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Designing of a Knowledge Base Expert System for Specific Risks Management in BOT Projects

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Abstract. Economic growth and development is the most important factor in the development of a country, and infrastructure projects such as water and sewage systems, airports, power plants, etc. are the most important factors for economic growth and development.One of the best methods is the use of BOT (Build Operate Transfer) contracts. Since the BOT projects are usually large, and they took relatively long time, risk management is highly important in these projects. In order to solve such problems that does not have precise algorithms but a complex structure and are based on the knowledge and experience of experts,Expert Systems are the best solution. This paper presents an expert system to manage risks in these types of projects; that can act as an expert assistant for project managers. Initial feasibility was conducted in Beckman method, and its knowledge base is designed on the Rule Base and in a way to be developed in the future without any damage in the Inference Engine. The inference engine of the system is a Forward Chaining,and deductive and inductive methods are used for inference. Increased efficiency, saved time and cost, and high availability are the main benefits of the system.

Keywords*:* BOT project, risk management, knowledge base expert system

1. INTRODUCTION

Risk management can be defined as a guided culture, process, and structure in order to understand and study opportunities while managing adverse and inconsistent factors. One reason for the increased interest in risk management is to have the opportunity to apply new thinking and tools to new risks. The main objective of risk management is an evaluation of future uncertainty and doubt to make the best decision possible right now. Better decisions will result in fewer surprises, improved planning, performance and effectiveness, and enhanced relations with shareholders and stakeholders. However, recent studies have shown that risk management is sometimes associated with failure due to reasons such as inefficient culture, lack of organizational knowledge management, and ineffective controls. For the project managers to guarantee their success in major projects with heavy investments, they should be able to identify early opportunities and threats. If we spend time to study each project and identify the risks, the opportunities may not exist anymore, or if we act with doubt, something unexpected may come out. Therefore, information and records of past projects can be considered as part of the solution. The results of the research also indicate that risk management approach may not be implemented broadly and effectively in projects for reasons such as time consumption, difficulties in assessing and estimating the likelihood and severity of risks, institutional and individual resistance to change, and difficulty in understanding and interpreting the output of the risk management process (Jabalameli, 2011).

Sustained economic growth in Iran, like other developing countries, requires investments in the different field of infrastructure. In this way, many obstacles such as lack of public resources and

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the lack of technology inhibit the growth of facilities to suit the society needs. In the meantime, by reducing the tenure of the government in recent years, a recent movement is done in the competitiveness for services and preparation for private sector investment. This movement, characterized by the presence of non-governmental sector in the construction of various projects and services, started long ago in developed countries, and is now regarded as one of the indicators of development in these countries. There are various methods for private sector investment in projects, and one of the most common methods of investment is Build, Operate, and Transfer (BOT) contract (Ebrahimnejad, 2007).

BOT Contracts

One of the concerns of the industry managers in developing countries is to overcome problems of financing projects. One of the main types of contract, which has attracted the attention of project owners in recent decades is BOT. The reason of this attention is the very limited liability of the employer in the project risks.

BOT is a construction contract in which the private sector takes the permission from the public sector or host government to build infrastructure projects such as dams, airports, subways, etc., and then transfer them to the government.

Risks of BOT Projects

Risk in BOT projects is divided into general risks and specific risks. General risks cannot be controlled easily, and the sponsor or contractor are not able to manage them. Instead, specific and technical risks can be controlled by management.

Specific Risks in BOT Projects

The risk that are usually controlled by the project investors, such as management capacity of project operators (Monirabbasi, 2005) (Mane, 2013).

Specific risks of the projects can be divided into the following categories according to the stages of the project cycle:

1. Development (Contractual) Risks

The risk of tender participants due to losing the tender or failure is in contract signing that results in the loss of fees paid to the tendering stage.

2. Completion/Construction Risks

These risks can occur for the following reasons:

- ✓ Increased actual construction costs compared to the anticipated cost
- ✓ Increased time of completion compared to the anticipated time
- ✓ Non-completion of the project

The degree of the completion/construction risk of a project varies for different projects. For example, in the design and construction of a nuclear power plant, the risk can be more significant than the construction of a road.

3. Operational Risks

The risks are resulted from the inefficiency of implementation, income, and the provision of raw materials and increases the operation costs (Khanzadi, 2009). These risks are divided into six main groups:

- ✓ **Infrastructure project risks**

The risks are associated with infrastructure facilities outside the project, such as access roads (in a highway project) and transmission lines (in a power plant). They usually should be constructed by third parties instead of the project investors.

