

***Keywords:*** *Risk, Risk Management, Techniques of Project Risk Management*

## INTRODUCTION

Since the beginning of business in human societies, people have been dealing with risk. In most cases, managers only took account of existence or nonexistence of projects and made decisions about it. In the past, few studies were conducted into risk management, while parameters of risk exist in various aspects of everyday life. Because of this, risk exists in a variety of aspects of an organization’s activities. What one can do is to earn a better recognition through a systematic study on its effects and how it happens, and in what follows a preventive program for negative effects of risk on projects and increase of positive effects of risk on it are expected.

It is clear that project and risk are closely related. Today, project risk management is an integral part of project management and then implementation of it is undeniable in project management software programs. It should be noted that project managers are familiar with project risks more than anyone else can.

**Statement of the problem**

In the modern world, we are witnessing the launch, maintenance, control and operation of various projects, in that they entail high costs and the use of this capital in the current economy of the world and a country has been receiving the attention of managers a lot. Conversely, in every project it is expected that certain goals can be achieved at specific time. The importance of this subject matter is to such an extent that in some cases delay in launching a project would result in prodigious financial loss or even it questions the existential reason of project. Project management invariably attempts to complete a project at best in terms of cost, time and quality.

Risk management is an important area of project management. Generally speaking, in our country risk management takes on less importance, which is why a more scientific and applied look at risk management calls on the attention of the country's managers given the current situation like never before. The result is prevention of a diversity of further potential damages. One of the national industries which has grown stunningly in recent decades is power plant industry. In recent years, we have witnessed the construction and development of power plants throughout the country and it is expected that in the years ahead maintenance of power plants will be of great value. Given the critical circumstance of the country, risk management can play a crucial role in reducing costs of potential risks, preservation of quality and project completion. In this thesis, an attempt was made to explore the role of risk management in operating and maintaining power plants and determine the use of risk management techniques for recognizing risks and controlling them and taking the best decisions.

**Research objectives**

The research pursues the following objectives:

1. an introduction to risk management and its techniques
2. study of the need for using risk management in operating and maintaining power plant projects and its effect on project objectives
3. identification of potential risks in maintaining power plant projects
4. demonstration of a definite pattern in this field in order to make use of similar projects

**Necessity for conducting the research**

The highly turbulent modern world is replete with a host of challenges and threats that threaten project goals. Identification of the threats, estimation of their risk level and adoption of good decisions seem totally necessary. In our country, given the current situation and existing critical circumstances, and on the other hand in competition with other nations there is no room for squandering any form of capital at all. For this reason, application of risk management techniques for recognizing, controlling and reducing or eliminating potential project risks is deemed to be necessary more than ever at this time and in this world.

Risk management is a group process and entails a systematic method, in that a wiser look based on experiences of teams, managers as well as all factors contributing to the same projects on likelihood of occurrence and identifying the repercussions of the likelihood of occurrence and alternative activities are utilized to avoid project deviations.

**Research questions**

1. what is project risk and project risk management?
2. how dangers would threaten goals of a project and what are the effects of the dangers?
3. can we expect to optimally make use of existing resources and possibilities for a project in question by applying risk management?
4. can we expect to complete a project with the least possible expenses in a period by applying risk management?

**Research hypotheses**

1. by applying risk management, we can take good decisions in the face of dangers and risks threatening project.
2. by applying risk management, we can use existing possibilities and resources in such a way that effects resulting from project risks are reduced to a minimum.
3. by applying risk management in carrying out projects, we can reduce expenses to a minimum at a desired time.

**Research Materials and Method**

In the beginning, references relating to risk management will be obtained from libraries, universities, companies and the internet as well as other librarian resources. In an attempt to get acquinted with history, terms and fundamental concepts, standards and applications of risk management, we carry out a librarian study into risk management.

Essential data will be obtained from the project in question and checklists, in that project risks and likelihood of occurrence and severity of their impacts will be determined. Various techniques of risk management such as qualitative and quantitative analysis and probability and severity tables are also used, and in the end, an appropriate simulation and necessary software programs will be utilized. The study population consists of activities performed in this project, which is collected from experts and professionals.

