



ORIGINAL ARTICLE

Special studies in management of construction project risks, risk concept, plan building, risk quantitative and qualitative analysis, risk response strategies



Ahmed Mohamed Keshk *, Ibrahim Maarouf, Ysory Annany

Architectural Engineering Department, Faculty of Engineering, Alexandria University, Alexandria, Egypt

Received 11 September 2017; accepted 19 December 2017
Available online 5 December 2018

KEYWORDS

Project management;
Time management;
Cost management;
Quality management;
Project risk management;
Analyzing;
Assessment;
Response;
Avoidance strategies of risks

Abstract Project management includes several managements, such as time management, cost management, and quality management...etc. Project risk management is one of the most important management, especially in this time, which has many unexpected events.

This management means with classification, analyzing, planning, identification, assessment, and response and avoidance strategies of risks.

Therefore, it should be too interested in risk management, to avoid many losses.

© 2018 Production and hosting by Elsevier B.V. on behalf of Faculty of Engineering, Alexandria University. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

1. Introduction

Production of projects is one of the most important production patterns, the success of these projects basically depend on effective management for planning, monitoring and scheduling project activities, and taking necessary actions to accelerate the completion of its certain activities.

One of important duties of management is the analysis of deviations are happened; also some tasks of management are preparation of controlling reports and taking necessary steps to correct them.

1.1. Research problem

As we also made reference at the forefront of research, the project management today is an important field in the fields of business, engineering management and information technology, although mastering skills of planning, control and scheduling of the project has become vital to its success, as today's business environment are dynamic and rapid change the lot of surprises and risks are taken into account highlights suddenly, leading to confusion and block the implementation of the project, or perhaps completely collapse. The problem posed by this research can be formulated following question:

What is the meaning of risk in a project? What is its sources? What are the methods of diagnosis? What are the strategies that can be adopted to confront it or respond to it?

* Corresponding author.

E-mail address: eng_ahm.keshk@yahoo.com (A.M. Keshk).

Peer review under responsibility of Faculty of Engineering, Alexandria University.

1.2. Importance and objectives of research

(Some studies show that most of the business organizations do not conduct an analysis of risks and, for example, only 30% of organizations conduct a risk analysis in it projects) [1]

Objectives that seek this research can be summarized as follows:

- 1.2.1. Identification of the project concept, its characteristics, the meaning of project management and the role of a project manager.
- 1.2.2. clarify the concept of risk and its sources.
- 1.2.3. Identify the most common methods to diagnose a risk of all quantity and quality types.
- 1.2.4. Statement of the most important adopted strategies to treatment risk or respond to it.

2. Project concept and characteristics

A definition of Project is a collection of activities or sequential and interdependent processes for production (good or service) of sole and unique in its characteristics, every project has a specific beginning and end; it is a temporary status, which is being, implemented gradually [2].

(Projects can be implemented in various administrative levels in the organizations; working team can consist of one individual or a work team).

(From this definition, we can conclude three major characteristics) [3–5].

2.1. Projects are temporary

It means that projects always have a limited period of time with specific beginning and specific end, where the end of project is to achieve the goals that the project was implemented for them, of course, duration time of a project varies from one project to another, according to its characteristics, some projects have a short time and others have a long time, they may take several years to implement. It should also be noted that the team that is being formed to manage a project ends with the end of a project.

2.2. Unique product, service or result

The project is usually alone in its properties and has never carried out with the same fully specifications, as each project has its circumstances, its activities and its method of implementation, for example, there are thousands of buildings that are being built, but each one has a different owner, a different design, a different contractor and a different location.

2.3. Progressive elaboration

Projects are implemented in a gradual and successive steps, where there is an increase in the value of a work done, in other words, the work in all its stages must be performed carefully

for all details. These needs to be clear and expanded definition of the project, and determine the scope of the project in detail, the most important actions to be taken when determining the project are Work Breakdown Structure “WBS segmentation. “For the work contained in the project”.

The three main characteristics of the projects are not the only, but there are other attributes, including that the project consists of several specific activities and limited budget, also it uses the financial and human resources, it requires time and effort according to the type of project and the estimated completion period.

