Investigating Causes of Delays in Iranian Construction Industry According to Project Delivery Methods

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ABSTRACT

Construction delays can be defined as the late completion of work compared to the planned schedule or contract schedule. Construction delays can be minimized only when their cause are identified. The objective of this study was to identify the major causes of construction delays and the effects of those delays in Iranian construction industry. Also in this research the relation between project delivery method and these delays has been discussed to achieve the best and most suitable method according to the situation in Iran. This study was carried out based on literature review and a questionnaire survey. A total of six groups were contributed to the identification of causes of construction delays including clients, contractors, consultants, public authorities, contractual relationship delay and external parties. The questionnaires were distributed to the target respondents in Iranian construction industry. The most important factors that contributed to the causes of delays were related to financial problems such as delay in progress payments by owner or difficulties in financing project by contractor. Alongside of these problems, the inflation has also high influence on delay and it is because of political and economical situation of Iran. Client-related delays were ranked the most significant groups that cause delays, followed by contractor-related delays, and public authorities-related delays. Time and cost overrun were the common effects of delays in construction projects and unfortunately most of Iranian companies did not pay attention to the causes of delay till they happened and usually they do not employ professional construction manager in this specific field during the construction phase of the projects.

Keywords: Project Delivery Method, Delay, Iranian Construction Industry.

ÖZ

İnşaat gecikmeleri planlanan program veya sözleşme takvimine göre işin geç tamamlanması olarak tanımlanabilir. İnşaat gecikmeleri tespit edildikten sonra azaltabilir. Bu çalışmanın amacı inşaat gecikmelerinin başlıca nedenleri ve İran inşaat sektöründe bu gecikmelerin etkilerini belirlemektir. Ayrıca bu araştırma, proje teslim yöntemi ve bu gecikmeler arasındaki ilişki İran'daki duruma göre en iyi ve en uygun yöntemi ulaşmak için ele alınmıştır. Bu çalışma, literatür taraması ve ankete dayalı yürütülmüştür. Toplam altı grupta müşteriler, yükleniciler, danışmanlar, kamu yetkilileri, sözleşme ilişkisi gecikme uzmani ve dış elemanlari dahil, inşaat gecikme nedenlerinin belirlenmesine katkıda bulunmuştur. Anketler İran inşaat sektöründek, hedef katılımcılara dağıtıldı.

Gecikme nedenlerinin en önemli faktörleri mali problemlerden kaynaklaniyor ve mal sahibi odemelerde geçiktiği zaman veya yüklenici tarafından finansman projesinde zorluklar çıkması gibi konulardenidi.

Bu sorunların yanı sıra, enflasyonun yüksek bir etkisi vardır ve bunun nedeni İran'ın siyasi ve ekonomik durumundan bayraklenecektedir**.** Müşteriler ile ilgili gecikmeler müteahhitler'le ilgili gecikmelere en önemli neden kamu otoritelerindeki gecikmeleri olduğu belirlendi.

Zamaninde tamamlanımı ve maliyetler inşaat projelerinde gecikmeler, ortak etkiler İran şirketlerinin çoğu gecikme nedenlerine dikkat etmediği ve genellikle inşaat projelerin aşamasında bu özel alanda profesyonel inşaat yöneticisi istihdam olmadiğinda sorun yaşadığı güzlemlenmıştır.

Anahtar kelimeler: Proje Teslim Şekli, Gecikme, İran İnşaat Sanayi.

This research is dedicated to my lovely parents and sister for their continued support and encouragement during my whole life.

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LIST OF ABBREVIATIONS

BOT	Build Operate Transfer
CM	Construction Manager
DBB	Design Bid Build
DB	Design Build
EPC	Engineer Procure Construct
GC	General Contractor
GMP	Guaranteed Maximum Price
PDM	Project Delivery Method
SPSS	Statistical Package for Social Sciences

Chapter 1

INTRODUCTION

1.1 Introduction

In this chapter brief information about background of construction industry and delays were presented. After that the main reason of conduction this research is provided. Therefore, a short description of purpose and achievements are clarified and at the end, thesis guideline is included a conception of framework of this master thesis.

1.2 Background Information

Delays in construction industry have always been issue of apprehension for construction management researchers. Ahmed et al. (2003) recognized delay as the most mutual, complex and universal phenomenon in construction which is typified by cost and time overruns (see also Abdul-Rahman et al., 2006; Arditi et al., 1985; Alaghbari et al., 2007; Xiao and Proverbs, 2002; Ahmed et al., 2003; Al-Khalil and Al-Ghafly, 1999). Arditi et al. (1985) even considered the brutality of delays in construction to have possible effects on the state of the overall economy of a country.

Most of the researchers in the field of construction management have tried to investigate the causes and effects of construction delays. For example, 70% of the construction projects in Saudi Arabia have been estimated to experience some form of delay (Assaf and Al-Hejji, 2006). In Nigeria, it has also been mentioned that seven out of ten projects suffered time overruns (Odeyinka and Yusif, 2002). Another

investigation in Malaysia determined that 17.3% of 417 public projects experienced a time overrun of around three months in 2005 (Sambasivan and Soon, 2007). All of these studies prove the fact that little has changed in spite of all the research into delays in construction.

All participants in a construction project (client, contractor and consultant) have important role in project completion; so their attention can negatively or positively affect the performance of project. In the other words, contributors with different skills and background experience have different curiosity and assumption (Dey and Ogunlana, 2004). Actually the importance of choosing the correct project delivery method (PDM) has not been understood by many countries and some organizations (specially Iranian government) are not thinking about the consequence of this selection, because the wrong choice could causes a lot of risk and delay for a project. In normal way, this major problem could be the main reason of time overrun and cost overrun plus low quality of the final project.

For the aim of this study, Iranian construction industry was chosen as the case study. Alike other countries, Iranian companies come across with different types of delay such as financial, technical, contractual or governmental. This research will investigate the most useful project delivery method (PDM) in Iran considering how the different delays will effect on each selected PDM.

This study has facing on a case study to examine how different project delivery methods could be causes of different delays during building and road project. Therefore, questionnaire survey was selected as the research method in order to

collect information and then with the asset of SPSS program, delay of each method was ranked and discussed.

1.3 Purposes and Objectives of the Study

The main purpose of this study was to identify major causes of delays in different project delivery method within Iranian construction industry through the evaluation of Iranians' perception about new and different project delivery method. To do so, the main objectives of this research have been assessed as:

- To identify and categorize the most major and common delays in the Iranian construction industry;
- To compare selected project delivery methods and identify the most catastrophic delays in each method;
- To choose and select which project delivery method is suitable according to the political and economical situation of Iran.

In order to accomplish these objectives, the following research questions have been adjusted to support the research:

i. What are the most catastrophic delays that cause cost overrun and time overrun during a construction project?
ii. What kinds of project delivery methods are being uses across the world and which one is suitable to be used in Iran?

1.4 Research Methodology

Robson (2002) projected that designing of research methodology is about changing the question of research into the study project. In this case, the type of research methodology is an anatomical one. In this regard, questionnaire survey technique was selected to gather the data and make further analysis.

The preparation of questionnaire will be described briefly in chapter 3. The questionnaire was arranged as a result of a number of research articles and books in the field of construction management. The developed sample of the questionnaire can be found in Appendix A.

1.5 Achievements

In order to succeed the mentioned objectives of research, the following points were achieved:

- The selected causes of delays were divided into six groups: client, contractor, consultant, public authorities, contractual relationship and external. Based on the results of questionnaires survey, there were 36 delays, which frequently happened during construction projects. Among recognized delays, "delay in progress payments by owner" was the most catastrophic parameter on the construction projects.
- Project delivery methods in Iran are limited to few ones and it could be because of lack of knowledge or unavailability of experienced people in this field. But according to this research with a little bit change in structure of Iranian construction industry the BOT method could be perfectly suitable for Iranian governmental projects.

- Iranian companies usually wait till delays happen in their project and then deal with it by their experience and have argument to other related parties such as consultants or contractors to make them feel guilty and be more responsible during the rest of project while sometimes the mistake happened because of their irresponsibility.

1.6 Thesis Guideline

The research began with some basic information and background knowledge on construction management and defining objectives and purpose of this research. Then, literature review provides a brief data about types of delay and project delivery methods, performed in different studies and countries. In further part, description of applied methodology to analyze data has been pronounced. Consequently, data collection and analysis from questionnaire survey are presented in next part of research. Then, results from questionnaires are discussed and some recommended actions are proposed in order to diminish problems. At the end, conclusions, answering questions and recommendations for future work are delivered. All mentioned progressions are divided into five chapters, which are separately described below.

Chapter 2 provides literature review that is brief information about types of delays which occurred in different research studies. Also the selected delays have been categorized separately. In this section the different project delivery methods which performed in different countries are presented.

Chapter 3 provides specific and complete information about how the research will go on and which method is suitable and more reliable to use in the case study. Also some main definitions about statistical package for the social sciences are presented.

In chapter 4 the collected data form each portion of questionnaire is presented and answer of first section of questionnaire shows with bar chart. Also this chapter is including the reliability test of research according to Cronbach's alpha coefficient.

Chapter 5 provides the outcomes of identified delays from different viewpoint of each respondent are shown in different figures and tables. Also, data analysis and the results have been presented. Thus, findings from questionnaire survey are argued in details. Finally, main causes of delay and recommended actions to ease and control the effect of them are presented.

Chapter 6 presents the conclusions of the research and offers some recommendations for further work. Also the questions of thesis have been answered and the final achievement of the research is determined in it.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

The word ‘delay’ implies performing a task either slower than anticipated or accomplishing an act which was initially planned to be done at a later than an earlier date. In the construction industry, any form of delay has repercussions which may constitute significant obscure or hidden risks as well as additional costs (Alaghbari, 2007). Given the synchronized and streamlined flow of different phases during construction, a delay in any one of the tasks may lead to some critical problems pertaining to one or more related parties engaged in the construction project but most often presenting certain challenges to owner and contractor. In term of performance and quality, the owner and the contractor usually value the time and cost considerations of any form of delay to the project and look for the most suitable way to minimize them (Majid, 2007).

Construction delays are often known to be the most critical factors affecting to deliver the project on time, within budget, and expected quality. Normally, the timely completion of construction project signals project efficiency. However, the construction processes depend up on a number of variables and unpredictable factors stemming from a variety of sources, including performance of involved party, availability of resources, site conditions and contractual conditions (Mansfield, 1994). The analysis of the delay impact with the causes and effects of the delaying

activities is one of the most complicated types of claims analysis. Expertise and substantial knowledge of construction projects, means and methods, project scheduling and the ability to develop a sound methodology to conduct the analysis is required by the experts to deliver a state of the art project within schedule. It should also worth recalling that most of these delay claims reach the expert after completion of the project.

2.2 Types of Delay

In the construction industry, delays are categorize in four principal types (Theodore and Trauner, 2009):

1. Critical or non-critical
2. Excusable or non-excusable
3. Compensable or non-compensable
4. Concurrent or non-concurrent

2.2.1 Critical and Non-Critical Delays

In this category, the project activities in a schedule can be critical and non-critical. For non-critical activities, it is possible that some days (float) to be delayed but ultimately the complete project scheduled termination time remains unaltered. For example five days float means that the activity can be delayed up to five days without delaying the whole project. The critical activities have zero float which means that each day delayed will delay the whole project by an equivalent delay float. The durations and logical sequence of activities over the project life time determines which activities are critical and which are non-critical. Rebuilding the schedule after the fact, determines which activities are critical and which ones are non-critical. Thereafter, the logic is established which usually changes through the project since it

requires highly technical research of the documents. Some assumptions and judgments may have to be taken during the analysis (Expert No. 51241, 2014).

2.2.2 Excusable and Non-Excusable Delays

Delays are either excusable or non-excusable. Non-excusable delays are events that are within the contractor's control or that are foreseeable. An excusable delay is a delay that is due to an unforeseeable event beyond the contractor's or the subcontractor's control. Normally, based on common general provisions in public agency specifications, delays resulting from the following events would be considered excusable (Wei, 2010):

a. General labor strikes
b. Fires
c. Floods
d. Earth quick
e. Owner-directed changes
f. Errors and omissions in the plans and specifications
g. Differing site conditions or concealed conditions
h. Unusually severe weather
i. Intervention by outside agencies
j. Lack of action by government bodies, such as building inspection

2.2.3 Compensable and Non-Compensable Delays

A compensable delay is a delay where the contractor is entitled to a time extension to compensate for the delay. With regard to excusable and non-excusable delays, only excusable delays are entitled to some sort of compensation. Non-compensable delays mean that although an excusable delay may have occurred, the contractor is not entitled to any added compensation resulting from the excusable delay. Thus, the

question of whether a delay is compensable or not must be answered. Additionally, a non-excusable delay warrants neither additional compensation nor a time extension (Wei, 2010).

Whether or not a delay is compensable depends primarily on the terms of the contract. In the most cases, a contract specifically notes the kinds of delays that are non-compensable, for which the contractor does not receive any additional money but may be allowed a time extension.

2.2.4 Concurrent Delays

The concept of concurrent delay has become a very common presentation as part of some analysis of construction delays. The concurrency argument is not just from the perspective of determining the project's critical delays, but from the standpoint of assigning responsibility for damages associated with delays to the critical path. Contractors will often cite concurrent delays by the owner as a reason why liquidated damages should not be assessed for its delays. Unfortunately, few contract specifications include a definition of concurrent delay and how concurrent delays affect a contractor's entitlement to additional compensation for time extension or responsibility for liquidated damages.

In order to effectively analyze concurrent delays, each delay is evaluated distinctly and its impact on other activities and the project duration is calculated. Certain guidelines for concurrent delays classification exist. Firstly, if excusable and non-excusable delays occur concurrently, only a time extension is granted to the contractor. Next, if excusable with compensation and excusable without compensation delays occur concurrently, the contractor is entitled to time extension,

but not to damages. Lastly, if two excusable with compensation delays occur concurrently, the contractor is entitled to both time extension and damages.

2.3 Causes of Delay

There are many factors that contributed to causes of delays in construction projects. These range from factors inherent in the technology and its management, to those resulting from the physical, social, and financial environment. Tables 2.1 to 2.6 outline the six separate groups of construction delays. In this section the criterion of choice of the selected parameters is based on studies from several articles and the most effective basis is as per the Iran construction industry.

Table 2.1: Causes of delay by client (Rajiv, 2013; Assaf and Hejji, 2005)

No.	Causes of Delay
1	Delay to furnish and deliver the site to the contractor
2	Delay in progress payment
3	Change orders by owner during construction
4	Poor communication and coordination by owner and other parties
5	Slowness in decision making process by owner

Table 2.2: Causes of delay by public authorities (Rajiv, 2013; Assaf and Hejji, 2005)

No.	Causes of Delay
1	Inflation
2	Obtaining permits from government
3	Changes in government regulations and laws

Table 2.3: Causes of delay by contractor (Rajiv, 2013; Assaf and Hejji, 2005)

No.	Causes of Delay
1	Incompetence project team
2	Difficulties in financing project
3	Delays in subcontractors work
4	Poor site management and supervision
5	Mistakes during construction and make rework due to specific errors
6	Unavailability of professional construction management
7	Delay in site mobilization
8	Ineffective planning and scheduling of project

Table 2.4: Causes of delay by consultant (Rajiv, 2013; Assaf and Hejji, 2005)

No.	Causes of Delay
1	Delay in approving major changes in the scope of work
2	Late in reviewing and approving design documents
3	Conflicts between consultant and design engineer
4	Inadequate experience of consultant
5	Misunderstanding of owner's requirements by design engineer
6	Delays in producing design documents
7	Complexity of project design

Table 2.5: Contractual relationship delays (Rajiv, 2013; Assaf and Hejji, 2005)

No.	Causes of Delay
1	Short and unrealistic contract duration
2	Legal disputes between various parties
3	Inaccuracy in cost estimates
4	Excessive contracts and subcontracts
5	Mistakes and discrepancies in contract documents
6	Controlling sub-contractors by general contractors in execution of works
7	Project delivery method used

Table 2.6: External causes of delays (Rajiv, 2013; Assaf and Hejji, 2005)

No.	Causes of Delay
1	Delay in material delivery
2	Changes in material types and specifications during construction
3	Problems with neighbors
4	Unforeseen climate conditions
5	Effect of social and cultural factors
6	Waiting for test sample approval

The causes of delays are integrated and shown in Figure 2.1.