**Research literature and background**

The history of project management is always associated with the construction of Great Pyramid of Giza and Great Wall of China. These are great and complicated buildings which are built by premier standards and still remain in time test. Modern project management are linked to Henry Gantt's bar graphs in the early 1900s. The history of bar diagram can be traced all back to world War I when American Henry Gantt developed bar graphs for planning for controlling shipbuilding projects. Almost all techniques of project management that we use today have been developed during 1950s-1960s by defense and aerospace industries of the United States.

Risk by definition refers to the probability of deviation from approaching a desired goal. The concept of risk has its root in the theory of probabilities and therefore stems from lottery and betting. The early scientific attempts in this regard were made by people like Pascal, Bayes, Bernoulli, Gaussian and Laplace working in the field of mathematics and statistics, which have led to publication of various works. The process of risk management is a systematic and preventive attitude which is applied in relation to project control and uncertainty reduction. Risk management can be applied in a variety of projects with diverse time intervals (multi-weeks to multi-year projects) and different funds (multi-thousand to multi-billion dollar projects).

Everything with certainty less than one hundred percent is considered risk and everything considered a fact is definitely not a risk.

Risk management is a systematic process of identifying, analyzing and responding to risks, which is implemented in order to maximize the results of positive events and minimize likelihood of occurrence or adverse effects.

Although concepts of risk and its managements are mostly raised in association with negative events and prevention of its consequences, the process of recognizing positive events or opportunities which are called positive risks at times can be influential in taking account of them.

**Literature review**

Hernández & et al, (2018), hurricane risk is evaluated for coastal cities through the definition of a system of indicators. Based on this indicators system, the Hurricane Risk Index (HR*i)* is calculated. This system allows the construction of vulnerability indices for different dimensions: physical, environmental, social, economic, cultural and institutional. The obtained results can contribute to the definition of public prevention policies and actions to reduce the levels of vulnerability and increase the resilience of these communities. This indicators model is applied to two coastal cities of the Mexican Caribbean; Mahahual, obtaining an of 82.13%, and Chetumal obtaining an of 69.31%, corresponding to the impact of Hurricane Dean in 2007. The proposed indicators system can be replicated for different hazards.

Taghipour & et al, (2015), addressed Risk analysis in the management of urban construction projects from the perspective of the employer and the contractor. Based on the results of the surveys in different groups, six factors including low commitment of the subcontractors to the quality of work, failure to complete the detail engineering by foreign contractors on time, lack of contractors' financial resources, contractors' offering of lower prices than reasonable one to win the tender, delay in the payment of contractors' claims and statements due to weakness in handling financial documents, governance of relations rather than rules in the system of tenders can be regarded as risks with the greatest impact on the project implementation process which need special attention.

Zubair Ahmada & et al, (2018), performs a thorough analysis involving international experts and practitioners. Data is collected in the form of open-ended interviews and typeset questionnaire along with case studies of running projects. Results reveal that BIM eliminates a majority of significant risks. Further, the findings fuel a new research problem; the lack of a dedicated BIM plugin for risk management. It is concluded that construction projects can greatly benefit from an automated risk management system and investment in developing a dedicated plugin is recommended, ensuring an effective penetration of BIM in the construction industry.

Tim Neerup Themsen & Skærbæk, (2018), examines the long-term dynamics among a best-practice risk management framework, risk management technologies and the translation of uncertainties into risks by using a longitudinal case study of a large mega-project. show that the construction of impure risks challenges the predictions of the framework causing a false sense of security for the project objectives, and that the continuous readjustment of technologies, in particular, is necessary to ensure the long-term realisation of these predictions. Finally, this article contributes to the literature on performativity by showing how technologies serve as buffers to shield failing economic frameworks against criticism.

Wua & et al, (2018), proposes a novel risk response method by opening the black box of the project process and considering the risk correlations among different sub processes to help practitioners create a practical risk response plan in their method, they first identified process risk factors from two-dimensional criteria called risk categories and project development sub processes. The result show that the risk response effects are better if managers control the process risks earlier. Moreover, the number of initial risk factors in each subprocess is an important reference in risk response resource allocation.