- ✓ **Technical Risks**

These risks include the defect in design or equipment of the projects.

- ✓ **Economical-Commercial Risks**

Most BOT projects that rely on market income are exposed to risks are associated with the sale volume or price. In case of its decrease compared to the expected rate, the projects return rate will be lower.

- ✓ **Supply Risks**

The risks are related to uncertain supplies of critical raw materials (such as power plant fuel supply) that would jeopardize the ability of the project in producing the expected amount of the product.

- ✓ **Management Risks**

Quality management is always an important factor in a project's success.

- ✓ **Force Majeure Risks**

They result from exceptional events outside the control of the BOT project staff, such as fires, floods, and earthquakes.

The Position of Risk Management in the Project Life Cycles

Some believe there is no need to risk management and uncertainty can be removed by a very detailed project planning. There are two problems with this approach: Firstly, experience has shown that increasing the accuracy of a program will require higher degree of effort, and secondly, risk can never be eliminated in the project, since the future cannot be accurately predicted.

Risk management is a continuous and integrated process throughout the project life cycle. In general, there is a fell correlation between the level of risks and project life cycle.

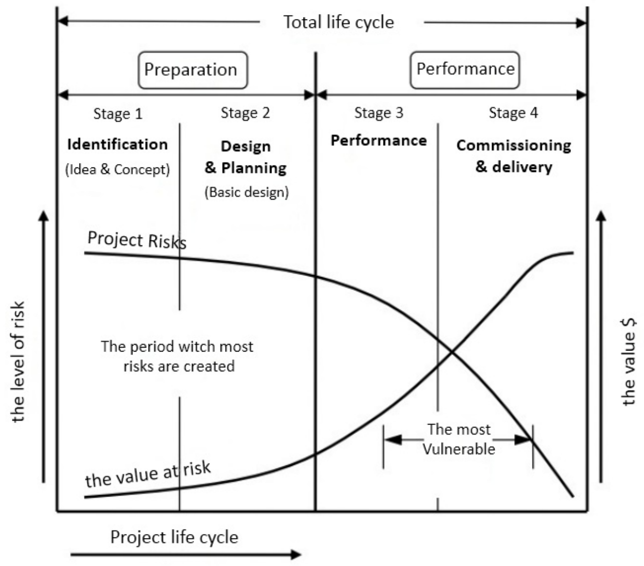

Figure 1. Project life cycle (the level of risk vs. the value at risk)

As shown in Figure 1, risks are relatively high in the two first stages of identification and planning. However, since a major investment has not been done at this stage of the project, the value of capital at risk is low. On the contrary, risks gradually decrease in the process of project implementation, commissioning, and delivery, because the project uncertainties become known. At this time, the value at risk rises. Since the resources required for the project have been gradually spent on the project (Feng, 1999).

2. THE RISK MANAGEMENT PROCESS AT THE PMBOK GUIDE

• Risk Management Planning

At this point, the level and type of risk management commensurate with the risk of the project and the importance of the project for the organization, the resources required for the risk management activities, and principles of and facing the risks are specified (Mousavi, 2009).

• Risk Identification

At this stage, the project risks are identified, described and documented by applying specific methods and tools.

• Qualitative Risk Analysis

At this stage, the risk priorities are determined based on their probability and impact on the project objectives to highlight the more important risks for the managers.

• Quantitative Risk Analysis

It is a numerical analysis of the total and collective impacts of the major risk of the project on its objectives.

• Planning the Response to Risks

It is decisions about how to respond to the identified and prioritized risks.

• Risk Monitoring and Control

According to the data collected, following actions occur in the stages mentioned earlier:

- ✓ Following the specific risks
- ✓ Monitoring the overall status of the project to use precautions sources
- ✓ Monitoring other unimportant risks
- ✓ Reviewing the implementation of monitoring process, controlling the review
- ✓ Evaluating how successful the response plan is.

Definitions of Risk Probability and Impact

Qualitative risk assessment process requires the definition of risk likelihood and severity of its effects at different levels.

Probability of Occurrence

According to statistics, every non-deterministic event can occur due to a certain probability. The probability of occurrence means the expectation that can be considered for the occurrence of an event. In practice, there are three ways to calculate the probability of an event. First, mathematical calculations; second, and last experience which should be acceptably similar to current situations; and third, relying on the judgment of specialists and experts.