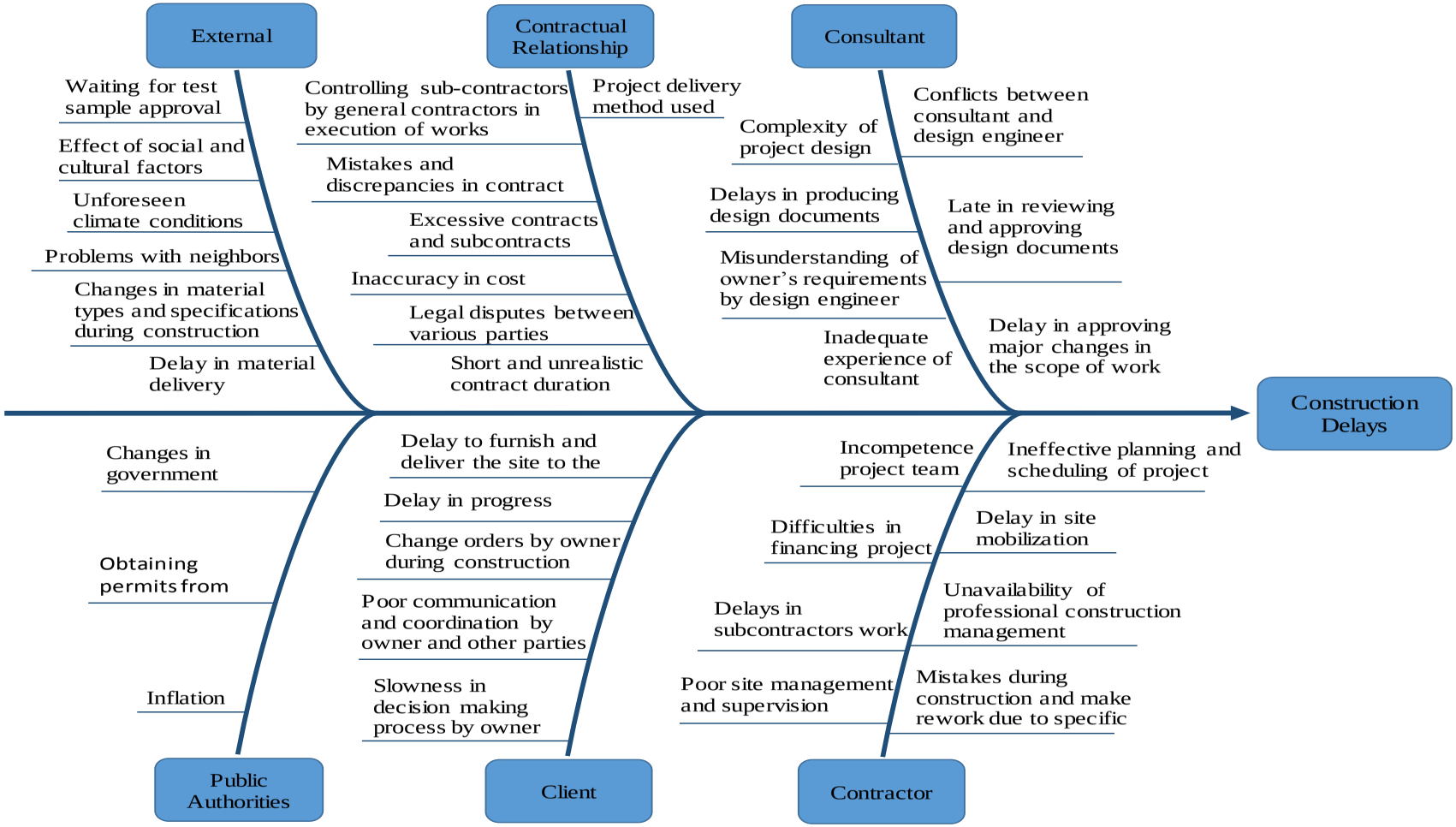

Figure 2.1: Factors that contribute to the causes of delays

2.4 Effect of Delay

Aibinu and Jagboro (2002) studied the effects of construction delays on project delivery in the Nigerian construction industry (see also Abedi et al., 2011; Assaf and Al-Hejji, 2006) They identified six major causes of construction delays namely:

1. Time overrun
2. Cost overrun
3. Dispute
4. Arbitration
5. Total abandonment
6. Litigation

2.5 Project Delivery Method

Alongside the delay, project delivery method is one of the other most important parameters to complete a project on-time. Most construction projects require the participation of owners, designers (architects and engineer), and contractors. The owner primarily determines when and whether or not a particular project is necessary. Depending on the nature and size of the project, the contractual arrangements between concerned parties may change. In some cases, one party may play two roles or even all these roles in a project depending on several factors. A clear understanding of these multiple roles is required in order to carefully evaluate the project. Moreover, the contractual relationship should be clearly understood and carefully evaluated to determine the contractual agreement required by each stakeholder for effective delivery of the project (Hinze, 1993).

2.6 Type of Project Delivery Methods

Each project delivery method has benefits and drawbacks and must be applied where the benefits outweigh the costs. In the public sector, this traditionally entails the almost exclusive use of the design-bid-build system, involving the separation of design and construction services and the sequential performance of design and construction. In recent years, however, the public sector has begun experimenting alternative methods to improve the speed and efficiency of the project delivery processes. These alternative systems move closer to the integrated services approach of project delivery which is preferred in the private sector. This model is put into perspective by the illustration in Figure 2.2. The traditional design-bid-build method can be seen on the left while on the right, the more innovative systems are arranged. From left to right according to increasing similarity to the private sector model in terms of greater responsibility and risk shifting to the contractor, and less separation between design and construction services.

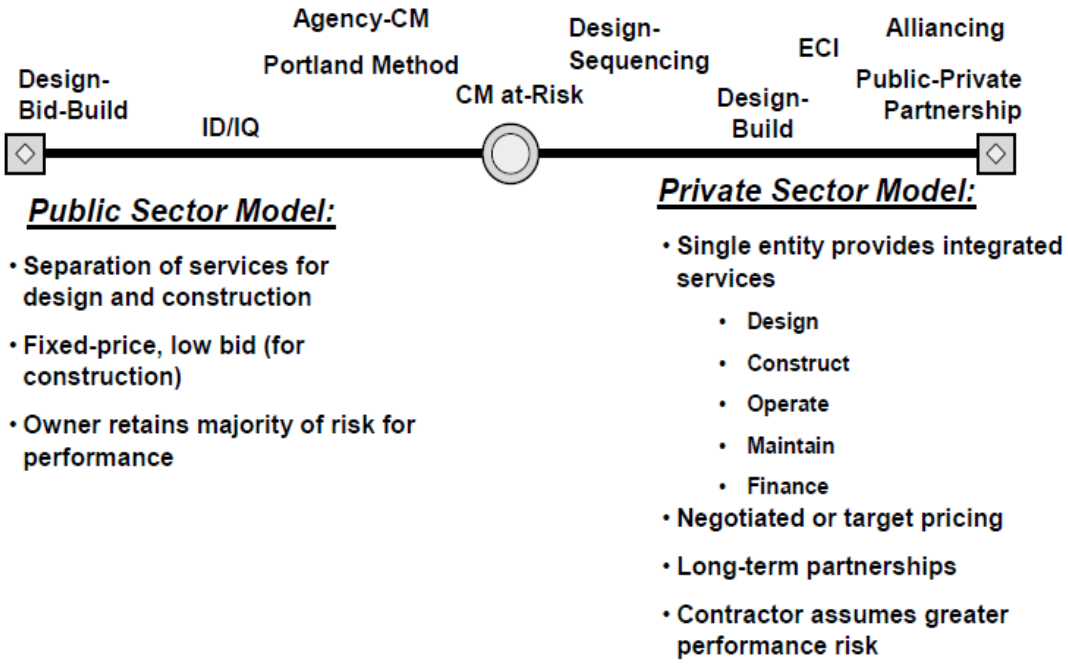

Figure 2.2: Project delivery method systems (Trauner Consulting Service, 2007)

In accordance with the Iranian construction industry, the three most popular project delivery methods labeled with (*) were selected for more discussions.

1. Design Build (*)
2. Design Bid Build (*)
3. Build Operate Transfer (*)
4. Construction Management Agency
5. Construction Management at Risk

2.6.1 Design Build (DB)

The Design-Build (DB) project delivery model is best suited for manufacturing clients that require fast-track project delivery and require a single point of contact for the project. The contractor and designers are hired by the owner to deliver a complete project. This model has been used extensively in the manufacturing industry for constructing warehouses and offices.

The owner selects a DB firm from pre-qualified companies that have submitted designs and prices based on the project requirements. The DB firms retain their own architects, engineers, and other consultants. The selection criteria are based on a combination of factors, including design, price, schedule, team etc. The DB firm selected by the owner is typically responsible for preparing the estimate and scope, as well as producing all construction drawings, details, and specifications.

The owner may provide the user requirement specifications, materials of construction, and the specifications for the manufacturing equipment. In some cases, the owner may enter into a contract with a third party firm for validation, commissioning, and qualification of the project at termination. Usually, DB contracts are typically lump sum and based on the design that precisely meets the owner's

requests. Based on certain pre-conditions, the owner may be given some guarantees regarding the maximum price that may be entailed to finish the project. The DB approach is well-suited for larger, less complicated, time-sensitive projects where the owner has a clear project definition and concept prior to soliciting bids and desires a firm price to be confirmed early in the process.

2.6.2 Design Bid Build

Design-Bid-Build (DBB) is the most common project delivery method in the manufacturing industry. Owners with sufficient in-house staff contract with different entities for each phase of design, construction, and validation, as well as take on the responsibility of organizing the various team members. This is done so that any given phase in the implementation process follows the preceding one in a sequential manner with minimal overlap. Under the DBB approach to project delivery, the owner functions as the overall project manager and hires external engineers, consultants, and contractors to deliver the project.

To begin with, the owner fundamentally commences by retaining an architect to program and develops a work scope as well as the project plans and specifications. Most often than not, the selection process for the architect is usually very competitive on a lump sum basis. Once the detailed design effort has been completed, prequalified general contractors (GCs) are invited to submit lump sum project construction bids. The DBB method often results in wide bid spreads, requiring the owner to match the project scope to the bid scope. If for some reason the bids exceed the owner's preliminary budget, additional time will be required to resubmit the project for funding.

The DBB approach is typically used when the project is not well-defined and there is adequate time for the design and construction phases. DBB projects are typically competitively bid and priced as a lump sum. The competitive nature of the bidding process usually results in a competitive cost for the owner, but the quality of the subcontractors is left to the GC. Under this method, all construction and performance risks are assumed by the contractor (design alliance, inc., 2008).

2.6.3 Build Operate Transfer (BOT)

The Build-Operate-Transfer (BOT) is one important approach for building new infrastructural facilities. In a BOT project, private investors receive a concession to finance, build, and operate a facility over an agreed upon period of time, in exchange for the right to charge the users of the facility at a rate which makes the investment commercially viable. At the end of the concession period the facility is turned over to the government. The goals of the government in a BOT-style privatization are to obtain infrastructural facilities with greater efficiency and speed, without the government taking on the adherent financial responsibility. The BOT system requires a facility to pay for itself on a commercial scale through implementation of the "user-pays" principle. In this type of model, the private investors take on the long-term risks of financing, developing, and managing an infrastructural facility based on potential commercial rewards (Handley, 1997).

2.6.4 Agency-Construction Manager (CM)

Agency-CM (also known as Program Management for multiple contracts or programs) is a fee-based service in which the construction manager (CM) is utterly accountable to the agency and acts as the agency’s representative at every phase of the project. The selection criterion for the CM is similar to the selection process for design services since it is based on qualifications and experience. CM is charged with

providing advice during the design phase, evaluating bids from prime contractors, overseeing on construction, and managing project cost, schedule, and quality. The CM may work with the designer or contractor to reduce the cost, but does not guarantee price or take on the contractual responsibility for design and construction. It is also used for large and complex projects (Trauner Consulting Service, 2007).

2.6.5 Construction Manager at Risk

Due to the substantial risk exposure of the CM to risk, the agency may involve a construction manager (CM) to act as the agency's consultant during the pre-construction phase and as the general contractor (GC) during construction. During the design phase, the CM acts in an advisory role, providing constructability reviews, value engineering suggestions, construction estimates, and other construction-related recommendations. At some specific point during the design process, a mutual understanding must be reached between the CM and the agency regarding negotiations on a Guaranteed Maximum Price (GMP). The GMP is typically based on a partially completed design and includes the CM's estimated cost for the remaining design features, general conditions, a CM fee, and construction contingency. The construction contingency can be split into CM and agency components. The CM contingency will cover increased costs due to unavoidable circumstances, for example material price increases. Meanwhile the agency contingency would cover cost increases from agency-directed or agency-caused changes, the construction contingency can be handled in different ways under the contract. Unused CM contingency can be returned to the agency, shared by the agency and CM, or given to the CM (Trauner Consulting Service, 2007).

Chapter 3

RESEARCH METHODOLOGY

3.1 Introduction

In this chapter the objectives and the aims of this research will be described and explained. The main focus of this study will be on questionnaire survey that was distributed among the famous Iranian companies that are working in construction industry. Furthermore, statistical package for the social sciences program would be used to analyze collected data. In other words, this chapter is divided into main following sections that will briefly be described in this chapter and with more detail in subsequent chapters.

- Literature review
- Questionnaire design
- Data collection
- Data analysis
- Conclusion

However in Figure 3.1, the complete research methodology of this study has been shown.

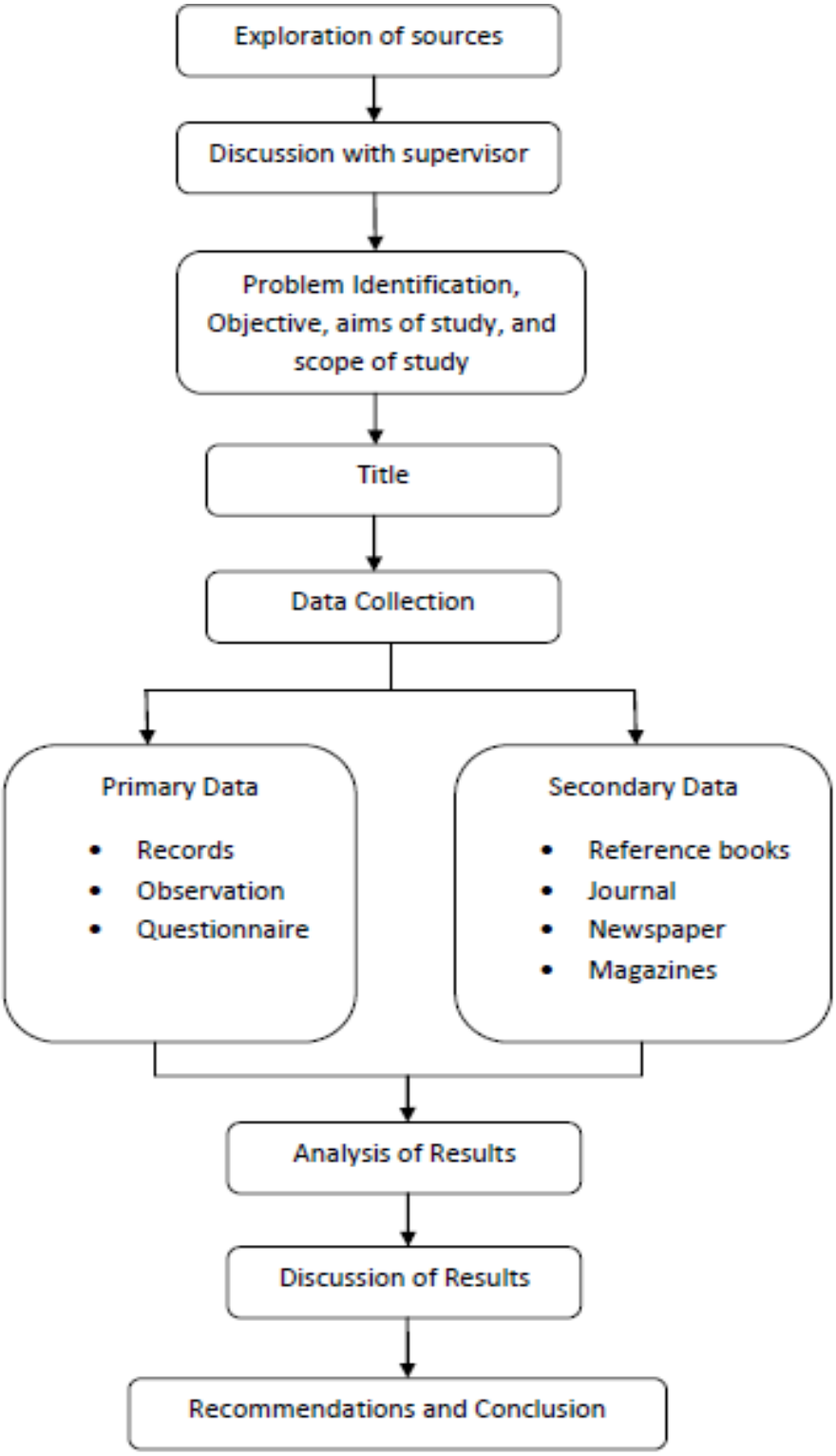

Figure 3.1: Flow chart of research methodology (Wei, 2010)

3.2 Literature Review

In the previous chapter, the literature review was finished through journals, related thesis sample, internet survey and construction management books. By observing this section of research, the most critical causes of construction delay, effect of each delay in different project delivery method, and the most important group that was causing of delay in construction industry were determined. Also some basic definitions were studied about different types of delay and some basic information about different type of project delivery methods.

3.3 Questionnaire Design

In most of the studies, the questionnaire would be designed according to the objective of the research. In this research, as it was mentioned before, the main aim is causes of delays in Iranian construction industry. In addition to that aim, the research has followed some specific objectives about the project delivery methods and the ways to reduce selected delays based on choosing the best PDM. However, it would be impossible to eliminate all delays but when the reliable data was collected and the related party causing the delay was determined, it would be easier to control the delays of projects. This questionnaire survey was developed to get the opinion of large number of Iranian companies about the construction delay and relevance between this problem and PDM. Also selected companies help to classification the causes of delay based on Iranian construction industry. The questionnaires were prepared in 4 different subcategories:

1) Part A: Respondent information
2) Part B: Project Delivery Method
3) Part C: Causes of construction delays
4) Part D: Identify related party

3.3.1 Part A: Respondent Information

In this part of questionnaire it was tried to collect some basic and general information about the selected Iranian companies. This part presented by nine questions of each one being abbreviated as follows:

1) Question 1: The organization part of respondent
2) Question 2: Field of activities in construction industry
3) Question 3: Administrative experience
4) Question 4: Companies' grade according to Iran's law
5) Question 5: Number of project during the year
6) Question 6: Number of permanent personnel
7) Question 7: Approximately annual turnovers
8) Question 8: Most common delivery method in governmental projects
9) Question 9: Most common delivery method in privet projects

3.3.2 Part B: Project Delivery Method

Project delivery methods were comprehensively discussed in literature review and according to social and political situation in Iran, three project delivery methods were chosen to be studied in this research. Each respondent was asked to answer all causes of delays in these three different PDM. In Table 3.1 the selected methods are specified.

Table 3.1: Selected project delivery methods

Project Delivery Method	Selection Reason
Design-Build	Popular in private projects
Design-Bid-Build	Common PDM in governmental projects
Build-Operate-Transfer	Create a chance to make it popular in Iran

The most important reason of selecting these PDMs is their application in Iran. Since some of PDMs are not very popular in Iran or according to the law, are not suitable for common projects. Although the BOT method is not very usual in Iranian construction industry but most of the companies had academic knowledge about that and few of them had experience in this field, especially in petrol and gas projects and road construction.