3. Project management and project manager

{Any project needs to an Effective team to make it a success, that is mean it needs management with high competence and mastery of the mechanisms of project management, Which can be defined as “a set of management skills, knowledge and tools they require to apply for project activities to meet the requirements of the completion of the project in full, starting from primary phase (Initiating stage) through the planning phase, implementation phase (Executing stage), control phase (Controlling) to ending with finishing phase and closing the project phase (Closing stage)} [6].

Thus, management of a project has to deal accurately and attention to times of completion of a project, costs and quality of work and to avoid the risks and knowledge of what was requested by the beneficiaries of the project. It is the task is not easy, it requires different skills and effective working methods to reach acceptable results, especially, working environment is characterized by being a rapidly changing dynamic environment as well as the fact that each project has properties that distinguish it from other projects, which makes a risk factor was present, risks may be very danger in innovative projects which have never been done other similar advance projects before. Sometimes, many views share (or interfere) with the implementation of a specific project as well as a long period of time required to implementation. This makes task of project management very complex and difficult.

These and other matters led to appear an independent field in the science of management called “project management” and specialist in it is Project Manager, it became focus on granting postgraduate degrees (PhD and MSc) in this field and it is studied in most universities and institutes around the world, where project management is no longer just the art of gaining experience and practice, but it became a science having its assets, rules and theories, a lot of specialized books of this field were written and a lot of specialized scientific magazines were released, most notably of those are issued by the American Institute of project management entitled “International Journal of Project Management”.

{The role of a project manager is a vital and essential role in success or failure of a project, so knowledge and skills package that must be mastered by him, the American projects Management Institute (formerly referred to it) as the argument in this regard, Accurately identified them as follows} [2]:

- 3.1. Project Integration Management
- 3.2. Project Scope Management
- 3.3. Project Time Management
- 3.4. Project Cost Management

- 3.5. Project Quality Management
- 3.6. Project Human Resources Management
- 3.7. Project Communication Management
- 3.8. Project Risk Management
- 3.9. Project Procurement Management.

Perfection of these knowledge and skills by a manager of project is an indicator of the success or failure of the project, according to this situation, he plays multiple roles, he is the commander and the head of the project also he is a link between a project and the elements of its external environment, whether governmental elements or project owners.

As well as some of the important roles of project manager are decision roles, where he will be is the organizer and processor of problems and unexpected bottlenecks, also he is responsible for distribution of available financial and human resources for a project's activities as well as informational and analytical role of the reports and treating deviations, he acts as the official spokesman for his organization, project manager must be responsible for all stages, Fig. 1 show project life cycle.

4. Project risk concept

According to definition a risk in any project, which is introduced in the book of Project Management Certificate Examination, by PMBOK Guide, Project Management Institute, {a risk in any project is an uncertainly Event or circumstance, which results to negative or positive impact on the aim of a project.}

{Risk can be defined in any project that an event or circumstance is uncertain which results from its occurrence a negative or positive impact on the goal of the project} [8].

Each risk has a reason, which leads to a result. for example, this reason may be available limited qualified workforce for a project or inadequacy of this force of the tasks assigned to it, so, the result or consequence will appears clearance in the additional cost or imbalance in work scheduling, also the length of implementation period or quality of implementation. As for the conditions of the project, which could lead to the occurrence of risks, the most important of these conditions is mismanagement or incompetence or depending on external participants (cannot be censorship and control of their