Choi & Tae Kim, (2018), investigate how the oil and gas project companies' decisions to hedge the risk of future prices of oil and gas respond to the changes in the price volatility of oil and gas, especially the role of the exposure of the sponsor company's stock returns to the risk of oil and gas prices. They find that the oil (or gas) price volatility increases the oil (or gas) project company's hedging likelihood, especially to a greater extent for the case in which the sponsor company's oil (or gas) exposure is smaller. Their findings suggest that the sponsor company's willingness to reduce its exposure to the risk of oil and gas prices increases the likelihood that the subsidiary project company will hedge the risk of future prices of oil and gas.

Gauthier & et al., (2016), deals with the economic conditions required from a candidate capital investment project for its admittance within a firm's project portfolio. In order to lower the firm's operational risk, the PMO can devise, assess and implement project efficiency management (PEM) and project risk management programmes (PRM) during the PM phase of the candidate capital investment project; their economic value determines their maximum admissible implementation budgets. When the correlation coefficient between the economic activities of the candidate project and the firm takes a negative value exceeding a threshold value, its addition to the firm's project portfolio will reduce the firm's operational risk while rendering counter-productive the implementation of any effective PRMprogramme.

Liu & et al., (2018), develop a model of how different types of BPO risks affect project satisfaction and how knowledge management capability changes the influences of BPO risks. Empirical evidence reveals that social system, technical system, and project management risks negatively affect BPO project satisfaction. However, cultural, technological, and structural levels of knowledge management capabilities weaken the negative risk effects of social system, technical system, and project management, respectively.

Qazi & etal., (2018), make use of the recently introduced concept of utility indifference curves based risk matrix to capture the risk attitude of the decision maker. We also present algorithms for assessing and mitigating interdependent risks for risk-neutral and risk-averse/seeking decision makers and demonstrate the application of our proposed process through a simulation study, and also propose a second approach that can help a decision maker determine a set of Pareto-optimal risk mitigation strategies and select optimal solutions subject to the budget constraint and specific risk appetite.

Rolik, (2017), studied a wind energy project, namely a wind farm working as part of the national energy system. The implementation of the project is related to both external and internal risk factors that are characteristic to such projects in the real economy sector under the current conditions. he current strategic management tools, such as SWOT analysis and McKinsey matrix, which are useful for the identification of project risks, have been examined. For the wind energy project that is being implemented, the project dot location coordinates were determined in the McKinsey matrix on axes: Advantages against competitors and Market attractiveness. Also, a sector characterising the project development prospects was established to be subsequently used as a tool for risk identification. Following the identification of risks, specific measures of state support and special project management measures were developed and proposed to be implemented with the aim of limiting the negative influence of the possible project risks.

Amirshenava& Osanloo, (2018), develop a generic procedure for mine closure risk management. To this end, a three dimensional (3D) risk model was developed for assessing mine closure risks. The results indicated that the identified events had a 51.4% low, 22.9% medium, 14.3% high and 11.4% extreme risk levels and accordingly revegetation with native species was recommended as the optimal PMLU. Compared with the 2D risk model, the assessment results are more effective and practical by adding the time value of risk which can help budget planning for risk treatment.

Chen & et al., (2018), propose a new risk measure termed mark to market value at risk (MMVaR) for settlement being taken daily during the holding period. MMVaR is a natural alternative risk measure to VaR as it is a direct generalization of VaR. It not only maintains easily interpretable feature held by VaR, but also better computes an asset's market risk in a financial institution having daily account settlements. We show that MMVaR is superior to VaR using simulation examples and real data. In real data analysis, we find that risks calculated using MMVaR are about 20% higher than risks calculated using classical VaR, which provides an evidence proof of Basel III's new capital adequacy ratio requirement, and hence it can become an implementable daily risk measure.

**Explanation of the method**

Information is collected from the site of the project by a questionnaire and checklist according to experts' opinions, and similarly for the literature and introduction of risk management a librarian study is used.

**Statistical population, sampling method and sample size**

The statistical population consisted of activities performed in the projects and the project restrictions such as costs and time of the projects.

Data analysis is based on qualitative and quantitative techniques of risk management such as probability and severity tables and monetary value analysis and Monte Carlo Simulation.

**Monte Carlo**

In this part, we use Monte Carlo to predict costs. In this research, costs are divided into the following parts.