3.3.3 Part C: Causes of Construction Delays

The main purpose of this portion was evaluating the selected causes of delay. In first step, as it was mentioned before in previous chapter, the major groups of construction delays were determined. The selected groups are:

1) Client
2) Contractor
3) Consultant
4) Public Authorities
5) Contractual Relationship
6) External Factors

In the next step the chosen causes of delays were categorized in the specific groups. In this case, it has been decided to use Likert's method. With this method, all parameters should be ranked from 1 to 5 as shown in Table 3.2.

Table 3.2: Ranking methods with application of Likert's method

Delay Rating	Delay Score
Catastrophic	5
Major	4
Moderate	3
Minor	2
Insignificant	1

3.3.4 Part D: Identify Related Party

Generally and in social life each person has different vision for each issue. So the difference between the opinions of people came from here. In each research one of the most inescapable parameter is that each issue is related to whom. In these case causes of construction delays in Iran were the main issue and it will refer to the selected group from portion C.

There are two ways to identify this factor. The first way is to use previous data in the management books or journals about this specific issue and the second way is consulting with experts. To associate the second way, the researchers need strong and powerful resources. In this case, the combination of these ways was used to reach more reliable results than other similar cases. Actually the collected data are from both literature and experts in Iranian companies. The complete result and comparison of these two are explained in Chapter 4

3.4 Data Collection

This part of research refers to obtained data from the questionnaires and it will be used to analyze and determine the most critical parameters and project delivery methods. The process of data collection was associated with interview with the best Iranian construction companies to help to fully understand Iran's situation about these problems.

All the respondents in this research were contractors and because of the different point of view in each civil engineering field, the final result would be closer to contractors' viewpoint. After collecting the data, the next step is analyzing the data and answer to main objectives of the study. But before analyzing the data, the method of analyzing and the computer program that was used, should be determined.

3.5 Data Analysis

The main purpose of this part is determining relative importance of parameters that contribute to causes of construction delays in the selected project delivery method and also revealing the responsible party for each factor. This problem is usually been solved in two different ways:

1. Statistical Package for the Social Sciences (SPSS) (Programming with automatic calculation)
2. Relative Importance Index (Handwork with manual calculation)

In this research only statistical package for the social sciences has been used.

3.5.1 Statistical Package for the Social Sciences

SPSS Statistics (originally, Statistical Package for the Social Sciences, later modified to read Statistical Product and Service Solutions) was released in its first version in 1968 after being developed. It is now officially named IBM SPSS Statistics. SPSS is among the most widely used programs for statistical analysis in social sciences. It is used by market researchers, health researchers, survey companies, government, education researchers, marketing organizations and others (Argyrous, 2009). In addition to statistical analysis, data management (case selection, file reshaping, creating derived data) and data documentation are features of the base software (Levesque, 2007). In this research, SPSS was used to separate selected PDMs easily and compare the delay causes in all PDMs together to reach the best answer to main question of study.

3.5.1.1 Calculation Process of Raw Data

In this statistic part, all of raw data were collected from respondents. As mentioned before, by assisting of SPSS program, the calculation could be done easily and faster than other ways. Especially in this case, according to massive volume of calculations, it would have been unavoidable to use other methods.

First of all in different views of SPSS program, the parameters and ranking method were entered. After that, the raw data should be put in correct order in data view tab. In this session of research, the mean, variance and standard deviation were needed to be calculated. So to understand a brief description of each parameter, the following parts are presented.

3.5.1.1.1 Mean

In everyday life, the word of “average” is used in a variety of ways – batting averages, average life expectancies and etc. But the meaning is similar, usually the center of a distribution. In the mathematical world, where everything must be precise, there are several ways to define the center of a set of data:

1) Median
2) Mode
3) Mean

In this case, only definition of mean was considered. For a data set, the terms arithmetic mean, mathematical expectation, and sometimes average are used synonymously to refer to a central value of a discrete set of numbers; specifically, the sum of the values divided by the number of values. The arithmetic mean of a set of numbers x_1, x_2... x_n is typically denoted by $\bar{x}$, pronounced "x bar" (Bradfield, 1998).

$$\bar{X} = \frac{X_1 + X_2 + \cdots + X_n}{n} \qquad \text{Equation 1}$$

3.5.1.1.2 Variance

In probability theory and statistics, variance measures how far a set of numbers is spread out. A variance of zero indicates that all the values are identical. Variance is always non-negative; a small variance indicates that the data tend to be very close to the mean (expected value) and hence to each other, while a high variance indicates that the data are very spread out around the mean and from each other (Montgomery, 1994). In mathematical field, two variances are defined; first is population variance and second is sample variance. In this case, the sample variance has been used. The reason of using this variance is when dealing with extremely large populations, it is not possible to count every object in the population, so the computation must be

performed on a sample of the population (William, 2006). The calculation process has been shown step by step in Figure 3.2 and the main formula is also shown in equation 2:

$$S^2 = \frac{\sum(X - \bar{X})^2}{n - 1} \qquad \text{Equation 2}$$

Where:

- X = Respondent opinion in each case
- $\bar{X}$ = Arithmetic mean of selected delay
- n = Number of respondents that answered the questionnaire
- S^2 = Sample variance

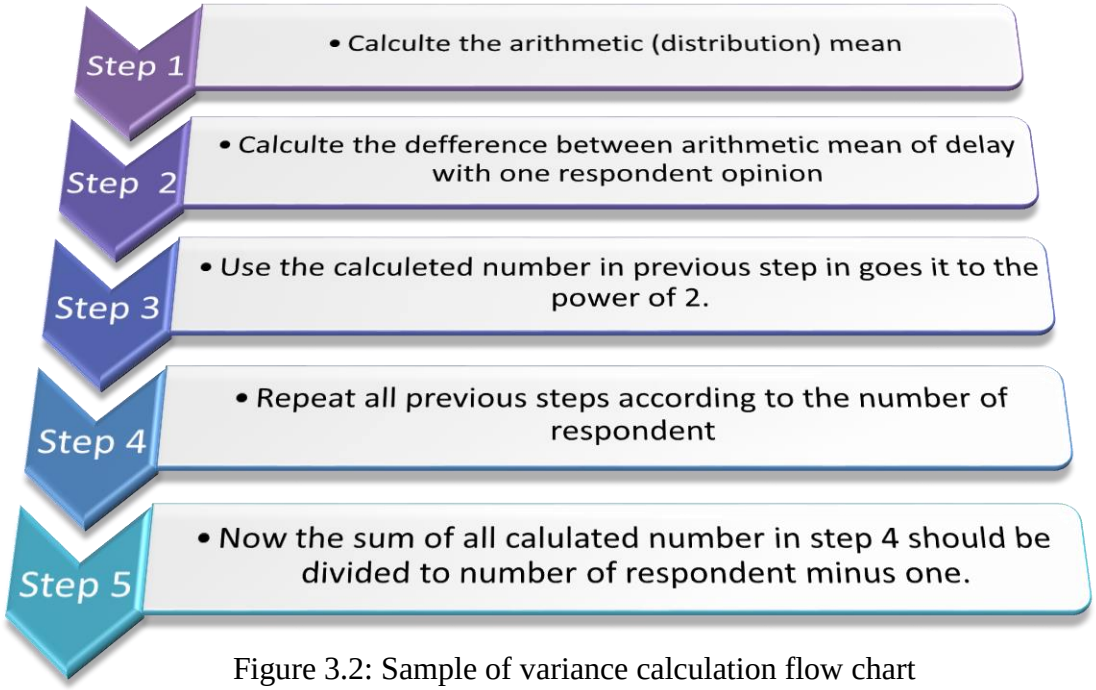

Figure 3.2: Sample of variance calculation flow chart

3.5.1.1.3 Standard Deviation

In statistics and probability theory, the standard deviation (represented by the Greek letter sigma, σ or S depending on sample or population variance) measures the amount of variation or dispersion from the average (Bland, 1996). A low standard deviation indicates that the data points tend to be very close to the mean (also called expected value); a high standard deviation indicates that the data points are spread out over a large range of values. To calculate the standard deviation, first the variance is needed. After calculating the sample variance of each parameter, the only thing that needs to be done is calculating the square root of the variance. The main formula is shown in equation 3:

$$S = \sqrt{\frac{\sum(X - \bar{X})^2}{n - 1}} \qquad \text{Equation 3}$$

Where:

- X = Respondent opinion in each case
- $\bar{X}$ = Arithmetic mean of selected delay
- n = Number of respondents that answered the questionnaire
- S = Standard deviation

3.5.1.2 Evidence for Internal Consistency of the Questionnaire

A reliability study that involves the administration of a single form of a test to a group of examinees is concerned with the internal consistency of the test. Analysis of the data in such a study yields a coefficient which provides an estimate of how consistently examinees perform across items within a test during a single test session (Crocker and Algina, 1986). One of these tests that is most common to identify the consistency of research is Cronbach's alpha. Coefficient alpha is the average of all

the split-half coefficients that would be obtained if the test were divided into all possible half test combination and the reliability estimated by using Rulon's procedure (Crocker and Algina, 1986). The coefficient of alpha is computed by the formula in equation 4:

$$\hat{\alpha} = \frac{k}{k-1}\left(1 - \frac{\sum \hat{\sigma}_i^2}{\hat{\sigma}_x^2}\right) \qquad \text{Equation 4}$$

Where:

- k = Number of selected delay in questionnaire
- $\hat{\sigma}_i^2$ = Variance of delay
- $\hat{\sigma}_x^2$ = Total questionnaire variance
- $\hat{\alpha}$ = Cronbach's alpha coefficient

In this research, according to the three PDMs, there will be three different Cronbach's alpha coefficient. It has been discussed comprehensively in Chapter 4.

Chapter 4

DATA COLLECTION

4.1 Introduction

In this chapter according to the questionnaire survey, the data has collected and shown. The collected data will be analyzed in the next chapter by using the method as was mentioned previously.

4.2 Data Collection

In this study, Tehran was chosen as a case study. This town is the capital of Iran with a population of around 8.4 million (Tehran Population , 2014). Tehran's urban area is about 730 km^2 and this state has totally 1274 km^2 area. In Tehran, according to specific engineering organization, there are a total 394 companies that have active license. Those legal companies are divided to three different sections. The first section is doing only design and performs as consultant in construction projects (298). The following two sections are contractor (79) and mass production (17). Sample of companies' information according to Tehran engineering organization was brought in Appendix H. (Tehran Construction Engineering Organization, 2013)

In this case, total number of distributed questionnaires was forty five and the respond number was different in each case because as it was mentioned before in Iran, the number of companies that had an experience in BOT method is limited. It has been shown in table 4.1. The questionnaires were distributed to identify the most important factors that cause delays in Iranian construction industry. It was distributed

to the contractors who had spent a long time in this industry and achieved a lot of experience. The questionnaire was filled by chief executives, general managers, professional construction managers and employees of selected companies.

Table 4.1: Questionnaire distribution and responses

Project Delivery Method	Number of Distributed	Number of Respondents	Response Rate
DB	45	32	71.11%
DBB	45	32	71.11%
BOT	45	25	55.55%

In Figures 4.1 to 4.9, the first part of questionnaire was analyzed and shown by the bar chart diagram to show the general information of respondents companies. In Figure 4.4 the respondent grade is shown according to Iran law. In Iran the institute that called Iran construction engineering organization are provide different grades for all contractors and consultant. This ranking method is use to categorize them base on their experienced, equipment, human resource and number of projects that they have done.

Based on the last two questions in part A, most of Iranian companies prefer to work in design build (DB) delivery method. Although the huge private projects are more popular in these days, but inadequate liquidity forces the companies to use some new delivery methods such as build-operate-transfer (BOT) to solve this important problem. In Figures 4.8 and 4.9, the popularity of each project delivery method is

shown according to the companies' feedback. Also in Appendix A and D this section of questionnaire is shown.