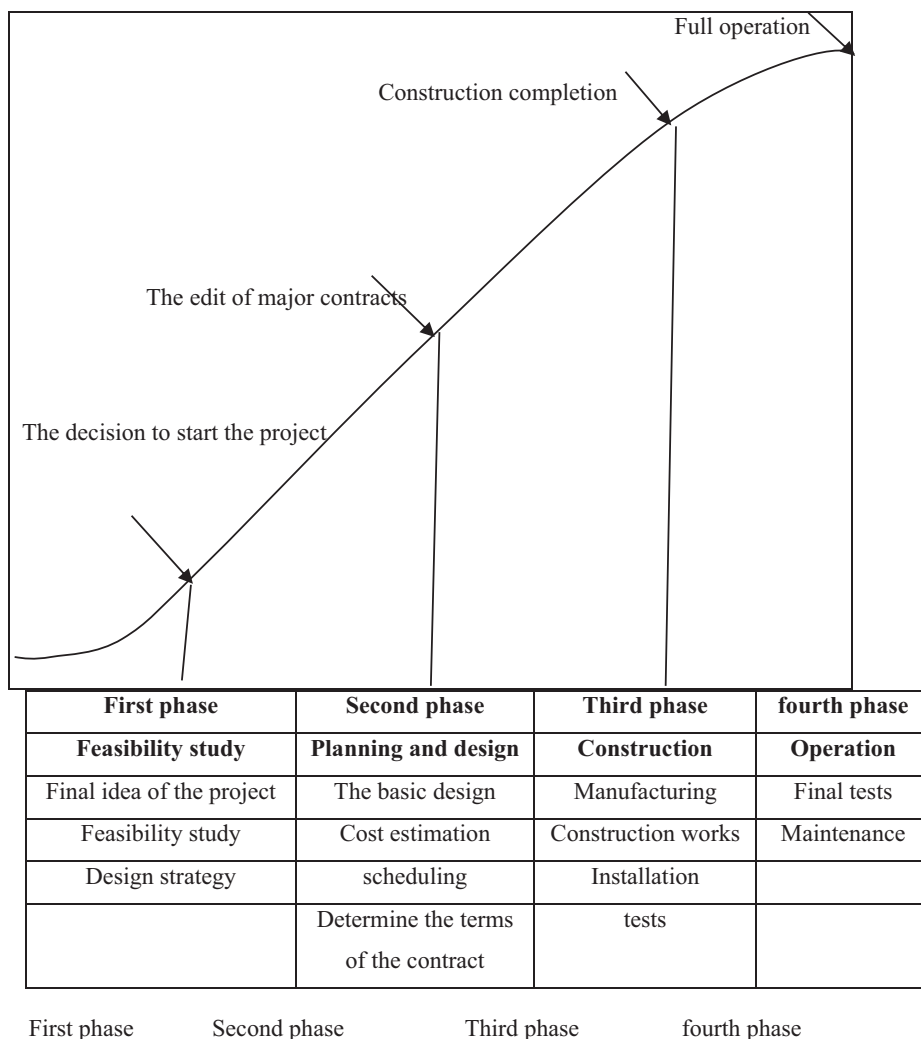


Fig. 1 Construction project life cycle [7].

performance) for implementation of the project. Some of risks are known (It is those risks that have been diagnosed and analyzed) can be planned. On the other side, another are unknown, which they cannot be managed, although the managers of a project can deal with it through general emergency Plans depending on previous experiences, there are risks as an opportunity. It is these risks that threaten the success of the project, but they are accepted for the results expected of them.

For example, to accelerate by adoption rapid scheduling of project activities having a great danger not to completion on exact time and high cost, but in contrast, benefits that arise from acquired time will be large.

5. Risk management plan building

{It means a decide how to prepare to deal with risk and the entrances to treatment and identify activities, coordination and planning process, this is very important because it describes the next steps to be taken to determine the level, type and extent of clarity of risk in the project, therefore the correct treatment.} [9].

{First step for preparing a plan of risk management is planning meetings. This preparing plan is very important for risks diagnosis, qualitative and quantitative analysis of these risks and response and control of these risks methods} [10,6].

It can be summed up elements of the plan as follows.

5.1. Methodology

It means the entrance, tools and data sources using in risk management project.

5.2. Roles and responsibilities

It means determine the team for risk management, it may needs offices to carry out the analysis and evaluation

5.3. Budgeting

Determine the estimated budget to cope risks and deal with them according to their size and the extent of their expected impact.

5.4. Scheduling and timing

Determining the frequency of occurrence of risks and the timing of likely occurred during the project life cycle, it must be reviewed timings periodically according to the project's progress in implementation.

5.5. Scoring

Before starting the quantitative or qualitative analysis, it must create standards and a Working knowledge of these standards mechanism and the extent of their stability over Time and though various other risks.