Unfortunately, many of the project risks are placed in the third category, which is why the quantitative methods are more attractive in project risk assessment.

Risk Impact

The second aspect of the risk is the impact that it will have on one or more of project objectives. Like the probability of occurrence, the risk impact of risk can also be expressed using the descriptive or numerical values (Pathan, 2013).

Evaluation Matrix

It should be noted that the risks cannot be rated only based on their probability of occurrence or impact, but both are important and should be combined. The usual approach in prioritizing the risks is probability and impact matrix (Table 1).

Table 1. The 2x2 Probability-Impact Matrix.

Probability \ Impact	Low	high
high	3	1
Low	4	2

The risk that has high probability and impact has higher priority. The prioritization can also be based on the source of risk.

Source of the Risk

Source of the risk is hidden realities that already exist, and in certain conditions cause the occurrence of a certain phenomenon called risk (Cervone, 2006).

One of the most important issues that should be considered in estimation and its implementation could raise the value and reliability of estimations is considering the source of the risk, instead of thinking about the risk phenomenon, since everyone agrees to the fact that projects are risky in nature. The question is what makes projects risky?

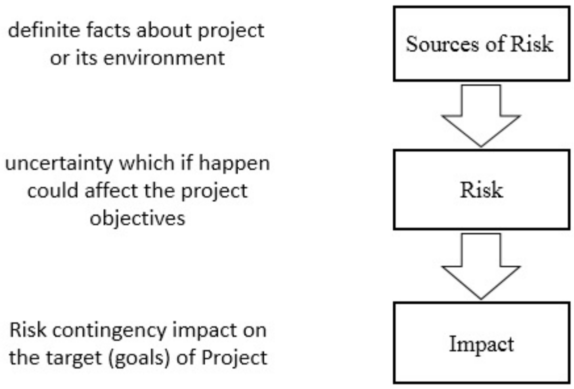

Figure 2. Distinction of the sources of risk, the risk, and its impact.

In the system presented here, with detailed question and knowledge, the source of the risk will be identified in the shortest possible route and time, and will be used in the next step (Fig. 2).

Responding to the Risks

Using the final list of identified risks and their evaluation, in terms of the probability of occurrence and their impact, and risk classification based on the source of the risk and the area affected by the in the project, an appropriate response will be given to the risk.

The need to Determine the Response Strategy to the Risk

The strategy will ensure that all considered responses are in a specific order, and duplication of work will be avoided. It should be noted that no strategy is the best, and strategy to deal with any risk should be considered according to its features (Thomas, 2006).

Table 2.

Responds to risk

Probability		Impact: Low	Impact: high
	high	**Transfer**	**Avoid**
	Low	**Accept**	**Mitigate**

Common Strategies for Responding to Risks

Avoid: This strategy seeks to cut off the connection between the risk source and the risk to make the occurrence of the risk impossible. It also seeks to cut off the connection between the risk impact and the risk to minimize the risk impacts on the project objectives.

Transfer: This strategy does not change the risk directly but involves the others in its management and responsibility.

Mitigate: This strategy seeks to weaken the relationship between the source-risk and the impact-risk to reduce the probability of risks or their severity.

Accept: This strategy believes that it is impossible or ineffective to have an impact on some of the risks. Therefore, it does not consider uncertainty and its probable impact on the planned project (Mosaveghkhah, 2013).

The Strategy Selection Using the Evaluation Matrix

The combination of risk prioritization and its strategy selection is given in Table 2.

The Proposed Expert System

Expert System (ES) is one of the branches of artificial intelligence and is an intelligent computer program that uses knowledge and methods of inference and deduction to solve the problems that need the human skills to be solved. Expert system are used to solve the problems for which there is no explicit knowledge and no special algorithms. In a knowledge base expert systems, knowledge is obtained through books, journals, and visiting experts. Today, expert systems are employed in a wide range of scientific, commercial, industrial and education fields, and issues such as management, design, training, forecasting and advice, selection, and simulation can be solved by these systems (Ghazanfari, 2010).