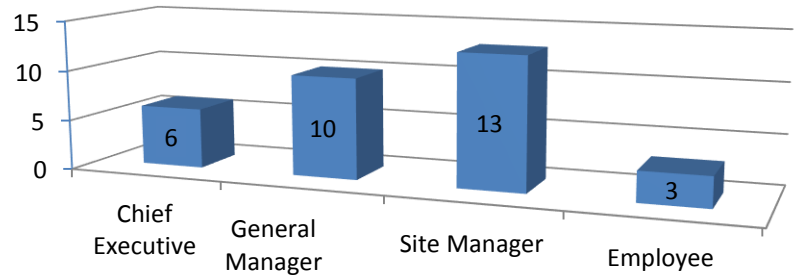

Figure 4.1: The position of the respondent in the organization

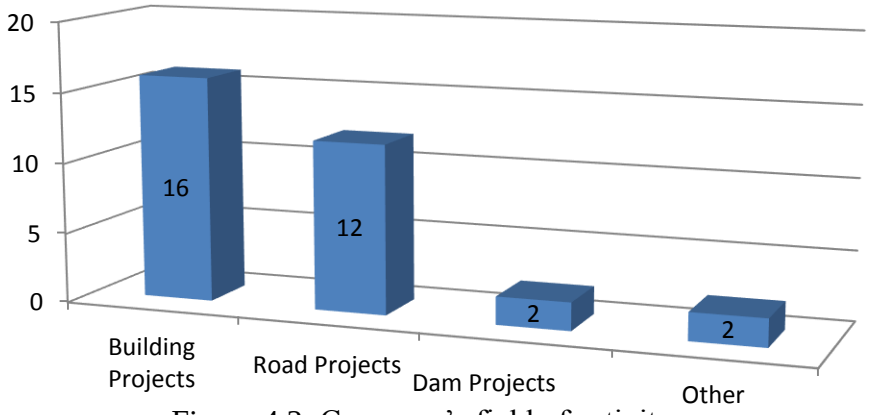

Figure 4.2: Company's field of activity

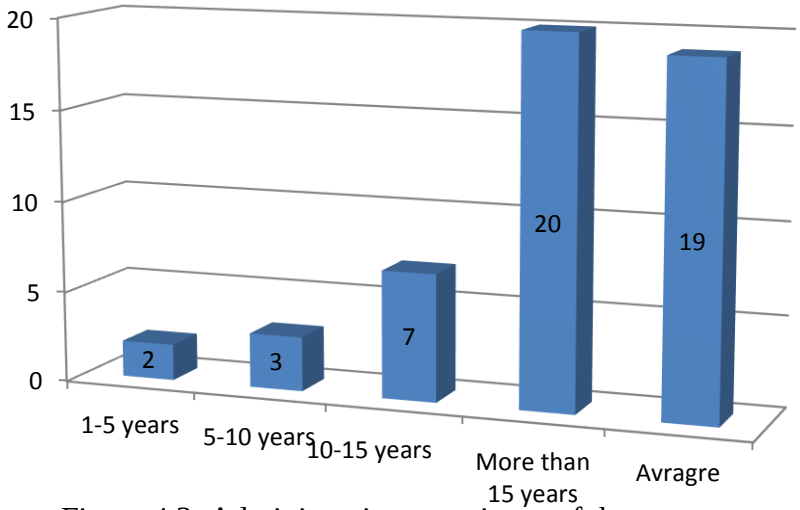

Figure 4.3: Administrative experience of the company

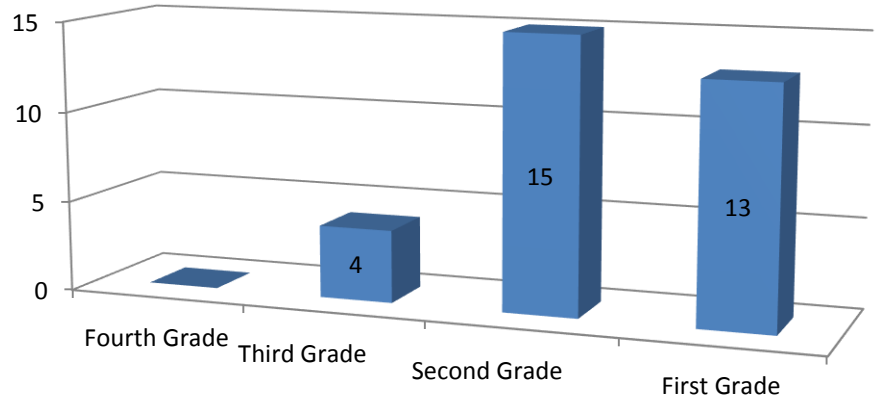

Figure 4.4: Company's grade according to Iran's law

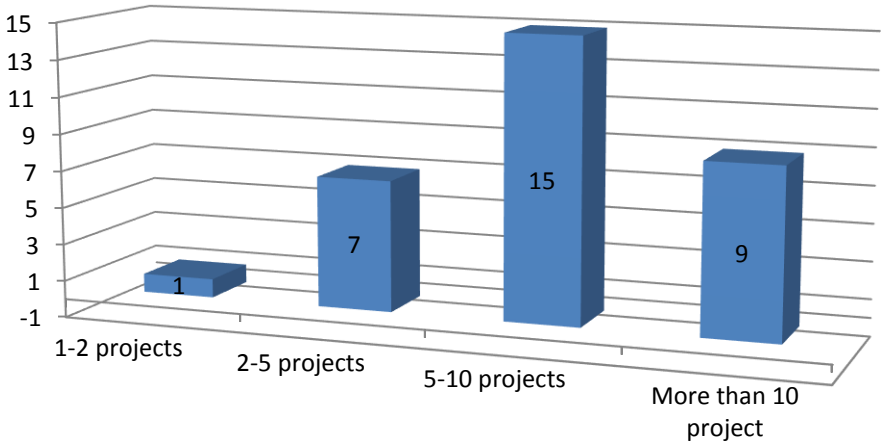

Figure 4.5: Number of projects during the year

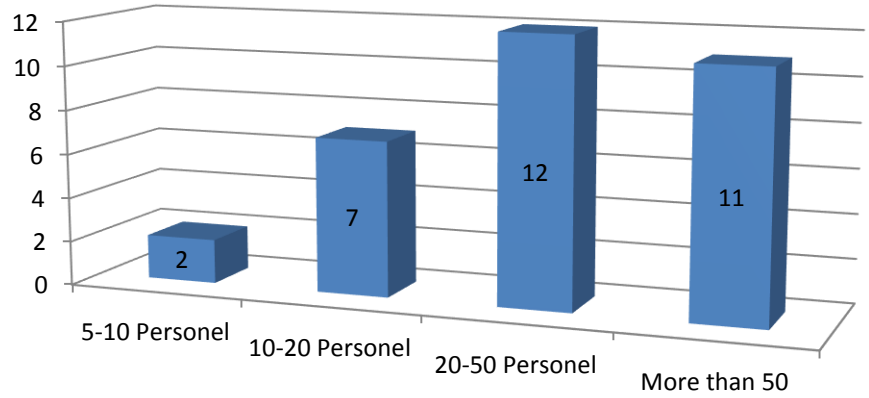

Figure 4.6: Number of permanent personnel

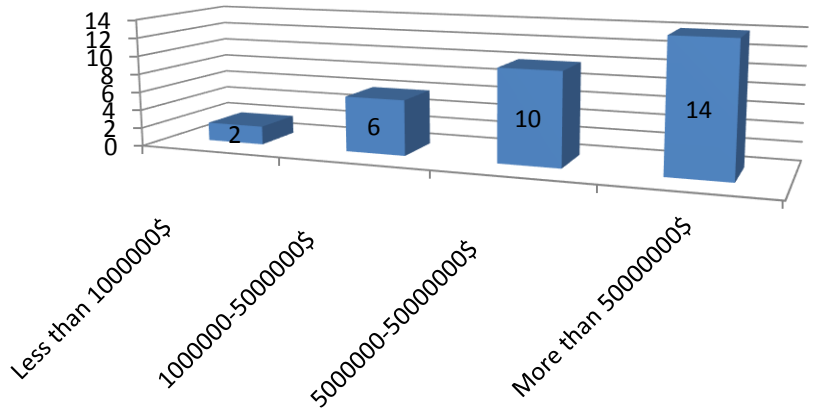

Figure 4.7: Approximate annual turnover

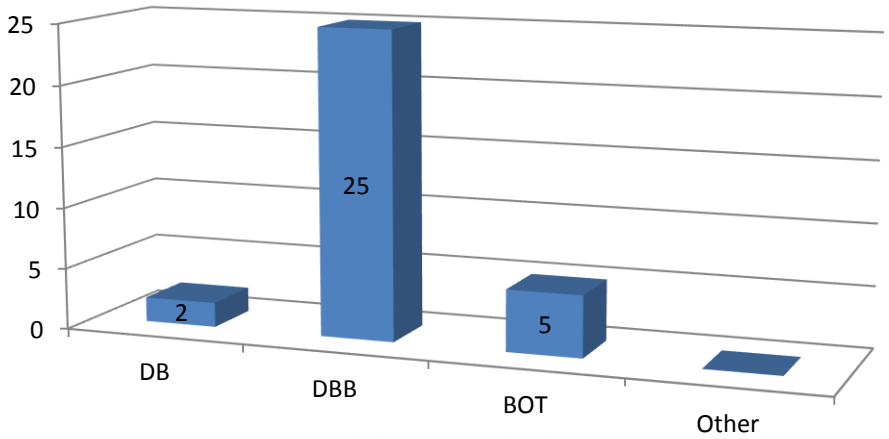

Figure 4.8: Most common delivery method in governmental projects

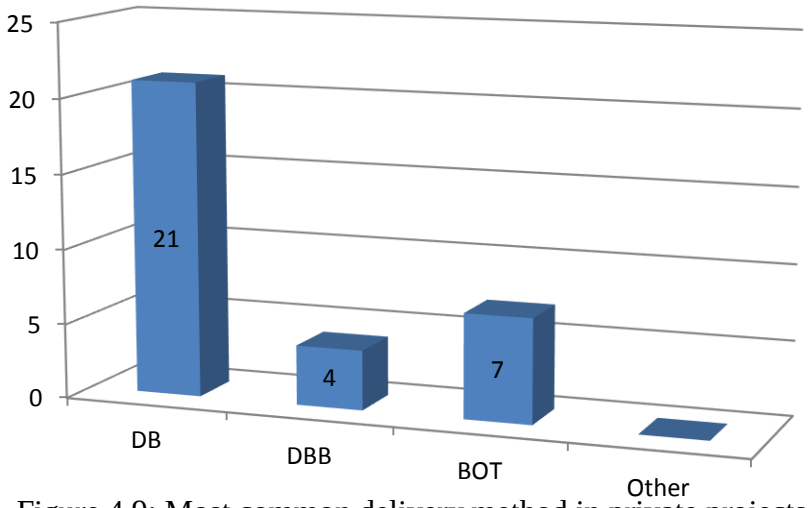

Figure 4.9: Most common delivery method in private projects

4.3 Pre Analysis of the Questionnaires

One of the most important things that should be considered in each research is the reliability of collected data. Because if the data is unreliable, the main process of study will be failed and the final answer to primary aim will be unacceptable. Researchers invented a lot of ways to solve this problem and show the internal consistency of each research. In this case as it was mentioned in Chapter 3, the selected method is Cronbach's alpha.

In this research, three methods had been chosen for 36 different delay causes. So to show the reliability of the prepared questionnaire, three coefficients should be calculated and each of those shows the validity of each project delivery method according to respondents' opinions. The process of manual calculation of this coefficient was described but for simplicity, SPSS has been used.

In this part Tables 4.3 to 4.5 are calculated and completed by SPSS program. For more information, all of calculation, tables and matrices obtained from SPSS are attached in Appendix G. They show the coefficient for each delay and also compare the correlation of all delays. Also in Table 4.2, according to George and Mallery (2003) rule, interpret of Cronbach's Alpha is represented.

As a result, all of the respondents' answers were acceptable because the Cronbach's alpha for each parameter has interpreted as excellent or good. Also the main coefficient of each project delivery method is displayed in Tables 4.3 to 4.5. It will be beneficial to mention that Cronbach's alpha based on standardized delays is based on the assumption that all of the delays have equal variance.

Table 4.2: Interpret of Cronbach's Alpha coefficient (George and Mallery, 2003)

Cronbach's Alpha	Interpret
$\hat{\alpha} > 0.9$	Excellent
$\hat{\alpha} > 0.8$	Good
$\hat{\alpha} > 0.7$	Acceptable
$\hat{\alpha} > 0.6$	Questionable
$\hat{\alpha} > 0.5$	Poor
$0.5 > \hat{\alpha}$	Unacceptable

Table 4.3: Reliability statistics of DB questionnaire

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Delays	Number of Delay
0.904	0.902	36

Table 4.4: Reliability statistics of DBB questionnaire

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Delays	Number of Delay
0.899	0.900	36

Table 4.5: Reliability statistics of BOT questionnaire

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Delays	Number of Delay
0.878	0.868	36

Chapter 5

DATA ANALYSIS AND DISCUSSION

5.1 Introduction

In this chapter, according to the questionnaire survey, the data will be analyze and discussed. The collected data were analyzed by using the method mentioned in the Chapter 3.

5.2 Analysis of Results

The main aim of conducting the analysis for second part of questionnaire is establishing all of thirty six factors under the identified groups. The ranking method was designed according to importance degree of each parameter. To achieve a better result, all factors were divided into different groups and each group was analyzed separately. With this method, the most influential factor of each group could be revealed easily.

5.2.1 Factors and Groups that Cause Delays

The thirty six selected factors were asked in three different project delivery methods and most of those had a distinct effect in each method. From thirty two sets of questionnaires, the major causes of delay has been revealed and separated to six different groups. Also in the questionnaires, respondents mentioned the responsible party for each parameter such as client, contractor or consultant. Actually the major groups of following analysis were provided by this answer and Figure 5.1 shows the diversity of the literature review studies to compare with respondents' answers about this specific situation.

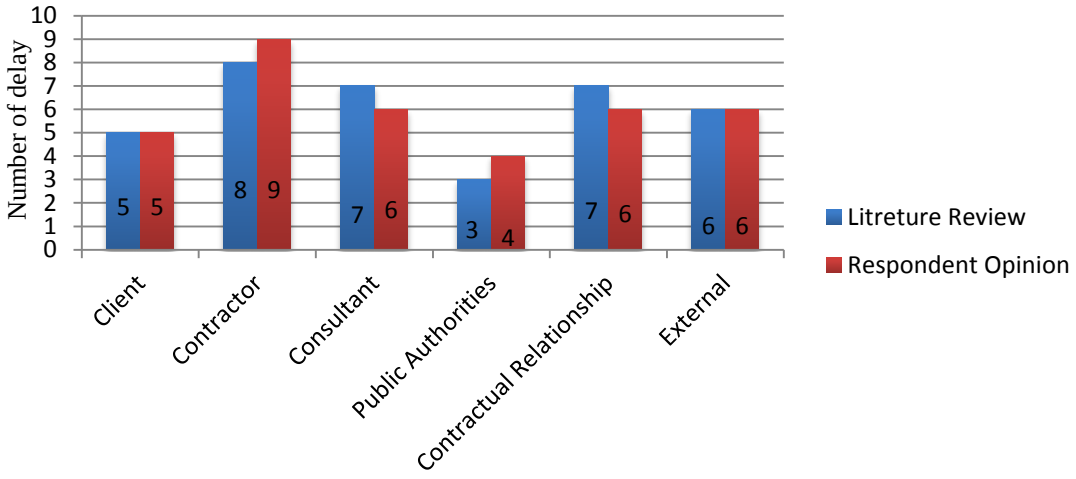

Figure 5.1: Diversity of major groups of delay

5.2.1.1 Client Related Delay Factors

Client or the owner of the project could be a private company, government or joint ownerships between two or more parties. By referring to Figures 4.8 and 4.9, it will be obvious that in governmental projects, DBB has been the most popular PDM and in private projects, DB is the suitable one for contractors.

Five factors were selected for this part as shown in Figure 5.2. Also by referring to Table 5.1, it could be understood that the delay in progress payment by the owner is the most critical factor in DB and DBB. Also, slowness in decision making process and change orders by owner during construction were ranked in second and third places. By referring to standard deviation of each parameter, it is obvious that respondents have different opinions about delay to furnish and deliver the site to the contractor and most of them agree (especially in DB) that the delay in payment progress is the most catastrophic cause of delay in Iranian construction industry.

Although in the first two PDMs the client related parameters were crucial, but in BOT, these factors and most other owner related factors were not critical as two other

PDMs. The main reason of this huge difference is because of the main definition of BOT that has been mentioned in Chapter 2. Usually owner does not have any important responsibility in this kind of projects, but it depends on contractual parameters between the parties.

Table 5.1: The client related delay factors

Factor	DB		DBB		BOT	
	Index	Std. Deviation	Index	Std. Deviation	Index	Std. Deviation
Delay to furnish and deliver the site to the contractor	2.53	1.3908	3.21	1.4532	3.08	1.1874
Delay in progress payment	4.06	0.9482	4.09	1.2791	1.88	1.4525
Change orders by owner during construction	3.03	1.1496	3.68	1.1482	2.76	1.2342
Poor communication and coordination by owner and other parties	2.81	1.1482	3.53	1.2696	2.84	1.5187
Slowness in decision making process by owner	2.75	1.0472	3.75	1.2700	2.40	1.2909

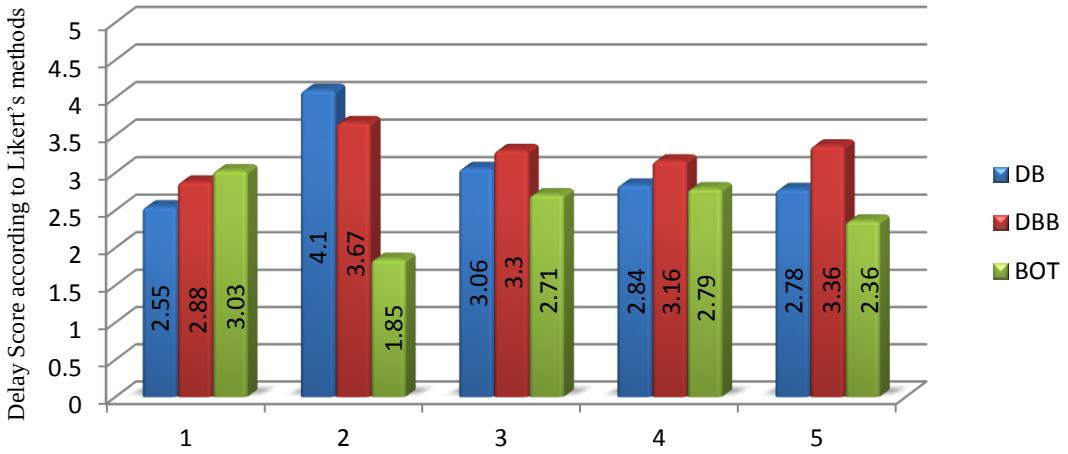

Figure 5.2: Client related delay factors

Where:

1. Delay to furnish and deliver the site to the contractor by the owner
2. Delay in progress payments by owner
3. Change orders by owner during construction
4. Poor communication and coordination by owner and other parties
5. Slowness in decision making process

5.2.1.2 Contractor Related Delay factors

The executive team of each project has direct effect on causes of delay because the primary organization that moves on the project into the next construction level is contractor. According to Figure 4.3 in this research, the average administrative experience of contractors was 19 years and it shows that most of respondents achieved a lot of experience.

In this step unlike the previous one, the BOT is the most crucial PDM in most causes of delay by contractor. The first factor that has a catastrophic effect on a project is difficulties in financing project by contractor and according to the respondents' opinions; it is the most important one in all selected PDMs. By investigating the

background about this cause in Iran, it was determined that most of the companies are creditor from government and just a few of them have strong financial support. The only solution that has been left to other companies is taking the project from government and giving it to other sub-contractors. By doing this work, the procedure of working goes longer than usual and also other causes of delay will rise up such as ineffective planning and scheduling of project by contractor.

The ineffective planning and scheduling of project by contractor will cause more delays in project such as delay in site mobilization, incompetence project team and delays in subcontractors work because when the scheduling of project is not suitable, a lot of problems will rise up and all of these problems are connected to each other like a chain. Also the other overriding factor is unavailability of professional construction management from respondent point of view. Figure 5.3 shows the importance degree of the discussed delays.

By take a quick look at Table 5.2 and comparing the standard deviation of each factor in each PDM, according to the respondents discretion it is determined that all of them had same opinion about the difficulties in financing projects and delay in subcontractors work. Also they had a common opinion about unavailability of professional construction management in projects.

Table 5.2: The result of contractor related delay factors

Factor	DB		DBB		BOT	
	Index	Std. Deviation	Index	Std. Deviation	Index	Std. Deviation
Incompetence project team	3.12	1.2636	3.15	1.3466	3.52	1.1590
Difficulties in financing project	3.59	0.9791	3.50	1.0160	4.00	1.0279
Delays in subcontractors work	3.25	1.1639	3.31	1.0606	2.84	1.0279
Poor site management and supervision	3.15	1.2210	3.25	1.1639	2.88	1.2688
Mistakes during construction and make rework due to specific errors	2.81	1.3545	3.43	1.1053	3.28	1.3076
Unavailability of professional construction management	3.12	1.5606	3.31	1.4466	3.88	1.3638
Delay in site mobilization	2.84	1.2727	3.12	1.0701	3.08	1.3203
Ineffective planning and scheduling of project	2.93	1.3425	2.81	1.1482	3.76	1.2675

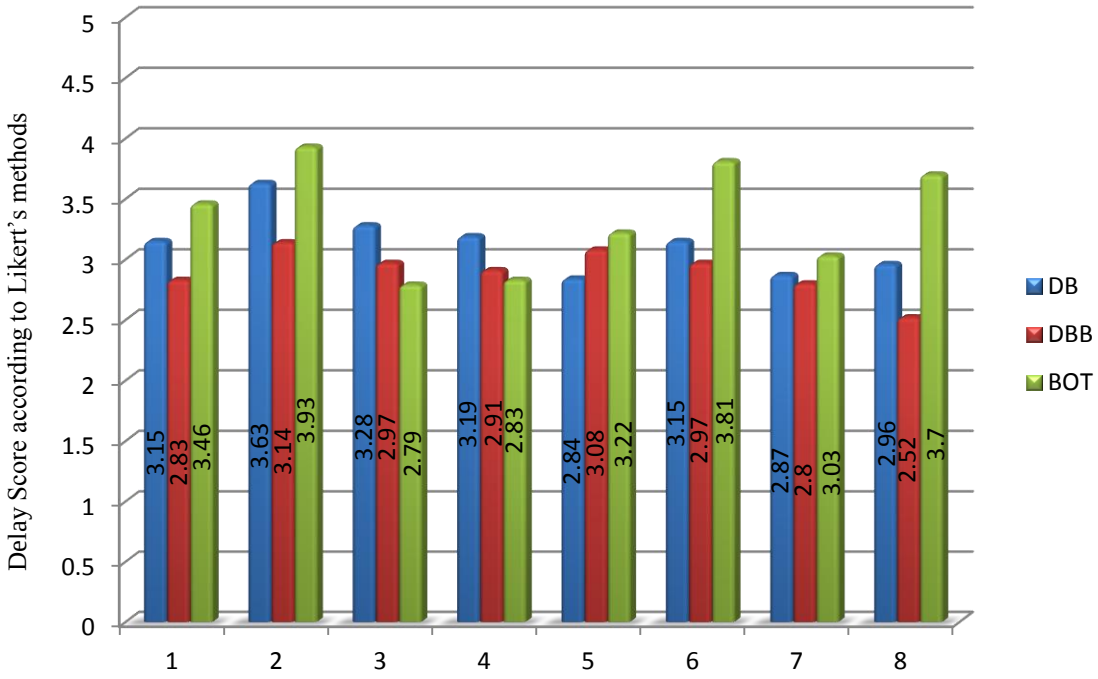

Figure 5.3: Contractor related delay factors

Where:

1. Incompetence project team
2. Difficulties in financing project by contractor
3. Delays in subcontractors work
4. Poor site management and supervision
5. Mistakes during construction and make rework due to specific errors
6. Unavailability of professional construction management
7. Delay in site mobilization
8. Ineffective planning and scheduling of project by contractor

5.2.1.3 Consultant Related Delay Factors

The third group of this study was consultants. The main purpose of using consultant is aiding to owner by expert team. This expert team could be classified in different subcategories of civil engineering. For example, if the case is related to the geotechnical science, the consultant must have expanded experience in this era to improve processing phase of project and make the main contractor to fast-tracking possible work and deliver the project as fast as possible to make it beneficial. But unfortunately in some projects the contractor and consultant frame-up and take more money from client.