5.6. Risk categories

According to nature of work and type of project, risks can be classified into several types by resorting to the same tasks segmentation method called (Risk Breakdown Structure) (RBS) (see Fig. 2).

5.7. Formats and templates

These are documents and forms are ready and prepared in advance to describe risk content and methods of responding to it, these documents are the tools can help manager to deal with risk to describe its content, to document it and to analyze its various aspects.

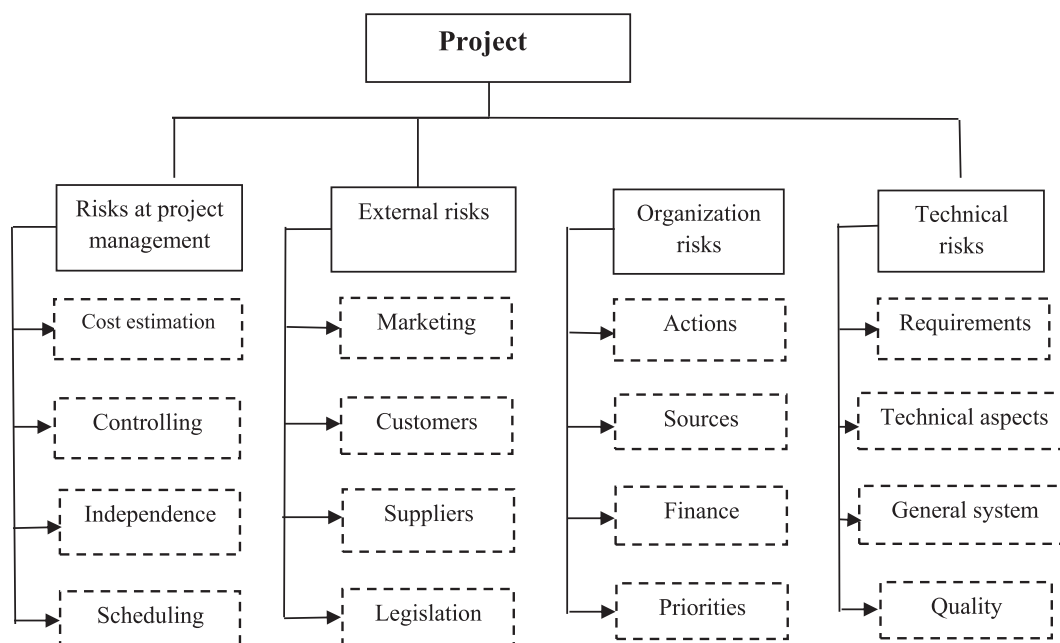


Fig. 2 Risk breakdown structure [7].

5.8. Tracing

It is a process of document for all the terms of risk, it is very useful for perpetrators of this project and all beneficiaries from it, this document contains explaining of future needs of the implementation processes also contains learned lessons.

5.9. Risk identification

{This phase includes identifying features of risks clearly and which will effect on the project and the extent of its potential impact includes documentation of all characteristics of these risks.} [8].

Diagnosis of risk task is defined by each of work team project, risk management team, experts of different financial and technical aspects of various sections of project, some Customers and beneficiaries of the project, managers of other projects and stakeholders, and experts from abroad.

{The diagnostic process is a procedural process that can pass through three stages: first stage is carried out by members of project team and risk management team, second stage is performed by entire project team and main beneficiaries of project, finally the third stage is carried out by all mentioned who were not involved in the earlier stages. It is used in diagnostic process, several tools in order to make it accurate, perhaps the most important of these tools as follows:} [6,11].

5.9.1. Documentation review

It is carried out by accurate reading of main contractor of project, its plans and primary proposals of it.

5.9.2. Information – Gathering techniques

The most well-known methods of data collection are Brainstorming, Delphi method, Interviewing, As well as analysis SWOT (Strengths, Weaknesses, Opportunities and Threats).

5.9.3. Checklists

These lists are based on available historical information and accumulated knowledge through implementation of previous projects and other sources of information.