- Raw material cost
- Worker cost

- Parts replacement cost

For which cost function can be obtained as follows

$$fixed\ price = \sum(\text{human resource cost} + \text{parts replacement} + \text{raw materials}$$

In this case, considering the determined interval for the project, we can calculate the fixed price suitable for project risk. In this thesis, using Monte Carlo method cost functions was predicted and using a fuzzy system a risk management system was determined, which is shown in the following figure as block diagrams;

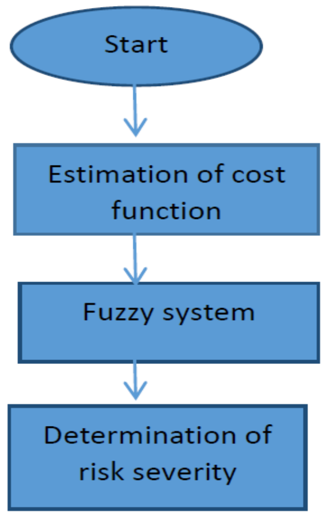


**Figure 1.** Block diagrams

In order to determine cost function, it was attempted to determine initial cost function as a log function, in which case we can estimate cost function in question by using Monte Carlo.
The tools of this method are divided into three sections in total;

1. probability density function (PDF) or cumulative distribution function (CDF)
2. random number
3. sampling methods

1. density or probability mass functions can be continuous or discrete. To use a function, we need to identify the study population (the sum of members in a system) in the first place, say its continuity or discreteness. In the next phase, we need to know in what way probabilities are distributed among various modes, distribution is normal or Poisson, geometric or exponential or other types. For each type of distribution, we can obtain density function. In this research, a Gaussian probability function has been considered.
Random numbers are generated in different ways. For this research, sampling of the research conditions was performed considering the process of costs in previous years as well as rate of inflation.
Generating random numbers involves two necessary conditions:
For different numbers to come, a similar probability exists and they should be completely independent.
For example, for MC to function, we can refer to measurement of π by throwing darts at a circle with diameter 1 within a square with length 1

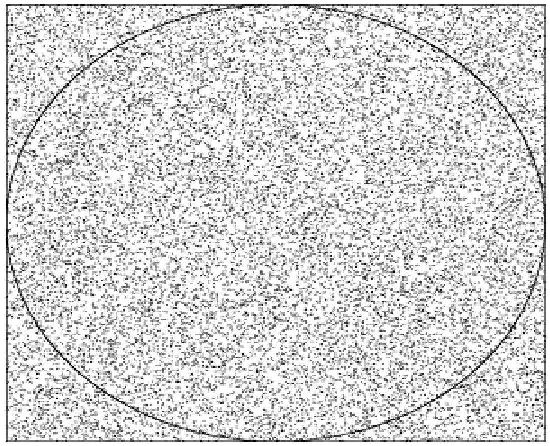

**Figure 2.** Likelihood of hitting the circle

Area of circle: $\frac{\pi}{4}$

Area of square: 1

Likelihood of hitting the circle: $1 / \frac{\pi}{4}$

Likelihood of hitting inside the circle as experienced is that the number of darts hitting inside the circle is divided by the total number of darts impacting inside the square, which is in turn a number. By putting this number as equal as the amount of the theory of this probability is, we can obtain the value of π.

In this example, we can consider darts as random numbers (or microscopic interactions), probability of impact as theory hypothesis of (PDF or CDF) test and n times throwing dart as n random sampling.

For instance, we can consider a sample space which includes worker cost, raw material cost and cost of parts replacement and in order to carefully estimate the area of cost, 1000 samples are considered, in that the more the number of the points is, the more approximation we can get of expected cost function.