The Iranian clients usually use consultant in large projects and according to the selected PDM of this research, most of the consultants preferred to use DBB because by referring to Figure 4.8, it is determined that most of the respondents think that the DBB is the best PDM for governmental projects. All large projects in Iran are related to one specific organization and also the large national projects such as oil and petrol has been taken by this organization.

Table 5.3 shows that in DB and BOT, the entire factors have a same range index according to the importance degree. But the complexity of project design in BOT and delays in producing design documents in DB have more influence. Also in DBB, conflicts between consultant and design engineer, inadequate experience of consultant and delay in approving major changes in the scope of work are the main three reasons of delay in Iranian construction industry.

Table 5.3: The result of consultant related delay factors

Factor	DB		DBB		BOT	
	index	Std. deviation	index	Std. deviation	index	Std. deviation
Delay in approving major changes in the scope of work	2.50	1.2951	3.18	1.0606	2.20	1.3844
Late in reviewing and approving design documents	1.93	0.9482	2.93	0.9482	2.04	1.2741
Conflicts between consultant and design engineer	2.40	1.1410	3.40	1.1030	2.20	1.5545
Inadequate experience of consultant	2.46	1.3674	3.25	1.0776	2.20	1.4142
Misunderstanding of owner's requirements by design engineer	2.31	1.3060	2.34	1.0957	2.72	1.2700
Delays in producing design documents	2.75	1.3440	3.15	1.2978	2.44	1.3253
Complexity of project design	2.25	0.9503	2.56	1.1053	2.76	1.1647

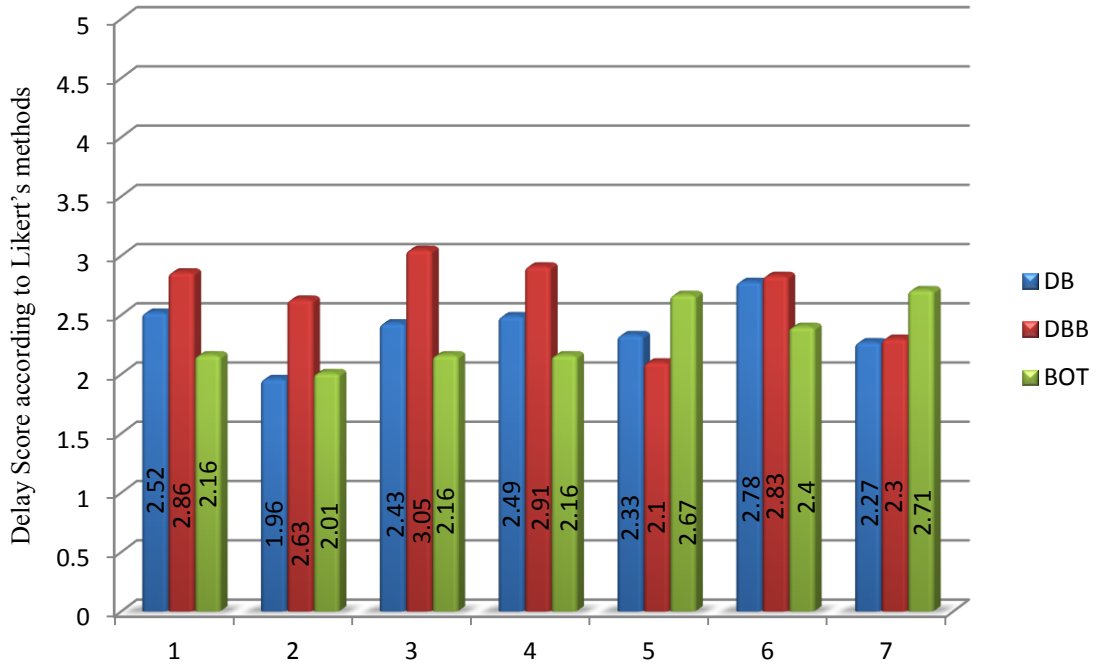

Figure 5.4: Consultant related delay factors

Where:

1. Delay in approving major changes in the scope of work by consultant
2. Late in reviewing and approving design documents by consultant
3. Conflicts between consultant and design engineer and contractor
4. Inadequate experience of consultant
5. Misunderstanding of owner's requirements by design engineer
6. Delays or mistakes in producing design documents
7. Complexity of project design

5.2.1.4 Public Authorities Related Delay Factors

In Iran the process of getting license to build a new structure is a little bit complex and if this structure is a large one, the process will be more complicated. The public authorities are the parties responsible for this complexity. Actually, it does not matter which PDM is being used in projects, the procedure has to be done before starting the project and because of the crumble administrative structure, it goes harder.

In this research, respondents answered to three important causes of delays that classified in public authorities group. The first one and the most important one is inflation. In economics, inflation is a sustained increase in the general price level of goods and services in an economy over a period of time (Blanchard, 2000). Consequently, inflation makes people to have limited purchasing power per unit of money. In Iran till end of the 2013 the inflation ratio was near 39.5 percent and the new government promised that till March of 2015 (end of Iranian calendar) this ration goes down to 25 percent (Economic Desk, 2014). Most of these problems are because of sanctions against Iran by European countries and U.S.A. So in this situation working for construction companies will be difficult because they do not know intervals of unit price changing during each year. Although with some adjustments, it will be somehow controlled, but the loss is unavoidable.

By referring to Table 5.4 and Figure 5.5, three selected items are shown and in BOT, this group of component has most critical effect. In second rank, the changes in government regulations and laws have been determined by the respondents.

Table 5.4: The result of public authorities' related delay factors

Factor	DB		DBB		BOT	
	index	Std. deviation	index	Std. deviation	index	Std. deviation
Inflation	3.53	1.1354	3.81	1.1760	3.60	1.7500
Obtaining permits from government	2.75	1.0472	2.75	1.1071	2.92	1.0376
Changes in government regulations and laws	2.62	1.3137	3.09	1.1738	3.32	1.0692

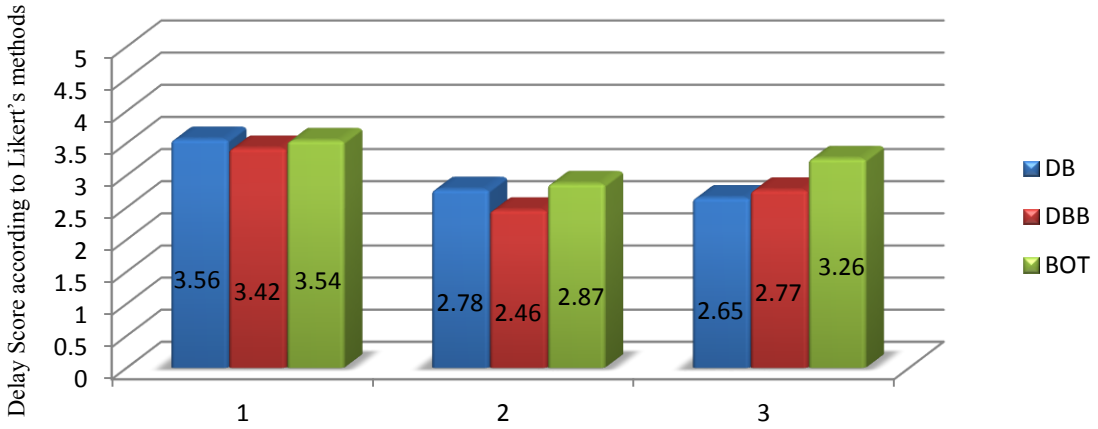

Figure 5.5: Public authorities related delay factors

Where:

1. Inflation
2. Obtaining permits from Government
3. Changes in government regulations and laws

5.2.1.5 Contractual Relationship Related Delay Factors

One of the most important documents of each project is contract. This phase has always been done before the starting of project. The specific duty of each party is shown in contract clauses and agreement between parties should be achieved before starting the project. In each delivery method, the contractual relationship between owner, contractor and consultant has a different variable in contract that was mentioned in Chapter 2.

In this case and by referring to respondents' belief, first of all, the chosen project delivery method in each project has critical effect on long-term project delay. Actually they thought that if the selected PDM was not suitable for the project, it would be the main reason of delay in this subcategory. Also the inaccuracy in cost estimates and short and unrealistic contract duration were in the next ranks. It is beneficial to mention that this two selected parameters have relation with each other and both of those will be causes of delay in the scope of project. The main reason of both delays could be the consultant (from contractors' point of view) or contractor (from client point of view).

The design-build delivery method in this group has the least importance degree. The main reason of this result is that DB contracts are single point for the owner. It means that excessive contracts and subcontracts are eliminated in this PDM and make the work easier for all involved parties. By referring to Table 5.5 and Figure 5.6, it is shown that the BOT is the catastrophic PDM and the contractors and clients (or government) should carefully choose contract clauses and substances to avoid other causes of delays as much as possible.

Table 5.5: The result of contractual relationship related delay factors

Factor	DB		DBB		BOT	
	index	Std. deviation	index	Std. deviation	index	Std. deviation
Short (unrealistic) contract duration	2.93	1.2684	3.40	1.1875	3.36	0.8602
Legal disputes between various parties	2.65	1.3102	3.06	1.1622	2.44	1.0832
Inaccuracy in cost estimates	2.87	1.1845	3.50	1.0160	3.40	1.2583
Excessive contracts and subcontracts	2.18	1.0298	2.50	0.9837	2.28	1.1372
Mistakes and discrepancies in contract documents	2.46	1.0771	3.06	1.2427	2.60	1.2583
Controlling sub-contractors by general contractors in execution of works	2.12	1.2378	1.93	0.9136	2.64	1.3190
Project delivery method used	3.12	1.1845	3.09	1.1175	3.68	0.8524

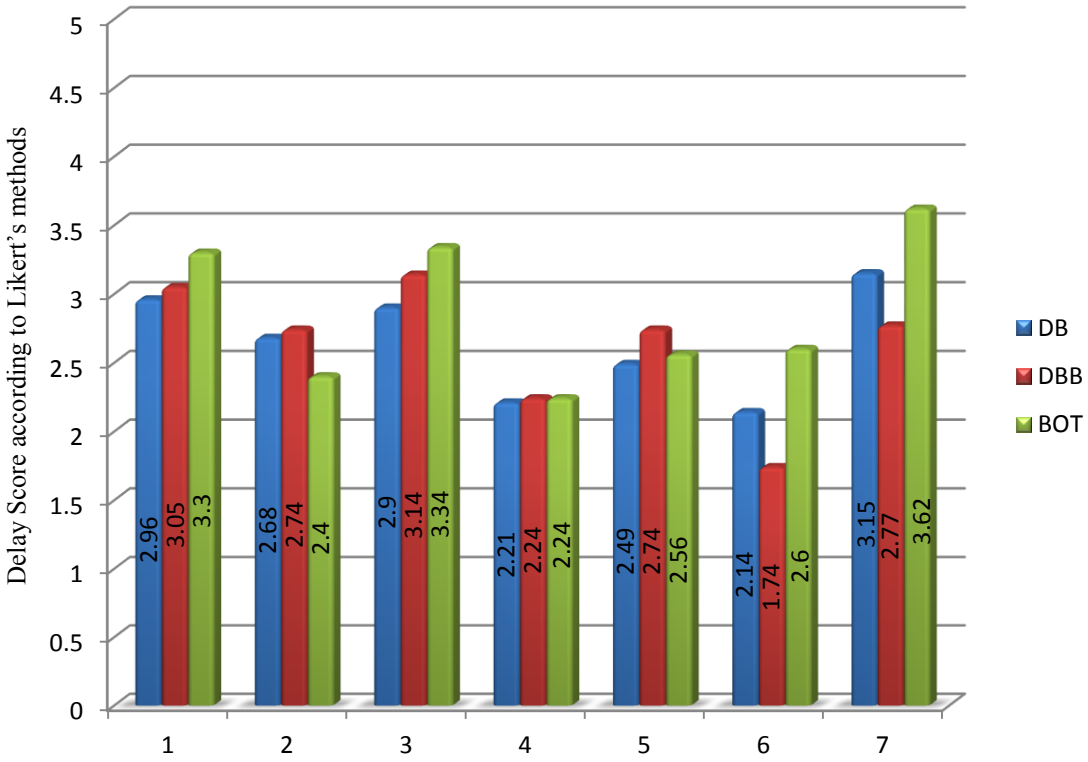

Figure 5.6: Contractual relationship related delay factors

Where:

1. Short and unrealistic contract duration
2. Legal disputes between various parties
3. Inaccuracy in cost estimates
4. Excessive contracts and subcontracts
5. Mistakes and discrepancies in contract documents
6. Controlling sub-contractors by general contractors in execution of works
7. Project delivery method used

5.2.1.6 External Related Delay Factors

There are six factors of external related delays that were ranked based on SPSS outputs. The respondents ranked delay in material delivery, changes in material types and specifications during construction, and problems with neighbors as top three of the external related delays in Iranian construction industry. According to Table 5.6, the standard deviation shows that all respondents had the same point of view about the selected delay in these subcategories. Also the all external factor compare to each other in figure 5.7.

Table 5.6: The result of external related delay factors

Factor	DB		DBB		BOT	
	index	Std. deviation	index	Std. deviation	index	Std. deviation
Delay in material delivery	3.50	0.9837	3.78	0.8700	3.60	1.1547
Changes in material types and specifications during construction	2.90	1.1738	3.62	1.1570	2.52	1.0456
Problems with neighbors	2.53	1.0467	2.53	1.0771	2.80	1.000
Unforeseen climate conditions	2.25	1.1359	2.50	1.0472	2.36	0.9521
Effect of social and cultural factors	2.06	1.1896	1.87	1.1288	1.76	1.0908
Waiting for test sample approval	1.90	0.9283	2.06	1.2164	1.68	0.8524

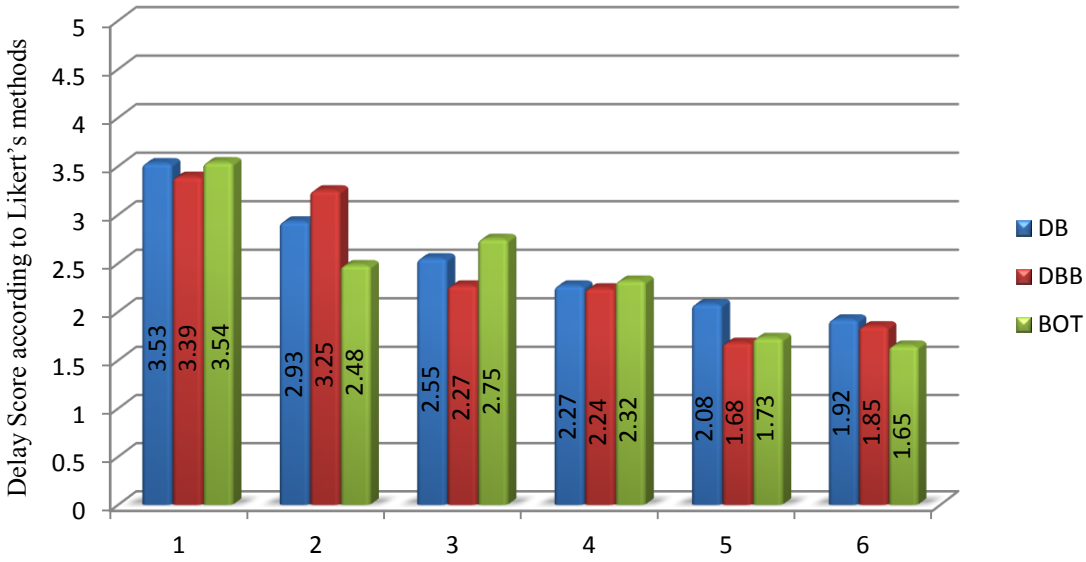

Figure 5.7: External related delay factors

Where:

1. Delay in material delivery
2. Changes in material types and specifications during construction
3. Problems with neighbors
4. Unforeseen climate conditions
5. Effect of social and cultural factors
6. Waiting for test sample approval

5.2.2 Critical PDM in Each Group

In this section, it has been tried to prepare a brief summary of analysis. As mentioned in pervious chapter, there are six groups that the causes of delays have been categorized in. According to research results and by referring to Table 5.7, it is presumable that the DBB method is the most critical PDM and has considerable effect in all selected causes of delays in Iranian construction industry. Also BOT method is in the second rank and has critical effect in contractor's related delay parameters. In the third rank, the DB method has been placed and the crucial effect of this method is on client and external group.

Also in the last two columns of Table 5.7, the most catastrophic delay of each group according to the critical PDM and relative importance degree of selected delay is shown.

Table 5.7: Critical project delivery method in each group

Group	Critical PDM	Catastrophic Delay	Index
Client	DB & DBB	Delay in Progress Payment	4.09
Contractor	BOT	Difficulties in Financing Project	4.00
Consultant	DBB	Conflicts between consultant and design engineer and contractor	3.40
Public Authorities	DBB & BOT	Inflation	3.81
Contractual Delay	BOT & DBB	Project Delivery Method Used Inaccuracy in Cost Estimates	3.68 3.50
External	DBB & DB	Delay in material delivery	3.78

Although in this study three popular project delivery methods were selected and discussed but based on the survey, finding BOT method was found to be uncommon in Iran so with this result it could be used in Iranian construction industry with a few terms. As it was completely discussed in literature review, in this method client does not have enough funds to make a project step by step to final phase. So they decide to transfer the whole project for specified years to one large contractor. According to this transfer all projects risk, delays and problems will be transferred to contractor. So to handle this important problem, the contractor should have knowledge about risk management and how to handle upcoming delays of projects.

The other term of using this method should be strong finance potential by contractor because the most substantial fund of the project have to be provided by the company due the lack of money by client. Also, they should have a strong planning team to make an effective scheduling plan and decrease the potential delays in scope of the project. So with this few terms, it could be possible to apply BOT method in Iranian construction industry and during a few years, all involved parties will be more familiar with it.

5.2.3 Ranking of Factors that Cause Delays

According to the results of the analysis of the parameters in each group, the overall ranking of factors that cause delay has been recognized. Also in this case as mentioned before, there are total three project delivery methods and in Tables 5.8 to 5.10 and Figures 4.8 to 4.10, each PDM is ranked and shown separately.