5.9.4. Assumptions analysis

Each project is based on a set of initial assumptions and possible scenarios and analyze the assumptions, assumptions analysis means discovering the validity of these assumptions in terms of inaccuracy or instability or lack of fullness or perfection.

5.9.5. Diagrams

{These include a wide variety known in the administrative literature and engineering works such as diagram of cause and effect, it is called “Cause – Effect Diagram”, maps cruise is called “Flow Charts”, other is called “influence diagrams” and others.

Risk diagnosis process will contribute for identifying the risks that will effect on the project, also it is considered an important phase for detection of the so-called symptoms or cues danger, it is called “ Risk Triggers”, sometimes it is called a warning against signals for occurrence of a certain danger.} [10].

The inability to deliver some of main parts of project in a timely manner is only a warning signal warning of the danger of not being able to deliver the entire project at the agreed time.

6. Risk quantitative and qualitative analysis

Risk Qualitative Analysis: it means Size and breadth of the impact potential risk, it is important to arrangement risks according to its degree of impact on the project objectives.

Risk Quantitative Analysis: it means Quantitative description of risk according to the probability of occurrence; the consequences of risk constitute a monetary value or any other value.

6.1. Qualitative assessment

Qualitative assessment is very important to determine the importance of risks and knowing which needs to treatment before another, this assessment depends on some Computational and graphical tools, one of these tools is matrices of arrangement of probability and consequence, it is called, “Probability Impact Risk Rating Matrix”, it is structured by estimating the following.

6.1.1. Risk probability

it is qualities ‘estimated by specific characters, like, very low, very high and another characters, Majoring possibilities ranging from 0.05 to 1.00 for assessment these Qualities’ characters, the common assessment is: 0.1 means very low, 0.3 means low, 0.5 means Moderate, 0.7 means high, and 0.9 means very high.

6.1.2. Risk consequence

It evaluates also by Qualities’ characters, like low or moderate or high, usually, it usually suggests the relative importance which reflect this impact, and the most common is 0.05 for the consequences of a very low impact, 0.10 for low impact, 0.20 for moderate impact, 0.40 for high impact and 0.80 for very high impact.

After identifying these two indicators, we can account the coefficient matrix of risk, this equal Multiplied by (probability × consequence) for each objective of project objectives, in Table 1, we have an example of a matrix of Order of probability and consequence of risk, in Table 2, we notice matrix risk factor, which has assessment of Risks, we notice that (0.05×0.9) equal 0.45, nearly 0.50, also (0.9×0.10) equal 0.09, (0.9×0.20) equal 0.18.

It is very important to know significance of three colors in the matrix, Green color indicates that the risk is little importance; Yellow color indicates that there are important risk and red color indicates that the risk would have a major impact on the project’s objectives.

There are other qualitative methods, such as another method specifies the order of risks, according to customize of marks or points for each risk by a group of residents in project, where each resident is allocated to him, 100 mark, he can distribute them according to the importance estimated by him for each risk, then, he order these risks according to their relative importance, as in the following example in Table 3.

Table 1 Matrix probability – the consequence of the risk [8].

Project objectives	Risk Assessment %				
	Very low 0.05	Low 0.1	Moderate 0.2	High 0.4	Very high 0.8
Cost	Increasing cost is not important	Increasing cost is less than 5%	Increasing cost is between 5% and 10%	Increasing cost is between 10% and 20%	Increasing cost is more than 20%
Project Scheduling	Simple glitch of scheduling	glitch of scheduling is less than 5%	Imbalance ratio in total scheduling is between 5% and 10%	imbalance ratio in total scheduling is between 10% and 20%	Imbalance ratio in total scheduling is more than 20%
Project scope	Simple change in scope of project	Some scope aspects is affected slightly	Main parts of scope will be affected	Changes in scope is not accepted by beneficiary	The final output of project cannot take advantage of it
Quality	Low quality	Scheduling of some aspects of project scope has low quality	Main parts of scope Non-conforming	Quality level is not accepted by customer	The final output of project cannot take advantage of it

Table 2 Matrix risk factor [8].