The Main Expert System Elements

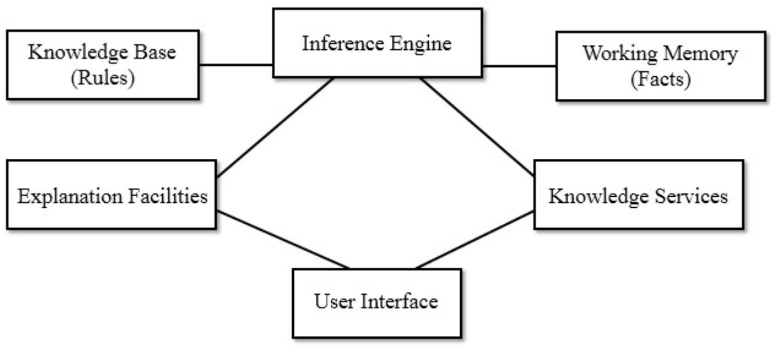

Figure 3

A. Knowledge Base: It is a place in which the expert knowledge is stored in an encoded form that is understandable for the system. The answer of questions about the system is received through the user interface and is recorded in the working memory as the system facts.

B. Working Memory: In addition to the knowledge base that can be considered as long-term memory, another short-term memory is also required to store various stages of finding the answers and the path passed from the question to the answer. Each time a new user comes, this memory will be cleaned.

C. Inference Engine: Based on rules and knowledge stored in the knowledge base and facts in the working memory, it interfere the results and announce it to the user via the user interface.

D. User Interface: the user interface of an expert system should certainly have a high exchange power to let the structure of information exchange take place in the form of a dialog between an applicant and an expert person. The user interface of an expert system not only enables the user to answer questions, but also it allows the user to disrupt the system operations by questioning about the descriptions. For example, if a user of medical experts is said that the patient suffers from Meningitis, the user may want to know how the system is concluded so.

Figure 3 shows the relationship between the components of the knowledge base expert system.

In this system, the probability of each risk is asked individually from the user. The facts are inferred in a way that the result is stored in the probability variable of each risk in a numerical form. After determining the probability, if it was not zero, and the user is asked if there is no impact of the risk in the knowledge (due to differences in different projects). The combination of probability and impact will have the necessary result.

Designing Knowledge Base

An important part of knowledge in expert systems is heuristic. To develop the knowledge base as part of the knowledge engineering operations that has an important and decisive role in achieving an outcome, the required knowledge is collected using the experience of an expert, books and other sources of scientific knowledge, and then it is designed and implemented using a scientific approach. In the proposed system, the Rule Base method is used for implementing the knowledge base.

Knowledge is shown using if... then... rules. Conditions are also linked to each other using Boolean operations "and" and "or".

Inference Engine

Since the results of the expert system can be different suggestions and solutions, the inference is done in the form of Forward Chaining, and some suggestions are offered for each area of risk. In this chain, according to the answers to questions, the basic facts are specified. Then the inference engine assesses the property of first layer ifs and consider the results as facts in the next layer. The knowledge base has 43 facts as a sample. According to the rules of the knowledge base, the deductive inference is used in most cases. In some of the facts, with respect to the certainty of some information in the management, inductive inference is used. Inference initially determines the probability for each risk, and if the risk occurrence was probable, its impact is determined by the rules and knowledge of the system. The combination of the probability and impact rules is shown in Table 2, and the risk response strategy is inferred. After determining the answers to all risks, according to Table 1, the responses are prioritized.