Table 5.8: Ranking of factors that cause delay in Design Build

Factor	Mean	Rank
Delay in progress payments by owner	4.10	1
Difficulties in financing project by contractor	3.63	2
Inflation	3.56	3
Delay in material delivery	3.53	4
Delays in subcontractors work	3.28	5
Poor site management and supervision	3.19	6
Incompetence project team	3.15	7
Unavailability of professional construction management	3.15	8
Project delivery method used	3.15	9
Change orders by owner during construction	3.06	10
Short (unrealistic) contract duration	2.96	11
Ineffective planning and scheduling of project by contractor	2.96	12
Changes in material types and specifications	2.93	13
Inaccuracy in cost estimates	2.90	14
Delay in site mobilization	2.87	15
Mistakes during construction and make rework	2.84	16
Poor communication and coordination by owner	2.84	17
Slowness in decision making process	2.78	18
Delays or mistakes in producing design documents	2.78	19
Obtaining permits from Government	2.78	20
Legal disputes between various parties	2.68	21
Changes in government regulations and laws	2.65	22

Delay to furnish and deliver the site to the contractor	2.55	23
Problems with neighbors	2.55	24
Delay in approving major changes in the scope of work by consultant	2.52	25
Inadequate experience of consultant	2.49	26
Mistakes and discrepancies in contract documents	2.49	27
Conflicts between consultant and design engineer and contractor	2.43	28
Misunderstanding of owner's requirements by design engineer	2.33	29
Unforeseen climate conditions	2.27	30
Complexity of project design	2.27	31
Excessive contracts and subcontracts	2.21	32
Controlling sub-contractors by general contractors	2.14	33
Effect of social and cultural factors	2.08	34
Late in reviewing and approving design documents	1.96	35
Waiting for test sample approval	1.92	36

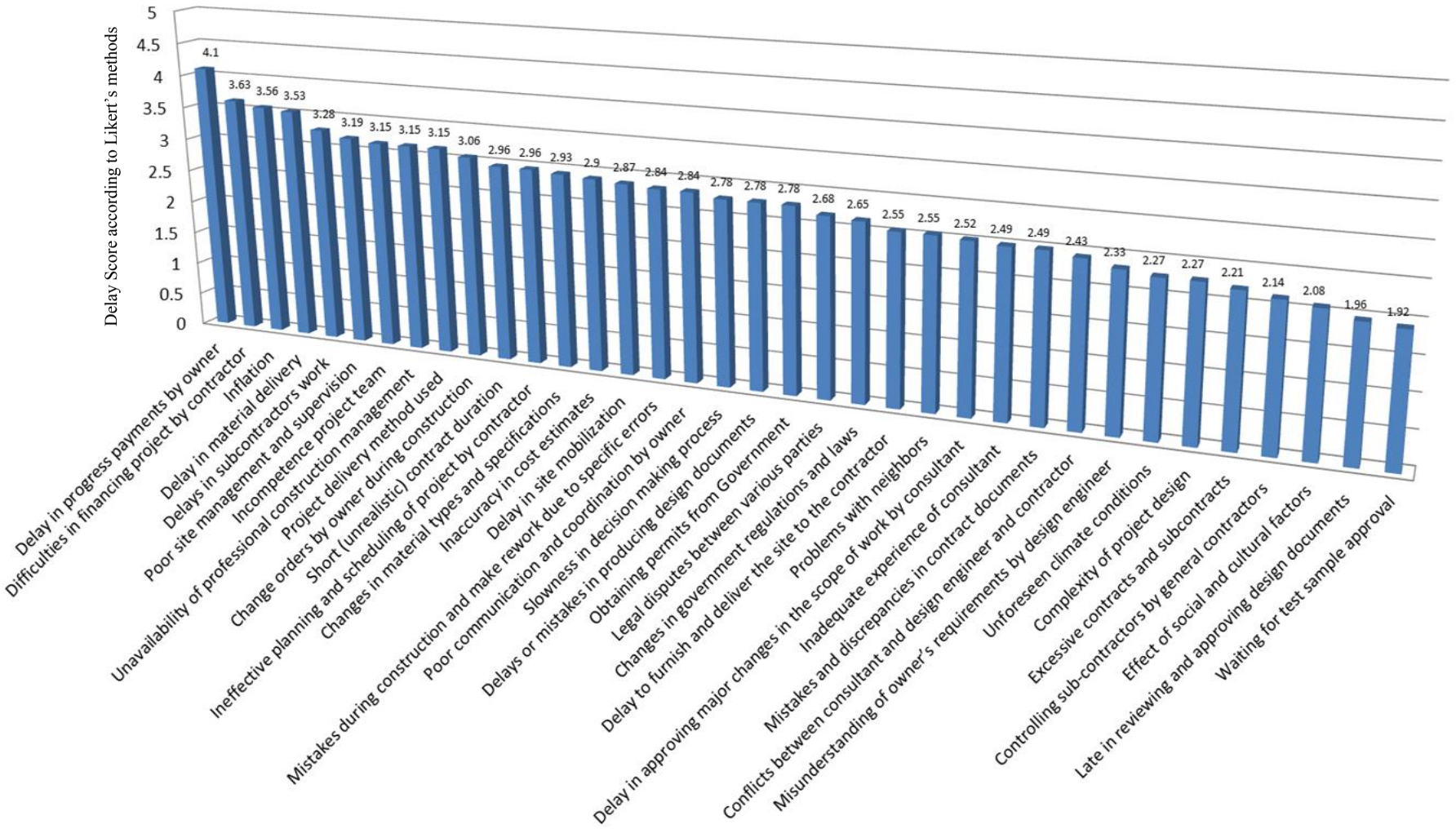

Figure 5.8: Ranking of factors that cause delay in design build

Table 5.9: Ranking of factors that cause delay in Design Bid Build

Factor	Mean	Rank
Delay in progress payments by owner	3.67	1
Inflation	3.42	2
Delay in material delivery	3.39	3
Slowness in decision making process	3.36	4
Change orders by owner during construction	3.30	5
Changes in material types and specifications during construction	3.25	6
Poor communication and coordination by owner and other parties	3.16	7
Inaccuracy in cost estimates	3.14	8
Difficulties in financing project by contractor	3.14	9
Mistakes during construction and make rework due to specific errors	3.08	10
Conflicts between consultant and design engineer and contractor	3.05	11
Short (unrealistic) contract duration	3.05	12
Delays in subcontractors work	2.97	13
Unavailability of professional construction management	2.97	14
Poor site management and supervision	2.91	15
Inadequate experience of consultant	2.91	16
Delay to furnish and deliver the site to the contractor by the owner	2.88	17
Delay in approving major changes in the scope of work by consultant	2.86	18
Incompetence project team	2.83	19

Delays or mistakes in producing design documents	2.83	20
Delay in site mobilization	2.80	21
Project delivery method used	2.77	22
Changes in government regulations and laws	2.77	23
Mistakes and discrepancies in contract documents	2.74	24
Legal disputes between various parties	2.74	25
Late in reviewing and approving design documents by consultant	2.63	26
Ineffective planning and scheduling of project by contractor	2.52	27
Obtaining permits from Government	2.46	28
Complexity of project design	2.30	29
Problems with neighbors	2.27	30
Unforeseen climate conditions	2.24	31
Excessive contracts and subcontracts	2.24	32
Misunderstanding of owner's requirements by design engineer	2.10	33
Waiting for test sample approval	1.85	34
Controlling sub-contractors by general contractors in execution of works	1.74	35
Effect of social and cultural factors	1.68	36

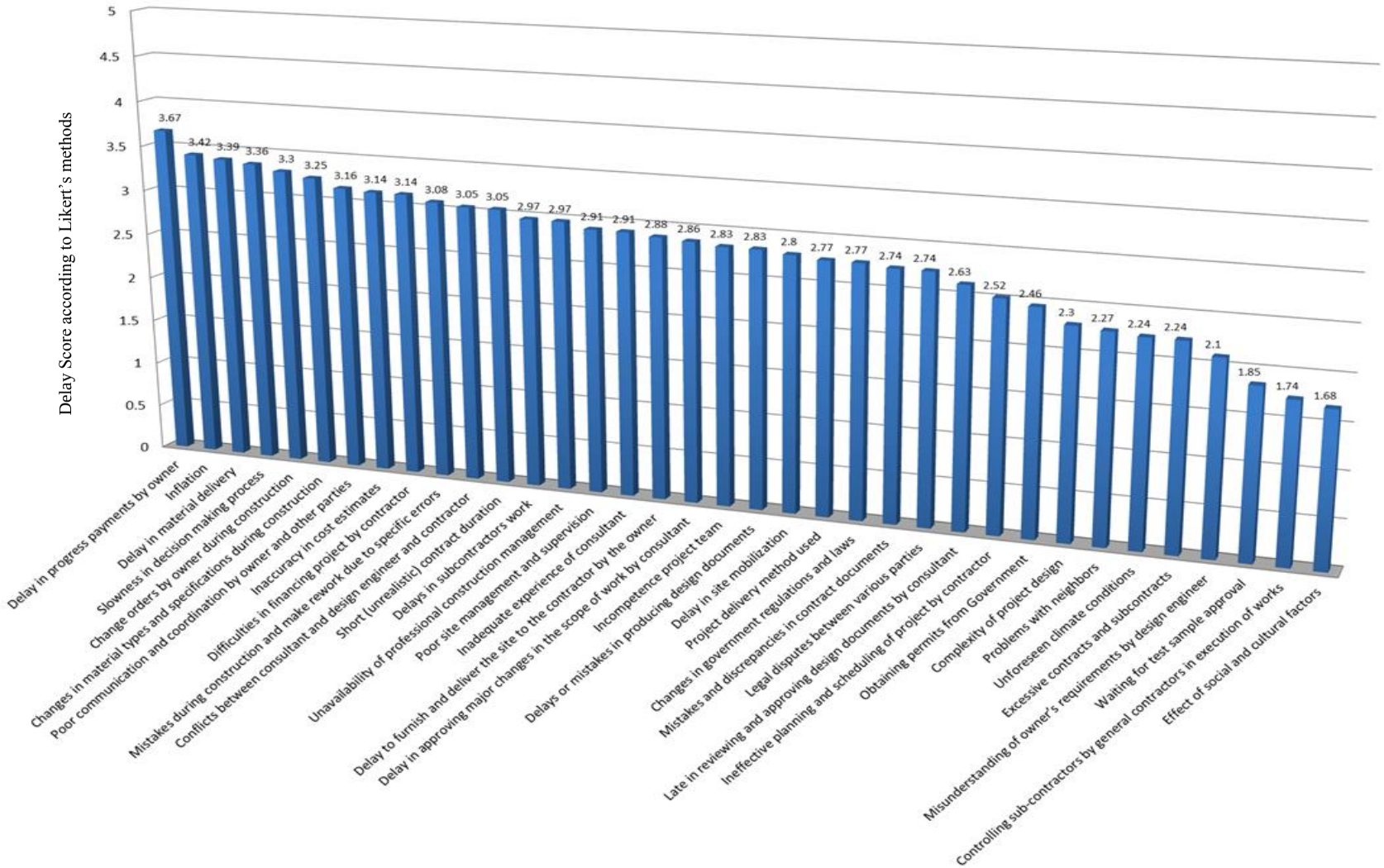

Figure 5.9: Ranking of factors that cause delay in design bid build

Table 5.10: Ranking of factors that cause delay in Build Operate Transfer

Factor	Mean	Rank
Difficulties in financing project by contractor	3.93	1
Unavailability of professional construction management	3.81	2
Ineffective planning and scheduling of project by contractor	3.70	3
Project delivery method used	3.62	4
Delay in material delivery	3.54	5
Inflation	3.54	6
Incompetence project team	3.46	7
Inaccuracy in cost estimates	3.34	8
Short (unrealistic) contract duration	3.30	9
Changes in government regulations and laws	3.26	10
Mistakes during construction and make rework due to specific errors	3.22	11
Delay in site mobilization	3.03	12
Delay to furnish and deliver the site to the contractor by the owner	3.03	13
Obtaining permits from Government	2.87	14
Poor site management and supervision	2.83	15
Delays in subcontractors work	2.79	16
Poor communication and coordination by owner and other parties	2.79	17
Problems with neighbors	2.75	18
Complexity of project design	2.71	19
Change orders by owner during construction	2.71	20

Misunderstanding of owner's requirements by design engineer	2.67	21
Controlling sub-contractors by general contractors in execution of works	2.60	22
Mistakes and discrepancies in contract documents	2.56	23
Changes in material types and specifications during construction	2.48	24
Delays or mistakes in producing design documents	2.40	25
Legal disputes between various parties	2.40	26
Slowness in decision making process	2.36	27
Unforeseen climate conditions	2.32	28
Excessive contracts and subcontracts	2.24	29
Inadequate experience of consultant	2.16	30
Conflicts between consultant and design engineer and contractor	2.16	31
Delay in approving major changes in the scope of work by consultant	2.16	32
Late in reviewing and approving design documents by consultant	2.01	33
Delay in progress payments by owner	1.85	34
Effect of social and cultural factors	1.73	35
Waiting for test sample approval	1.65	36

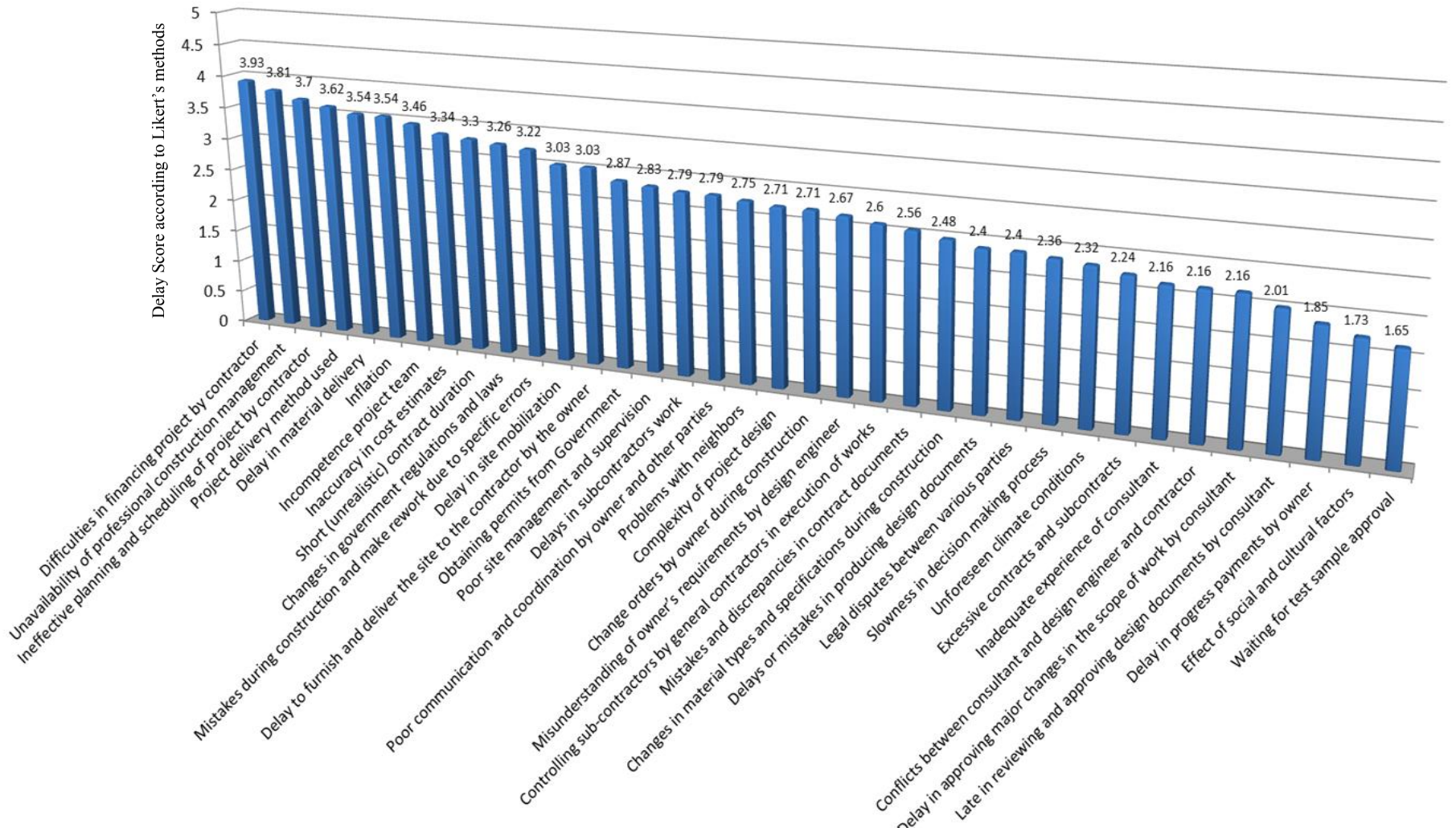

Figure 5.10: Ranking of factors that cause delay in build operate transfer

5.3 Summary

The major delay groups were recognized and ranked, where group of client related delays was the top main group that contributed to the causes of delays. The top five most important factors that contributed to the causes of delays are shown in Figures 5.11 to 5.12 and separated for each project delivery method. Also in these figures, some restrains have been mentioned to reduce the devastating impact of each catastrophic delay and it is aimed to help to control the cost and time overrun effects by this solution.

This research commonly shows that Iranian construction companies cope with obstacle and delays of project in their daily operations with a structure that they even do not know is somehow the framework of construction management. In addition, techniques and strategies to handle these problems by Iranian companies are presented as a list:

- Past experience and consultation (discussion, brainstorming) in order to find the probable project delays.
- Knowledge and skills of experienced people in this field
- Conduction and mitigation are commonly used actions to control delay when it occurs during the work.