The risk of certain risk scale					
possibility	The degree of risk (the risk coefficient) =P×I				
0.9	0.05	0.09	0.18	0.36	0.72
0.7	0.04	0.07	0.14	0.28	0.56
0.7	0.03	0.05	0.10	0.20	0.40
0.3	0.02	0.03	0.06	0.12	0.24
0.1	0.01	0.01	0.02	0.04	0.08
	0.05	0.10	0.20	0.40	0.80
	The impact on one of the goals (such as cost, time or achievement scale)(Ratios measure				

Based on this, order of risks according to its importance will be as follows in Table 4.

There are many other ways depending on qualitative analysis and vary in degree of its complexity and accuracy.

6.2. Quantitative assessment

There are disparate methods in their degree of complexity, but they can have a biggest clearer as for risk, the ability to confront it, and taking the necessary actions to mitigate its impact, the most important of these methods as follows.

6.2.1. Interviewing

The first step in the quantitative assessment of risk is interviews are conducted with the main beneficiaries of project (Stakeholder) and specialists in various project activities.

The information will be collected based on the probability distribution type, which will be adopted in quantified estimating of risk.

The most commonly methods is triple estimating for the cost, to quantitative assessment of risk (in cost), it needs calculate the cost of Completion of a project.

For example, if the triple-an assessment of one project was as follows in Table 5.

Here we find that the most moderate estimate is 41 thousand units of cash, if we need to estimate the probability of completion of this project with same cost by a simple graphical method, we will find that the probability of achievement is only 12%, if executing company wanted to determine the probability of completion of 75% of the cost, this means that the cost will be 50 thousand monetary union (as in the figure below). An increasable equal 22% (as shown at Fig. 3).

Table 3 Matrix qualitative assessment [11].

Residents	Risks										Number of points allocated to each resident
	1	2	3	4	5	6	7	8	9	10	
A	10	5	0	10	0	0	0	25	30	20	100
B	5	10	30	0	0	15	10	0	30	0	100
C	10	25	15	20	0	0	5	0	5	20	100
D	5	20	17	15	33	10	0	0	0	0	100
E	5	18	20	7	20	30	0	0	0	0	100
Total point	35	78	82	52	53	55	15	25	65	40	500

Table 4 Order of risks according to its importance.

Number of points	Risk	Sequence
82	Risk 3	1
78	Risk 2	2
65	Risk 9	3
55	Risk 6	4
53	Risk 5	5
52	Risk 4	6
40	Risk 10	7
35	Risk 1	8
25	Risk 8	9
15	Risk 7	10

6.2.2. Decision tree

Decision Tree is one of approved graphical methods of quantitative analysis of a risk, it contains decision points and normal cases points, Decision points represent options or available strategies, while normal cases points represent the external conditions that can occur.

The value of each branch of the decision tree can be calculated, the right decision are making based on these calculations.

We can explain this method by the example following (see Fig. 4).

After subtracting the cost from the profit for both options, the decision will be updated the current factory because expected profits will be 49 thousand units in cash while the new factory building will lead to a profit equal 41.5 thousand units in cash.

6.2.3. Simulation

It is an important scientific method, which translates diagnosed uncertainty cases in parts of project in detail trying to be circulated to the entire project.

One of the main methods used is Monte – Carlo method.

Table 5 Triple-An assessment of the project.

Assessment			Work item (stage)
High	Most probability	Low	
10	6	4	Design
35	20	16	Building
23	15	11	Testing and commissioning
41			Total

Computer software helps much to success of the simulation process and achieve good results for the project.

7. Risk response strategies

{There are several well-known and proven strategies to respond to risk, it should be sure to choose the right ones to confront risk based on the type of this risk and the circumstances surrounding the project}.

{The most important of these common strategies to confront the risks are}: [11,9,5].

7.1. Risk avoidance strategy

This strategy is based on changing the project plan to eliminate risk, or to unwanted circumstance or to protect the objectives of the project from its effects. Of course, not all risks can be avoided or removed them, but some risks have proven experience in many of projects could be avoided.