By studying an estimation of the predicted cost function, as shown in the figure, total costs are in the form of an exponential function. A pseudo-code is as follows in order to estimate cost function;

```
h=0;
N=10^6;
While i=1: N;
    x=rand (#);
    y=rand (#);
    r=expected cost function
      if   r<=1;   h=h+1;
end
```

**Figure 3.** A pseudo- to estimate cost function

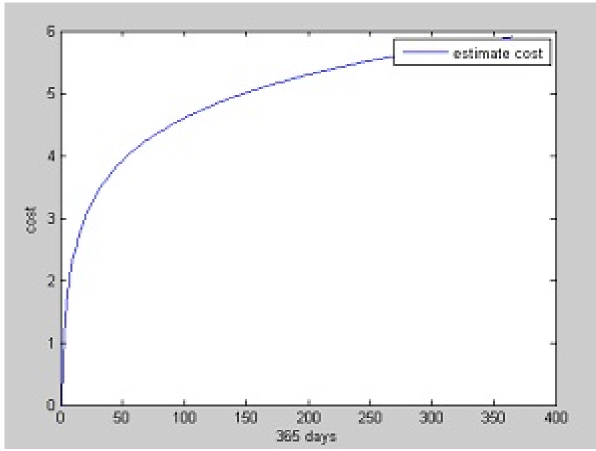


**Figure 4.** Cost function expected for detecting correct estimate

In Monte Carlo Method, the length of the project is considered 365 days and the aim is to determine the area below the chart in order to estimate total cost of project. Each sample can be determined as total costs in a day, considering the fact that this function has been calculated based on other three cost functions. Therefore, estimate of this function is not as simple as it seems.

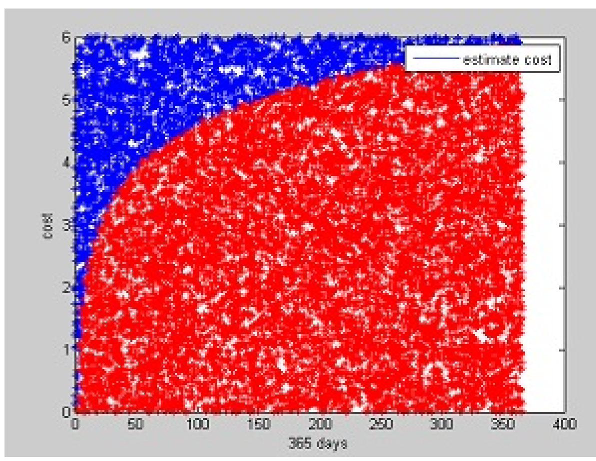


**Figure 5.** Results of using Monte Carlo

In Monte Carlo calculations, error is considered as follows:

$$ERROR = \int_{1}^{365} (\log(i) - estimate)di$$

Red area is cost area for the entire 365 days a year, which was calculated by Monte Carlo. Blue area is external area and red areas is the area of costs. To increase the precision of Monte Carlo Method, this technique was used four times and the results are shown in the following table;

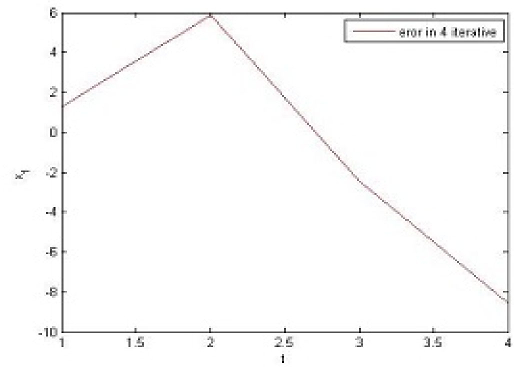


**Figure 6.** Error results using Monte Carlo

In the former par, using Monte Carlo, a good approximation of cost function was obtained. In this part, the aim is to use the outputs of the previous part and add a number of another inputs in the fuzzy system for risk management.

Classification refers to relating a previously defined class, i.e. the aim of document classification is to find a good thematic class, which represents the topic of discussion with the least error. This can be accomplished by relating a concept to any predefined class, or it may result in a new thematic class definition for the document at hand within a dynamic classification. Classification is a kind of learning methods based on observation, in that first a set of documents is given to system, and their class was specified. After this, it is expected to classify new samples by seeing the samples. The aim of classification is to analyze training samples and construct a precise model for each class by using existing characteristics of data and then using the models for classification of future data. Document classification methods mostly fall in two categories, statistical and conceptual algorithms. At this point, a synthetic fuzzy system is used. Estimation of risk severity is performed on the basis of a fuzzy system.