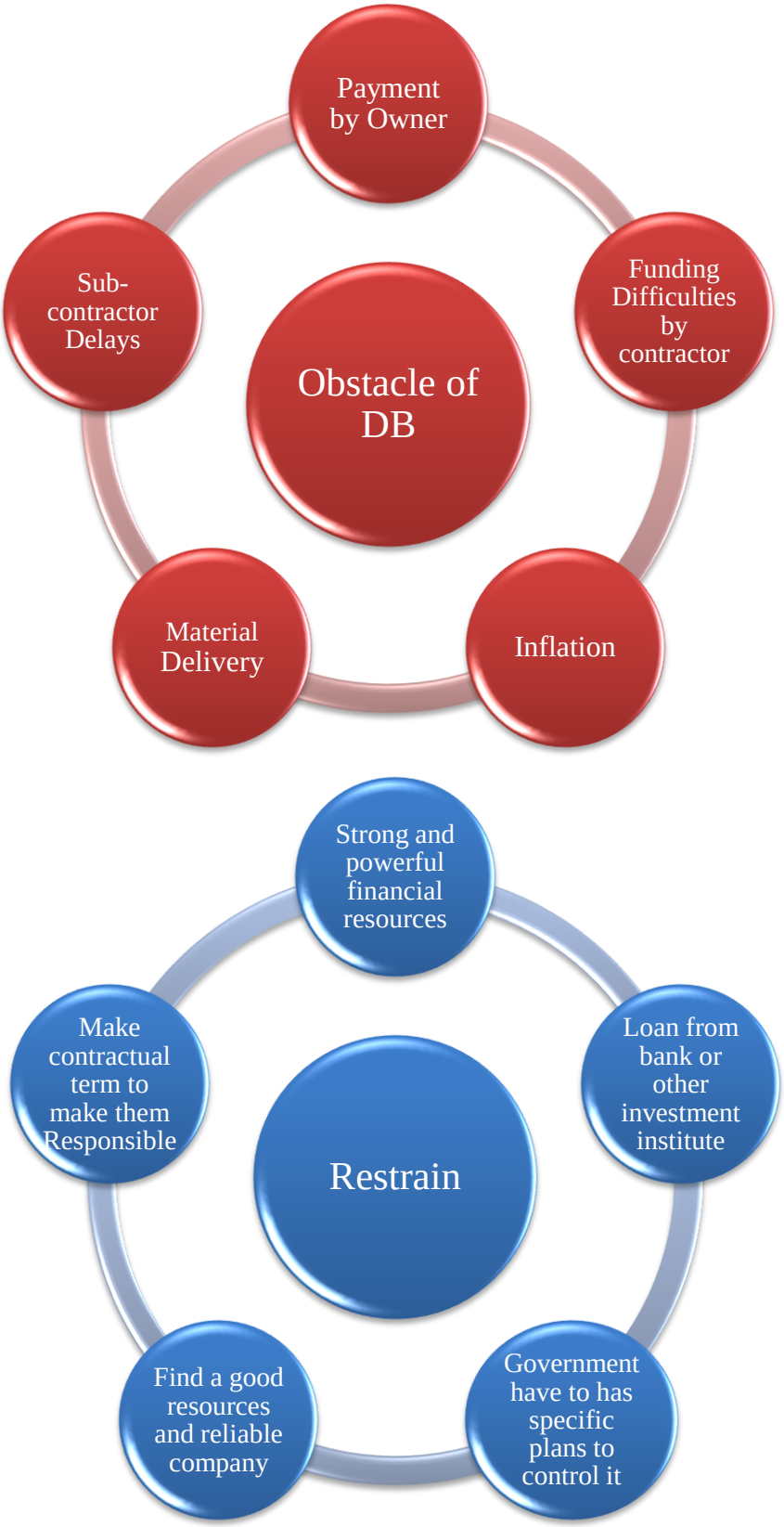

Figure 5.11: Obstacles and restrain for major causes of delay in DB method

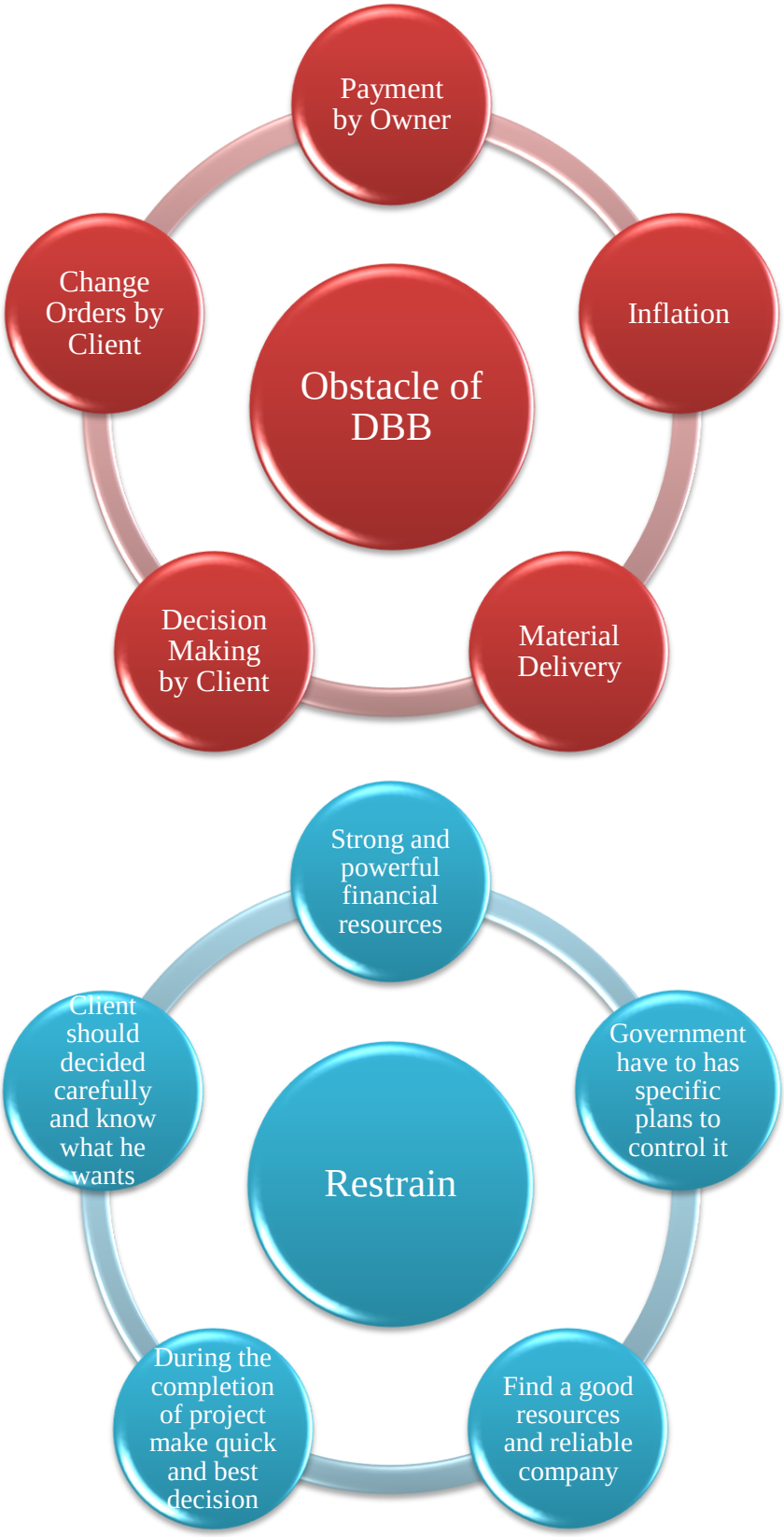

Figure 5.12: Obstacles and restrain for major causes of delay in DBB method

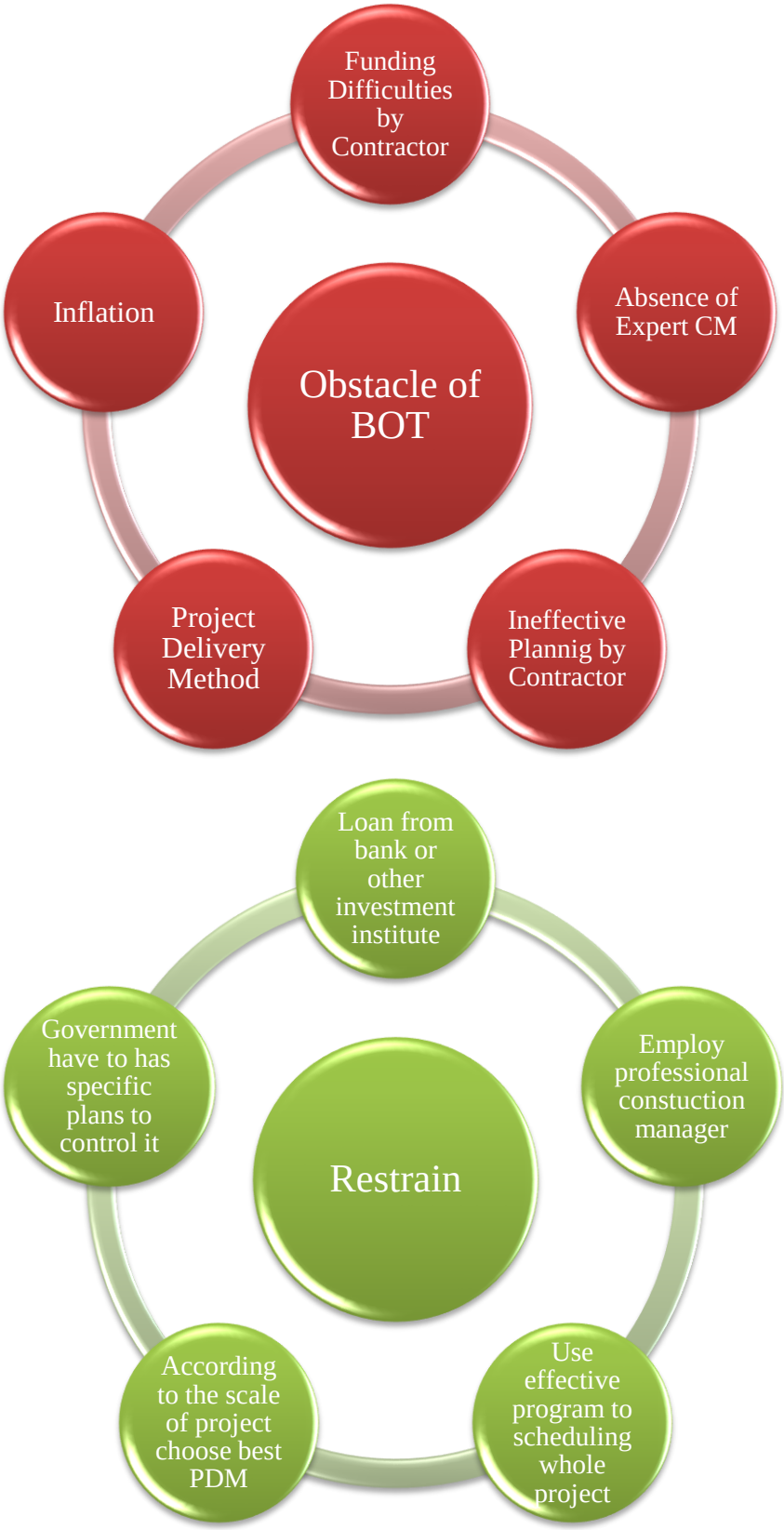

Figure 5.13: Obstacles and restrain for major causes of delay in BOT method

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDIES

6.1 Introduction

This chapter presents and describes overall achievements of this research based on respondents' opinions. In the first part, the brief summary of achievement of this research is presented and in the following topic, the recommendations for further research.

6.2 Conclusions

The main objective of this research which has been determined at the beginning of study was identifying the major causes of delays in three different projects delivery methods. These objectives were performed through questionnaire survey which was designed with regard to the knowledge of Iranian construction companies and their respond had a significant influence on this research. Also the oral interviews during the process of filling questionnaire helped in realizing the best answer for the main and also side objective of the study. In addition to those, after the data was analyzed, a few meetings had been arranged with first grade companies in Iran and the final results were shared with those companies. During each session, they told their opinion about the result and tried to find a solution for how to decrease each critical parameter. In the following paragraphs, their guidance was used to answer the entire research questions and recommend some new topics for further work.

In this research, three different project delivery methods were considered. So the rankings of selected delays in each method were different and to identify them, the major causes of delays should be divided by referring to three designated PDMs. In DB and DBB, the results were somehow similar. However, the main difference was observed in BOT method and it is because of the various usage of this method in comparison to other methods.

The main top five catastrophic delays in design build method were found as delay in payment progress by owner, funding difficulties by contractor, inflation, material delivery and sub-contractors delays. The most five important delay factors of DBB were also found to be payment difficulties by owner, inflation, delay in material delivery, slowness in decision making by client and make changes during the construction phase of project by client.

On the other hand, the BOT method resulted with completely different results. The main reasons of delay in this type of project delivery method were financial difficulties by contractor, unavailability of professional construction manager, used project delivery method, and inflation.

Unfortunately in all methods, inflation was the most critical parameter and it is because of the political and economic situation of Iran. Also Iranian companies use one adjustment coefficient to handle inflation and reduce the effect of it during construction phase.

In this study and according to the respondents' points of view, all delivery methods could be suitable depending on the project coordination and its scope. At the

beginning of each project, if the consultant or client decides correctly about project delivery method according to project coordination, it will be beneficial for both of them and decrease delays and make the project to have less cost and time overrun. So they should be informed about PDM by taking part in training sessions and read about previous and new methods to improve their knowledge.

According to the survey nowadays in Iran, the DBB method is the most popular method in governmental projects and DB is usually used in private projects. Although in this study three popular project delivery methods were selected and discussed but based on the survey finding BOT method was found to be uncommon in Iran and one of the objectives of this research was investigation of the potential of Iranian construction industry to use BOT method. After analysis of the filled questionnaires and interview with respondents, it was determined that the BOT method could be suitable in Iran and it has been discussed completely in previous chapter.

There were totally six groups considered in this study and each of those has different type of delays that has diverse effect on projects. Based on the results of the survey, the most catastrophic group was found to be the client. In this group, there are five different delays and delay in progress payments was at the top. Also in this group, slowness in decision making was the most important problem in execution of work.

After the client, the contractor was in second place with totally eight delay factors. Among these parameters, the financing difficulties were the most catastrophic problem that may cause delay during the project. This delay could be occurred in all PDMs; but in this research, it was specifically hazardous in BOT method because the

contractor must have a perfect funding support to make project to the final phase with minimum cost and time overrun. Also Low technical and managerial skills of contractors are the problems that faced by contractors which might cause construction delays. Therefore, contractors should organize some training programs for their workers in order to update their knowledge and improve their management skill.

The third rank belonged to public authorities in Iranian construction industry by only three parameters. But the important point of this group is that all delays are extremely effective causes in all selected PDMs, specially the inflation since in Iran this matter is grown fast. Although the government tries to control it and make it with less growth, but it is very exhausting process and as a regard, some coefficients are developed to decrease the amount of loss, this problem could be handled somehow by Iranian companies.

6.3 Recommendations for Future Works

The following recommendations could be proposed for future studies:

- It would have been good to gather data individually from three main factors of project scope; time, cost and quality and compare those to see which are the critical ones in other case studies.

- This research could be great help to anybody interested in relation between delays and project delivery methods and it could be used for further research and comparison to other PDMs such as public-private partnerships or engineer-procure-construct (EPC).
- Correlation Matrix is one the most important outcome of SPSS results and with assist of this matrix, it will be easier to compare each parameter with other specific parameter of the case but it need a time and mathematical knowledge .

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APPENDICES

Appendix A: General Iranian companies information form

Name and Surname:	Telephone Number:
Company Name:	Email:

1. What is your Position in the company?

Chief Executive ☐ General Manager ☐ Department Manager ☐ Employee ☐

2. What is your company's field of work?

Building Projects ☐ Road Projects ☐ Dam Projects ☐ Other ☐

3. How many years do you have experience in construction industry?

1-5 years ☐ 5-10 years ☐ 10-15 years ☐ more than 15 years ☐

4. What is your company's grade according to Iran's government law?

Fourth Grade ☐ Third Grade ☐ Second Grade ☐ First Grade ☐

5. How many projects do you regularly have in each year?

1-2 projects ☐ 2-5 projects ☐ 5-10 projects ☐ more than 10 project ☐

6. How many permanent personnel do you have in your company?

5-10 ☐ 10-20 ☐ 20-50 ☐ more than 50 ☐

7. What is your approximately annual turnover?

Less than 100000$ ☐ 100000-500000$ ☐ 500000-5000000$ ☐

More than 5000000$ ☐

8. Which Delivery Method do you prefer for governmental projects?

Design-Build ☐ Design-Bid-Build ☐ Build-Operate-Transfer ☐ Other ☐

9. Which Delivery Method do you prefer for privet projects?

Design-Build ☐ Design-Bid-Build ☐ Build-Operate-Transfer ☐ Other ☐

Appendix B: Sample of Questionnaire

General Information																
Work Experience (Years):						**Field of working:**										
Parameters	**DB**					**DBB**					**BOT**					**Responsible Party**
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Inflation																
Incompetence project team																
Short (unrealistic) contract duration																
Legal disputes between various parties																
Delay to furnish and deliver the site to the contractor by the owner																
Delay in progress payments by owner																
Change orders by owner during construction																
inaccuracy in cost estimates																
Unavailability of professional construction management																

Responsible Party: Owner (OW), Contractor (C1), Consultant (C2), Designer (D), Public Authorities (PA), Site Manager (SM), Other(Please specify in this case)

Parameters	**DB**					**DBB**					**BOT**					**Responsible Party**
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Poor communication and coordination by owner and other parties																
Slowness in decision making process by owner																
Difficulties in financing project by contractor																
Delays in subcontractors work																
Poor site management and supervision																
Mistakes during construction and make rework due to specific errors																
Excessive contracts and subcontracts																
Delay in site mobilization																
Ineffective planning and scheduling of project by contractor																
Delay in approving major changes in the scope of work by consultant																

Responsible Party: Owner (OW), Contractor (C1), Consultant (C2), Designer (D), Public Authorities (PA), Site Manager (SM), Other(Please specify in this case)

Parameters	DB					DBB					BOT					Responsible Party
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Late in reviewing and approving design documents by consultant																
Conflicts between consultant and design engineer and contractor																
Inadequate experience of consultant																
Misunderstanding of owner's requirements by design engineer																
Mistakes and discrepancies in contract documents																
Delays or mistakes in producing design documents																
Complexity of project design																
Delay in material delivery																
Changes in material types and specifications during construction																
Controlling sub-contractors by general contractors in execution of works																