Some risks may arise at the beginning of implementation of project, so it would be easy to deal with it, this may be by one of the following means:

- 7.1.1. More clarify for requirements and supplies related to the project.
- 7.1.2. Obtaining additional information.
- 7.1.3. Improve communications.
- 7.1.4. Contracting with specialist.
- 7.1.5. Reduce scope of the project to avoid high-risk activities.
- 7.1.6. Adding resources or time.
- 7.1.7. Adopt known execution methods instead of adopting innovative methods.
- 7.1.8. Not to deal with subcontractors who lack previous experience.

7.2. Risk transference

Risk Transference means transforming consequences of risk to a third party; this means transforming the responsibility of risk

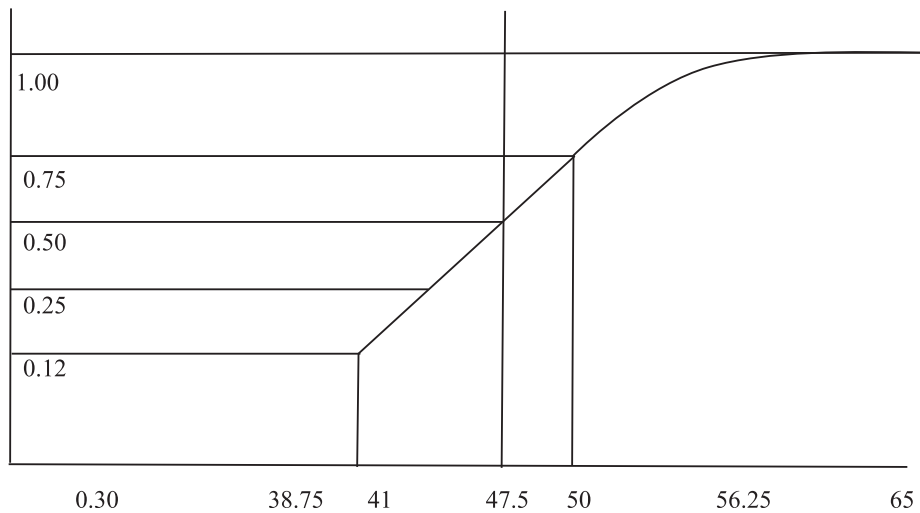


Fig. 3 Estimate probability of completion of a project at a certain cost [2].

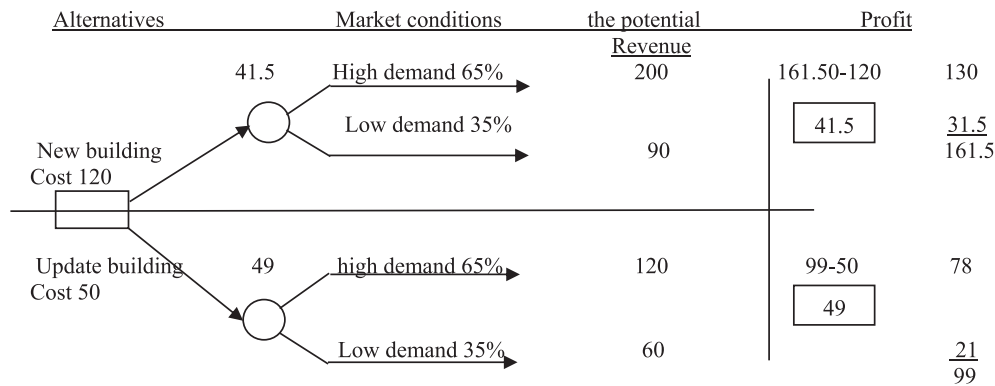


Fig. 4 Example of decision tree diagram.

management to others without removing it or avoid it. This is common in the financial obligations, project contractor will bear the financial burden in exchange for transferring of consequences burden or risk results to another party, he has resorted to use of insurance services or giving guarantees or other means, For example, a project contractor can consistent fixed price for materials or other with suppliers, as such he transfers the risk managing responsibility of prices volatility to the suppliers, or prior agreements with customers or beneficiaries of the project to re-estimate the cost in the event of a rise in prices, or others of future events.