Mockler Chart

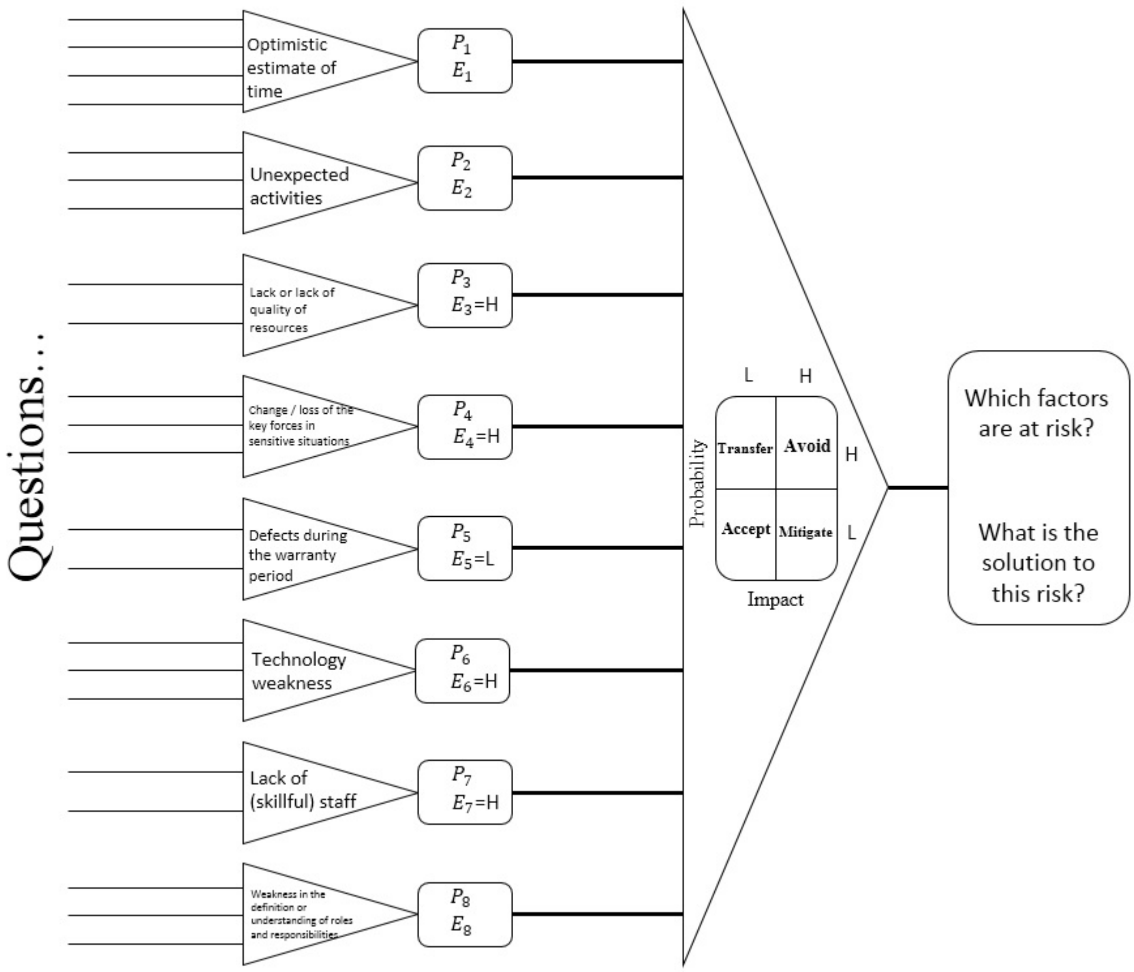

Figure 4. An examples of Mockler chart to determine the source of the risk and its solutions.

Example (Case Study)

Table 3 provides the solution and ranking according to a combination of probability and impact for an airport construction project in BOT based on the reports and records analysis in similar projects.

Table 3.

How to respond	response strategy	The level of impact	The probability of occurrence	The impact on (time/quality/cost)	The source of the risk	
Forecasting sufficient storage time	mitigate	high	low	time	Optimistic estimate of time	1
Developing detailed structure of breakdown / planning checklist	mitigate	high	low	time /cost	Unexpected activities	2
Planning and appropriate allocation of resources to activities	mitigate	high	low	time	Lack or lack of quality of resources	3
Increased morale and morality / final reward strategy	mitigate	high	low	time/quality/cost	Change / loss of the key forces in sensitive situations	4
Get a second guarantee (insurance)	transfer	low	high	quality/cost	Defects during the warranty period	5
Taking an appropriate business strategy	avoid	high	high	time/quality/cost	Technology weakness	6
Recruitment planning and timely allocation	avoid	high	high	time	Lack of (skillful) staff	7
The exact definition of tasks and responsibilities matrix	mitigate	high	low	time/quality	Weakness in the definition or understanding of roles and responsibilities	8

To implement this expert system exsys CORVID program is used. It provides a new and powerful shell for implementation of expert systems that facilitates the implementation of expert systems easily. It also has complete facilities for the use of fuzzy logic. Finally, with the help of this software, the expert system will be presented as an html file that can be run in the home systems. The user interface is also graphical, which make it easier to work and communicate with the system.

3. CONCLUSION

Experience shows that projects are subject to uncertainties in business and life. In the case of BOT projects, the uncertainty is institutionalized in the nature of the project. Uncertainty in the project will be converted to risk through interaction with project objectives. The risks, if occurred, will affect one or several project objectives. Implementation of the risk management process has obvious benefits for the project. This article seeks broad purposes, including ensuring that the risk management process is done correctly by considering quality measures. In this regard, we presented an expert system that identifies a strategy to respond to risks and prioritize the risks. The purpose of this paper is to facilitate the procedures for project managers in facing source of the risks in infrastructure projects.

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