Influential parameters of fuzzy system are as follows;

- Worker cost
- Raw materials cost
- Replacement cost
- Time elapsed

Cost of raw materials is the first input of fuzzy system. We need to bear in mind that values were obtained considering simulated network based on try and error.

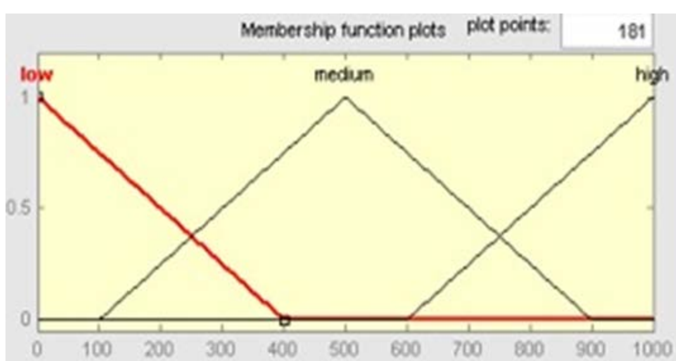


**Figure 7.** Cost of raw material

Cost of worker is the second input of fuzzy system. In figure 3, its membership function is shown.

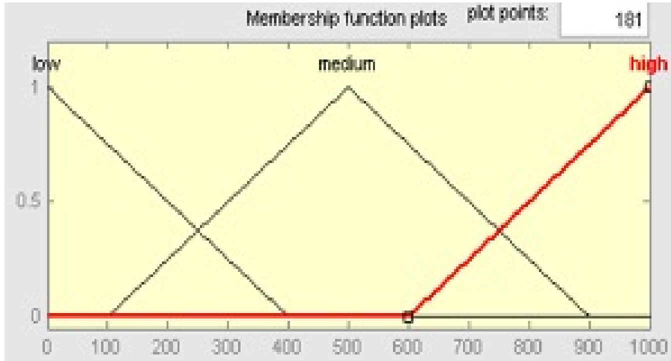


**Figure 8.** cost of worker

Cost of parts replacement is the third input of fuzzy system, which was calculated by Monte Carlo. In figure 4, its membership function is shown.

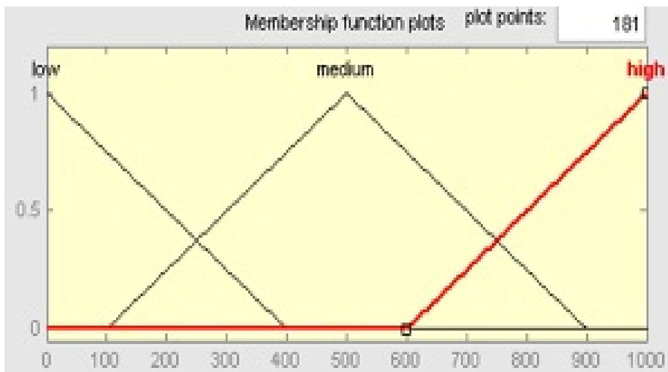


**Figure 9.** Cost of replacement

Another input which is influential in determining fuzzy system is project time, for which its membership function is shown in figure 5 and is determined from zero to one base.

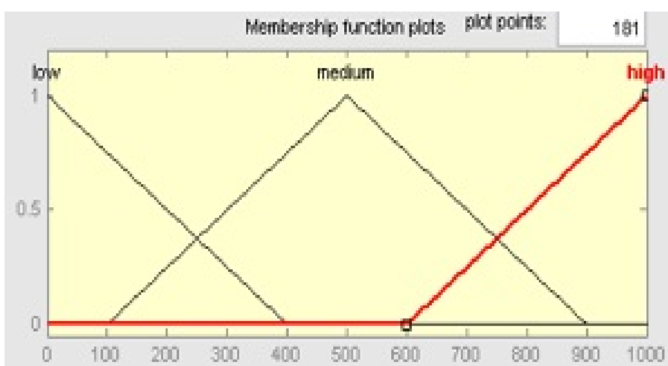


**Figure 10.** Cost of time

The output of fuzzy systems is the amount of project risk.
Given the costs, we can predict cost functions of fuzzy system inputs as follows, and in the end assess the amount of project risk by using fuzzy systems. Given the dependence of risk on cost in this research, a criterion for risk index is needed, for which risk index is calculated for fuzzy inputs in this thesis as follows;