Responsible Party: Owner (OW), Contractor (C1), Consultant (C2), Designer (D), Public Authorities (PA), Site Manager (SM), Other(Please specify in this case)

Parameters	DB					DBB					BOT					Responsible Party
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
Problems with neighbors																
Unforeseen climate conditions																
Effect of social and cultural factors																
Obtaining permits from Government																
Changes in government regulations and laws																
Waiting for test sample approval																
Project delivery method used																

Responsible Party: Owner (OW), Contractor (C1), Consultant (C2), Designer (D), Public Authorities (PA), Site Manager (SM), Other(Please specify in this case)

Appendix C: Questionnaire Result Sample (Persian Version)

اطلاعات کلی																
تعداد سال‌هایی که به فعالیت عمرانی پرداخته‌اید: حدود 60 سال											زیرشاخه اصلی فعالیت: سدسازی ، تونل سازی ، راه ، فرودگاه و راه آهن					
موارد منتخب جهت بررسی	DB					DBB					BOT					مسئول وقوع تاخیر
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
تورم	0					0					0					PA
بی کفایتی تیم اجرایی	0					0					0					C1
ذکر مدت زمان کوتاه و نامعقول در قرارداد	0					0					0					C2&OW
اختلافات حقوقی میان بخش‌های مختلف			0				0							0		C1&C2&SM&OW
تاخیر در تحویل سایت اجرایی از سوی کارفرما به پیمانکار	0					0					0					OW
تاخیر در پرداختی‌ها از سوی کارفرما	0					0									0	OW
ایجاد تغییرات در حین اجرای کار از سوی کارفرما			0				0								0	OW
عدم دقت در تخمین مبلغ کلی پروژه			0			0									0	C1&C2
عدم حضور مدیر اجرایی حرفه‌ای	0					0					0					SM

مسئول وقوع تاخیر: مالک (OW) ، پیمانکار (C1) ، مشاور (C2) ، طراح (D) ، مدیرکارگاه (SM) ، دولت (PA) ، موارد دیگر (با ذکر نام کامل سِمَت مورد نظر)

موارد منتخب جهت بررسی	DB					DBB					BOT					مسئول وقوع تاخیر
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
ارتباطات ضعیف و عدم وجود هماهنگی میان بخش‌های مختلف			0			0									0	SM
سرعت تصمیم‌گیری بسیار کم از سوی کارفرما			0			0									0	OW
وجود مشکلات مالی از سوی پیمانکار			0					0			0					C1
تاخیر در تحویل کار پیمانکاران فرعی		0					0					0				C1
نظارت و مدیریت ضعیف بر روی سایت اجرایی پروژه			0			0									0	C2
بروز مشکل اجرایی در حین ساخت پروژه و ایجاد شدن دوباره کاری			0			0									0	C1&C2
تعداد زیاد قراردادهای اصلی و فرعی در طول پروژه			0			0									0	C1&C2&OW&SM
تاخیر در راه‌اندازی سایت اصلی برای شروع پروژه			0			0									0	SM
برنامه‌ریزی و زمان‌بندی غیر حرفه‌ای توسط پیمانکار			0			0									0	SM
تاخیر در توصیب تغییراتی بنیادین در برنامه زمان‌بندی بلند مدت پروژه توسط مشاور			0			0									0	C2

مسئول وقوع تاخیر: مالک (OW) ، پیمانکار (C1) ، مشاور (C2) ، طراح (D) ، مدیرکارگاه (SM) ، دولت (PA) ، موارد دیگر (با ذکر نام کامل سِمَت مورد نظر)

موارد منتخب جهت بررسی	DB					DBB					BOT					مسئول وقوع تاخیر
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
تاخیر در بررسی و تایید مدارک مرتبط با فاز طراحی توسط مشاور			○			○							○			OW
ناسازگاری و کشمکش میان مشاور و مهندس طراح و پیمانکار			○			○									○	C1&C2&D
عدم تجربه کافی و سابقه اجرایی از سوی مشاور	○							○							○	C2
برداشت اشتباه از خواسته‌های کارفرما توسط مهندس طراح		○				○									○	D
وجود مشکل و اختلاف در قراردادهای تنظیم شده		○				○									○	C1&C2&OW
بروز تاخیر یا اشتباه در ارائه دادن و تهیه نقشه‌های ساختمانی		○				○									○	C1
پیچیدگی‌های پروژه در فاز طراحی		○				○									○	D
تاخیر در تهیه و تحویل مصالح		○				○									○	C1
تغییر در جنس مصالح مورد نظر جهت اجرای پروژه در حین اجرا	○								○		○					C1&C2
نظارت بیش از حد پیمانکار اصلی بر روی کار پیمانکاران فرعی در حین اجرای پروژه			○			○					○					C1

مسئول وقوع تاخیر: مالک (OW)، پیمانکار (C1)، مشاور (C2)، طراح (D)، مدیرکارگاه (SM)، دولت (PA)، موارد دیگر (با ذکر نام کامل سِمَت مورد نظر)

موارد منتخب جهت بررسی	DB					DBB					BOT					مسئول وقوع تاخیر
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	
مشکلات متعدد با مالکین مجاور	○					○							○			OW
شرایط جوی و آب‌وهوایی	○					○					○					D&C1&C2
تاثیرات فاکتورهای اجتماعی و فرهنگی	○					○								○		OW&D
پروسه اخذ مجوز برای شروع پروژه		○				○					○					OW&SM
ایجاد تغییر در قانون‌های مصوب در حین اجرای پروژه			○							○	○					PA
انتظار بیش‌از حد برای تایید نمونه‌های فرستاده شده به آزمایشگاه (بتن، خاک و .....)	○									○	○					C1
روش اجرایی مورد استفاده در پروژه			○			○									○	C1&C2

مسئول وقوع تاخیر: مالک (OW)، پیمانکار (C1)، مشاور (C2)، طراح (D)، مدیرکارگاه (SM)، دولت (PA)، موارد دیگر (با ذکر نام کامل سِمَت مورد نظر)

Appendix D: Filled Companies Information Questionnaire

Name and Surname: Pooya Nikdast	Telephone Number: +98 21 88335750
Company Name: Technic Co.	Email: techdesignoffice@gmail.com

1. What is your Position in the company?

Chief Executive ☐ General Manager ☐ Department Manager ■ Employee ☐

2. What is your company's field of work?

Building Projects ■ Road Projects ■ Dam Projects ■ Other ■

3. How many years do you have experience in construction industry?

1-5 years ☐ 5-10 years ☐ 10-15 years ☐ more than 15 years ■

4. What is your company's grade according to Iran's government law?

Fourth Grade ☐ Third Grade ☐ Second Grade ☐ First Grade ■

5. How many projects do you regularly have in each year?

1-2 projects ☐ 2-5 projects ☐ 5-10 projects ■ more than 10 project ☐

6. How many permanent personnel do you have in your company?

5-10 ☐ 10-20 ☐ 20-50 ☐ more than 50 ■

7. What is your approximately annual turnover?

Less than 100000$ ☐ 100000-500000$ ☐ 500000-5000000$ ☐

More than 5000000$ ■

8. Which Delivery Method do you prefer for governmental projects?

Design-Build ■ Design-Bid-Build ☐ Build-Operate-Transfer ☐ Other ☐

9. Which Delivery Method do you prefer for privet projects?

Design-Build ■ Design-Bid-Build ☐ Build-Operate-Transfer ☐ Other ☐

Appendix E: Respondents and Companies Profile

Names of Respondent	Company Name	Work Experience	Company's Grad
Asadi N.	Vanarah	5 Years	Third Grade
Fakhrai A.	Technic co.	35 Years	First Grade
Rastifar P.	Technic co.	35 Years	First Grade
Mirzai M.	Arsa Khak-Pey	12 Years	Second Grade
Rasoli K.	Moshaver Atek	15 Years	Second Grade
Paknezhad A.	Moshaver Atek	15 Years	Second Grade
Molazadeh A.	Nezam Mohandsi	5 Years	Third Grade
Zare M.	Nezam Mohandsi	8 Years	Third Grade
Shah Sahebi S.	Nezam Mohandsi	22 Years	First Grade
Monzavi N.	Nezam Mohandsi	14 Years	Second Grade
Firozi Kh.	Nezam Mohandsi	7 Years	Third Grade
Omidvar M.	Nezam Mohandsi	17 Years	First Grade
Tajali P.	Iran Saze Novin	10 Years	Second Grade
Lotfi H.	Vanco co.	20 Years	Second Grade
Vahabi O.	Ghatare Shahri Tehran	23 Years	First Grade

Navabi A.	Ghatare Shahri Tehran	13 Years	Second Grade
Yusefi V.	Ghatare Shahri Tehran	16 Years	Second Grade
Jelodariyan B.	Maskane Ghods	26 Years	First Grade
Shariatmadari A.	Omran Ghods Razavi	24 Years	First Grade
Nakhjavani K.	Mashad Mall	19 Years	First Grade
Talebi S.	City Hall	18 Years	Second Grade
Maghfori Sh.	City Hall	16 Years	Second Grade
Janfeshan A.	City Hall	17 Years	Second Grade
Rezai K.	City Hall	28 Years	First Grade
Mousavi S.	City Hall	11 Years	Second Grade
Jalili K.	Mahab Mehr Co.	30 Years	First Grade
Baradaran A.	Pars Abnie	21 Years	Second Grade
Hedayatifar M.	General Mechanic	60 Years	First Grade
Fadavi A.	Mehrab Omran Tehran	17 Years	Second Grade
Aliabadi H.	Sarmayegozari Maskan Pardis	14 Years	Second Grade
Shojai J.	Barbon	25 Years	First Grade
Brojerdi M.	Parnak	27 Years	First Grade

Appendix F: Questionnaire Reliability (SPSS, Cronbach's Alpha)

Reliability Statistics

Cronbach's Alpha (DB)	Cronbach's Alpha Based on Standardized Items	N of Items
.904	.902	36

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
99.0938	426.217	20.64502	36

Reliability Statistics

Cronbach's Alpha (DBB)	Cronbach's Alpha Based on Standardized Items	N of Items
.899	.900	36

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
111.6250	375.532	19.37865	36

Reliability Statistics

Cronbach's Alpha (BOT)	Cronbach's Alpha Based on Standardized Items	N of Items
.878	.868	36

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
101.7200	365.460	19.11701	36

Appendix G: Sample of Companies' Information According to Tehran Engineering Organization

ردیف	شماره مجوز	وضعیت	اسم مسئول	آدرس دفتر	تلفن
۲۸۹	۵۱۰۰۱۱۸۵	داری مجوز معتبر(فعال)	امیر اسماعیلی مکرم	تهران-خ کارگر شمالی-خ پانزدهم-پ۷۸-طبقه همکف-واحد۲	۸۸۰۰۸۴۴۹
۲۹۰	۵۱۰۰۱۱۸۶	داری مجوز معتبر(فعال)	علی عاکف	رودهن-خ مجتمع امیریه-خ سهند-بلوار امام خمینی-روبروی اداره کل امور مالیاتی شرق تهران-ساختمان کوثر-پ۱۳۵۴-ط۱	۷۶۵۰۳۳۳۶
۲۹۱	۵۱۰۰۱۱۸۷	داری مجوز معتبر(فعال)	رضا اتفاقی اسکوئی	تهران-خ شریعتی-بالاتراز میرداماد-خ میناب-پ۱۱-واحد۳	۲۲۹۲۴۱۲۷
۲۹۲	۵۱۰۰۱۱۸۸	داری مجوز معتبر(فعال)	سیدمحمدحسن ابطحی	شهریار- خ مصطفی خمینی-روبروی اداره برق-نبش کوچه اشرفی اصفهانی-پ۸۰- طبقه۱-واحد۲	۵-۶۵۲۶۳۱۹۳
۲۹۳	۵۱۰۰۱۱۸۹	داری مجوز معتبر(فعال)	محمد احمدی	تهران-خ فرصت شیرازی-بین جمالزاده شمالی ووالعصر-طبقه۵-واحد۱۸	۶۶۹۳۲۰۷۷
۲۹۴	۵۱۰۰۱۱۹۰	داری مجوز معتبر(فعال)	آرش فدائی	تهران-صادقیه-خ شهید مهندس موسوی-خ یازدهم-ساختمان ارکیده-پ۱۸-طبقه۱- واحد۱	۴۴۲۹۹۷۲۸
۲۹۵	۵۱۰۰۱۱۹۱	داری مجوز معتبر(فعال)	مرتضی مشایخی	تهران-جنت آباد شمالی-خ شهید علی شهبازی-نبش بهارستان پنجم-پ۱/۱-طبقه۵- واحد۵	۴۴۸۲۱۰۳۳
۲۹۶	۵۱۰۰۱۱۹۲	داری مجوز معتبر(فعال)	علی تقوی	پردیس-فاز۷-جنب۷-جنب بانک صادرات-طبقه فوقانی تشک رویال پارس	۷۶۲۱۳۶۲۰-۷۶۲۱۳۵۸۵
۲۹۷	۵۱۰۰۱۱۹۳	داری مجوز معتبر(فعال)	داریوش فرخی	پردیس-فاز۲-محله۱-بلوار ملاصدرا- مجتمع تجاری و اداری کوه نور-طبقه اول- واحد۶۸	
۲۹۸	۵۱۰۰۱۱۹۴	داری مجوز معتبر(فعال)	احمد خوش بین	شهریار- فاز یک اندیشه-انتهای شاهد شرقی -مجتمع گل یاس-پ۲۶۱ -طبقه سوم - واحد۹	۶۵۵۲۷۸۳۱

ردی	نام شرکت	شماره پروانه	آدرس شرکت	تلفن
۷۳	شرکت مهندسی شایان ابنیه مدرن-مسؤلیت محدود	۱۹۱۰۰۰۰۱۵	تهران-خ سهروردی شمالی-خ خرمشهر-ابتدای خ مرغاب-پ۱۲-واحد۲	۷-۸۸۵۳۵۵۹۶
۷۴	شرکت نوتاش انبوه سازان نیکا-مسؤلیت محدود	۱۹۱۰۰۰۰۳۱	تهران-دارآباد-خ پور ابتهاج-نرسیده به بیمارستان مسیح دانشوری-پ۲۸-واحد۱۲	۲۲۸۹۲۵۱۷
۷۵	شرکت نیک اجراء -سهامی خاص	۱۹۱۰۰۰۰۵۳	تهران- میدان فاطمی- خ بیستون-بوعلی سینای غربی-پلاک۴۷-طبقه۲-واحد۵	۸۸۹۸۶۷۲۴-۸۸۹۶۱۰۴۸
۷۶	شرکت همکار متین-سهامی خاص	۱۹۱۰۰۰۰۴۳	تهران-خ شریعتی-خ خواجه عبداله انصاری-خ چهاردهم-ک زروان-پ۵-واحد۴	۳-۲۲۸۸۱۵۰۱
۷۷	شرکت هنزا هرم-مسؤلیت محدود	۱۹۱۰۰۰۰۴۷	تهران-سهروردی شمالی-خ شهید قندی-خ سیبویه-کوچه۱۰-پ۲۸-واحد۱	۸۸۷۵۶۷۸۳
۷۸	شرکت کامور ایستا سازه-مسؤلیت محدود	۱۹۱۰۰۰۱۵۰	تهران-خ شهید فیاضی-خ بیدار-پ۲۷-واحد۳	۲۲۶۵۰۰۹۳-۲۲۶۵۰۰۹۴
۷۹	مدیریت پروژه های عمرانی صنعتی وهان بنای پارس- مسؤلیت محدود	۱۹۱۰۰۰۰۰۱	تهران-بزرگراه رسالت-چهارراه شهیدحیدرخانی-خیابان خاموشی-بین بست خاموشی- شماره۳۴-واحد۴غربی	۷۷۸۹۰۶۵۶

ردیف	نام شرکت	شماره پروانه	آدرس شرکت	تلفن
۱۰	شرکت ساختمانی مآب ساره-سهامی خاص	۱۳۱۰۰۰۲۰۳	تهران-اقدسیه-میدان ارتش-بین بست طاهری-پ۸-واحد۱	۲۶۱۲۴۴۲۱-۲۶۱۲۵۵۱۰
۱۱	طرح و ساخت سام-سهامی خاص	۱۳۱۰۰۰۲۲۶	تهران-خ ولیعصر-شاهید غربی-پلاک ۵۶	۲۲۰۲۳۶۳۱-۲
۱۲	عمران آذرستان -سهامی خاص	۱۳۱۰۰۰۳۸۷	تهران-خ مطهری-خ کوه نور -کوچه ششم-پ۵-طبقه۵	۸۷۹۶-۸۸۵۲۹۳۴۵
۱۳	محراب عمران تهران-سهامی خاص	۱۳۱۰۰۰۳۶۶	تهران-کارگرشمالی-روبروی بیمارستان قلب-کوچه مجد-پ۶۹	۸۸۰۰۸۱۴۸-۸۸۰۰۶۹۴۱
۱۴	مهندسی راه و ساختمان ابنیه گوهر دنا-سهامی خاص	۱۳۱۰۰۰۲۸۲	تهران-تهران پارس-تقاطع وفادار و استخر-بوستان یکم شرقی-پلاک۳۳	۷۷۰۴۱۶۴۰-۷۷۰۴۱۶۴۵
۱۵	مهندسی عمران و تولیدی نیرو(سهامی خاص)	۱۳۱۰۰۰۳۲۶	تهران-سرگراه شیخ فضل اله نوری- بلوار مرزداران -مجتمع حکمت-ساختمان امید	۸۸۲۸۲۲۰۱-۸
۱۶	مهندسی یادگار ساره عمران-سهامی خاص	۱۳۱۰۰۰۳۹۱	تهران-خ آزادی-بلوار استاد معین خ پور شمس-ک فتاحی-پ۱۲	۶۶۰۱۱۲۲۲-۶۶۰۲۱۹۰۴-۶۶۰۱۱۲۲۳
۱۷	کیان بتن آماده -سهامی خاص	۱۳۱۰۰۰۲۵۹	تهران-خلکه اول صادقیه-خیابان سازمان آب-روبروی پارک همیشه بهار-پلاک۳۱۲-واحد۹	۴۴۲۵۷۱۰۸-۹