7.3. Risk mitigation

The goal of this strategy is to mitigate or reduce probability or consequences of a particular risk to an acceptable level, to take some of the procedures that minimize the potential for risk better than to take actions to treatment the effects or consequences of that risk, Examples of actions taken before start of the implementation of projects or during execution are Engineering or seismic tests or the selection of suitable and known suppliers with their credibility, these measures may include changing the conditions to minimize potential for risk, such as adding resources or time to activities of the project.

7.4. Risk acceptance

This strategy is meant not to change the project plan to deal with risk, or the management is unable to diagnose or adopt any other strategy.

The effective acceptance of risk includes the development of plan “contingency plan”, while “passive acceptance” means to take no action and leave the team in the project dealing with the risk by themselves. The development of Contingency plan leads to diagnose risks, therefore it has a good effect on reducing the cost of actions to be taken if the won risk. When risk gets and has significant effects, “fallback plan” is being developed to confront this great risk, when the chosen strategy is not fully effective, perhaps a clearer example for this is allocation of backup resources or development alternatives for implementation be ready in case of risk, including changing project scope.

8. Conclusions

This paper deals with - also suggests the following pages - a vital topic in the management and planning of projects, it is a risk of all different types, which is gaining its importance of consequences that can result from its occurrence, the conse-

quent of these consequences of these negative effects on the objectives of the project Both on cost or delivery time or extra effort And accompanied by other problems.

At the beginning of the search was to focus on the meaning of the concept of the project and the project management and the importance of their studies, after that it has been reviewed concept of risk and its sources and how to plan it?, how to diagnose and measure quantitatively and qualitatively? Risks of different types when they are diagnosed, the basic goal behind this is to identify appropriate strategies to confront or avoid them or at least reduce the severity or transferred entirely to the other hand, the most important conclusions of research are the following:

- 8.1. It is very necessary to interest of risk study in projects seriously; the implementing agency of project or its beneficiaries should not to start of implementation before configuring management or specialized working team of risks management and it should have prepared a study of potential risks.
- 8.2. Risk management team should continue its work in any project and do not stop until end of project because risks may emerge their indicators at different stages of project life cycle.
- 8.3. Extraordinary interest of capabilities development of risk management team in project in the field of methods of diagnosis, qualitatively and quantitatively assessment of risks, whenever, skills are more high- in this field, results were more accurate and therefore it can be overcome risks or reduce their severity at least.
- 8.4. The adopted strategies of responding risks depend on type and size of risk, the risk management of the project must take notice that there is no single strategy suitable to confront all risks.

- 8.5. Conscious careful planning which leads to risk manage plan in project, is the basic for success of work team to overcome risks, so, previous experience of other smel-lier projects and Assisted of experts of various disciplines may be ordered instrumental in success of management by diagnosis risks, their Combat and reduce of their impact.

References

- [1] David Baccarini et al, Management of risks in information technology projects, *Ind. Manage. Data Syst.* 4 (2004).
- [2] Project Management Institute, PMI, 2000.
- [3] Saad Sadek Beheri, Project Management by Using Computer, AL Dar Alga Maia, Alexandria, 2005.
- [4] Parameshwar P. Iyer, Engineering Project Management, Wheeler Publishing, New Delhi, 1996.
- [5] S.A. Keller, Information Technology Project management: A Concise Study, Prentice – Hall, New Delhi, 2006.
- [6] Phillips Joseph, Project Management Professional: Study Guide, M.C. Grew – Hall, California, 2005.
- [7] Irem Dickmean, Talat Birgonul, An analytical hierarchy process based model for risk and opportunity assessment of international construction projects, *Can. J. Civ. Eng.* 33 (2006).
- [8] Project Management Institute, A Guide to the Project Management Body of Knowledge (PMBOK Guide), 2002 ed., PMI, Pennsylvania, USA, 2000.
- [9] Wide man, R. max, Project Risk Management, The Project Management Handbook, PMI Institute, Pennsylvania, 2004.
- [10] Leon A. Kappelman et al, Early warning Signs of IT Project failure: The Dominant Dozen, *Information Systems Management*, fall (2006).
- [11] Well Stan, D. Van, et al, Project Risk Management, Kogan Page Limited, India, 2005.