Likelihood of occurrence * cost = risk index

The first input of the fuzzy system is shown as raw materials. Risk index is defined as follows, in that given the cost of raw materials dependency on raw materials in maintenance and repairmen phase is high, so in case of lack of access to raw materials and supply of raw materials, risk of project is high due to various reasons, as it carries high cost of maintenance. The likelihood of risk occurrence is considered 5 percent with respect to experts, and the cost incurred has been estimated to be about a maximum of 10 million rials a day. Given overhaul calculations, risk approximation is calculated as follows;

$$\text{raw materisl risk index } = 8000 * .05$$

risk index has been calculated to be 400 for the first input of the fuzzy system, which is considered an average rate based on fuzzy system.

The second input of the fuzzy system was shown as dependency on workforce and worker. Risk index is defined as follows, which is average given the cost of worker in the phase of repair and maintenance; therefore, in case of failure to provide good workforce, project risk is average and it carries average cost of repair and maintenance. The likelihood of risk occurrence is considered 1 percent with respect to experts, because providing workforce is easily achieved given the unemployment situation of the society and the cost incurred has been estimated to be almost a maximum of 1 million rials a day. Given overhaul calculations, risk approximation is calculated as follows;

Workforce risk index= 8000*.01

Risk index has been calculated to be about 80 for the second input of the fuzzy system, which is regarded a low quantity according to fuzzy system. The third input of the fuzzy system was shown as dependency on replaceable parts. Risk index is defined as follows, which is very high given the cost of replacement in the phase of repair and maintenance. Therefore, in case of failure to supply good replaceable parts, project risk is very high due to various reasons, and it carries high cost of repair and maintenance. The likelihood of risk occurrence is considered 10 percent given expert individuals, because replaceable parts are not easily replaced because of sanctions and sustained cost has been estimated to be almost a maximum of12 million rials a day. Given overhaul calculations, risk approximation is performed as follows;

$$\text{parts replacement risk index} = 10000 * .1$$

risk index is calculated to be roughly 1000 for the third input of fuzzy system, which is considered a maximum rate according to fuzzy system.

The fourth input of the fuzzy system is failure to timely deliver project. The cost of this parameter has been invariably mentioned as numerical quantity in repair and maintenance contracts, in that risk index is calculated as follows for this quantity;

Time risk index= 700*.7

By the inputs of the fuzzy system, we can consider the risk of maintenance and repair project as half, which is an average rate according to project risk. With respect to the membership function of the following figure, the index is shown.

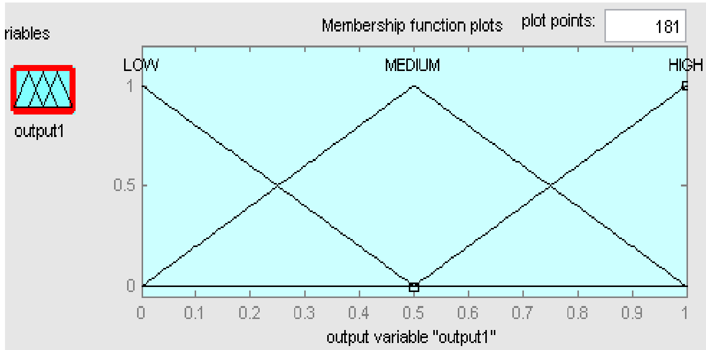


**Figure 11.** risk of maintenance and repair project

## Conclusion

In this research, having reviewed risk management thoroughly and described various sections of it, considering the new state of this discussion and a complete account of it was provided, it was attempted to introduce methods that can employ risk management in an applied manner. In the fourth chapter, Monte Carlo and fuzzy methods, which are believed to be complementary to one another, were introduced, and a complete account was provided on how to use them in the field of risk management. Given the existing data and opinions of experts and use of the methods, potential costs in question were predicted, in that, considering defined indexes of risk, a value was obtained for the whole project. Methods like these in the field of risk management can enable managers to take timely and good decisions on recognizing and dealing with potential risks of a project, and in addition to preventing extra costs form being incurred on project, they obtain specified objectives at specific time.

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