

PREDICTION OF LITIGATION PROBABILITY FOR INTERNATIONAL
CONSTRUCTION PROJECTS DURING BIDDING STAGE

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CONSTRUCTION PROJECTS DURING BIDDING STAGE**

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ABSTRACT

PREDICTION OF LITIGATION PROBABILITY FOR INTERNATIONAL CONSTRUCTION PROJECTS DURING BIDDING STAGE

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Over the years many researchers agreed that between the parties involved in construction projects such as; owner, contractor, engineer and suppliers trying to perform different scopes in different timetables. Therefore, disputes are inevitable due to the complexity of the work. Occurrence of litigation is the most terrifying process to deal with during any construction project for both owner and the contractor because of the time and money consuming nature of the process. Hence, contractors should try to eliminate any potential risk factors that will lead to litigation. The aim of this study is to investigate the factors that influence court action between parties in international construction projects and develop a statistical model that will predict the litigation probability of an international construction project during bidding stage.

The final prediction model revealed that contractual awareness and consciousness of risk factors is the key to predict litigation probability. Considering awareness of the factors affecting litigation probability are displayed in this thesis. Companies may have the opportunity to develop risk assessment and management strategies while reconsidering their contingency estimates.

Keywords: Dispute, Litigation Prediction, t-test, Linear Regression, Logistic Regression

ÖZ

ULUSLARARASI PROJELERDE ANLAŞMAZLIKLARDAN KAYNAKLI MAHKEME OLASILIĞININ İHALE AŞAMASINDA BELİRLENMESİ

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Yıllar boyunca pek çok araştırmacı inşaat projelerinin karmaşık yapısı sebebiyle bünyesindeki işveren, müteahhit, tasarımcı ve tedarikçiler gibi çeşitli iş tanımlarını farklı zaman çizelgelerine göre tamamlamaya çalışan katılımcı taraflar arasındaki anlaşmazlıkların kaçınılmaz olduğu konusunda hemfikirdir. Herhangi bir inşaat projesi sırasında konu olan bir hukuk davası zaman ve para kaybına neden olan süreç sebebiyle, hem işveren hem de yüklenici firmalar tarafından en sıkıntı verici durumdur. Bu sebeple firmalar yasal yollara başvurulmasına yol açacak potansiyel risk faktörlerini ortadan kaldırmaya çalışmalıdır. Bu çalışmanın amacı uluslararası projelerde tarafların yasal yollara başvurmaya etki eden faktörleri araştırmak ve yine uluslararası projelerde mahkemelik olma ihtimalinin ihale aşamasında iken tahmin edilebilmesini sağlayacak bir istatistiksel model oluşturulmaktır.

Oluřturulan son model sözleşme ve risk faktörlerine hâkimiyetin hukuk davalarının tahmini konusunda kilit noktalar olduğunu ortaya çıkarmıştır. Bu çalışma ile ulařılan bir projenin taraflarının yasal yollara başvurmasına etken faktörler ışığında firmalar risk deęerlendirme ve yönetim stratejilerini geliřtirebilir, aynı zamanda belirlenen risk primi deęerini gözden geçirebilirler.

Anahtar Kelimeler: Anlařmazlık, Mahkeme Tahmini, t-test, Lineer Regresyon, Lojistik Regresyon

To My Parents

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LIST OF ABBREVIATIONS

AAA	American Arbitration Association
ADR	Alternative Dispute Resolution
ANN	Artificial Neural Network
BDT	Boosted Decision Tree
CBR	Case Based Reasoning
DRB	Dispute Review Board
ENR	Engineering News Record
HGCR	Housing Grants Construction and Regeneration
MLE	Maximum Likelihood Estimation
MSE	Mean Square Error
OLS	Ordinary Least Squares
PCC	Percent Correctly Classified
SPSS	Statistical Package for Social Sciences
SSR	Sum of Squared Residuals
TMB	Turkish Contractors' Association

CHAPTER 1

INTRODUCTION

The "Top 225 International Contractors" list according to 2009 Engineering News Record (ENR), an international construction sector magazine, includes 31 Turkish contractor companies. Turkey is on the second place behind China which has 50 companies in the list. Turkish Contractors' Association (TMB) stated that the ENR's list was based on the income of companies earned by projects made in foreign countries the previous year.

Moreover, according to the Turkish Undersecretariat of the Prime Ministry for Foreign Trade (T.C. BAŞBAKANLIK DIŞ TİCARET MÜSTEŞARLIĞI) International Contracting Industry Report (2008), international projects performed by Turkish Contractors increased more than the expected values over the past years and total value of 23,6 billion dollars of contracts awarded to Turkish Companies during 2008. From 2003 to 2008 Turkish contractors completed several projects in Russia (% 20), Libya (% 10,9), Turkmenistan (% 9,8), Qatar (% 6,9), Kazakhstan (% 6,8), UAE (% 6,5) and Iraq (% 5,8). Characteristics of the projects performed also alternated from small scaled effort based projects to big integrated projects in the past years.

Turkish companies encountered several problems due to unfamiliarity laws and regulations, partners, owners and host countries etc. during this rapid expansion in international construction business since, construction projects integrates many project participants such as; owners, designers, contractors, and suppliers

and requires a coordination of the different processes and timetables necessary to complete a scope. Due to the dynamic nature of construction and uniqueness of each project most of the time disputes between the contract parties are inevitable. It is noted that number of event of disagreements and claims has increased over the past years (Arditi and Pulket 2005, Kilian and Gibson 2005, Goetz and Gibson Jr. 2009). The increased complexity of the construction projects creates conflicts between parties resulting in disputes and claims. (Caldas *et al.* 2002). It was found that in UK 52% of all construction projects ends up with a claim (Ren *et al.* 2001). Moreover, it is recognized that claim management, is not considered as a subsequent procedure anymore, has become one of the essential concerns of the construction management. Several researchers tried to identify the reasons of disputes and developed different perspectives. Some researchers focused on law and contractual issue, some draw attention to organizational and managerial aspects while some point out the disruptions during construction period. Consequently, poor organization, lack of communication, design errors, change orders, late delivery, economic conditions, weather and site conditions, unrealistic expectations, contract documents are some common points that are stressed by researchers during the past studies. *Chapter 2* of this study covers general information on reasons of disputes in construction project and resolution methods from literature.

Usually, the impacts of the disputes rise to the surface as problems concerning schedule or budget or both. Gebken and Gibson (2006) tried to systemize the dispute resolution process with a similar frame work to risk management and proposed Dispute Resolution Management System includes three main components; dispute identification, dispute assessment, and dispute control. Additionally, the study emphasized in this three components dispute assessment is the least explored one by researchers and also by practitioners. Thus, under dispute assessment heading Gebken and Gibson (2006) tried to identify the dispute frequency and severity in order to reduce the catastrophic effects of disputes between parties.

Most of the time disputes between the owner, designer, and the contractor are settled through negotiation as the project progress (Goetz and Gibson Jr. 2009). If parties cannot manage to settle the dispute at this level, a higher level of management shall be necessary for dispute resolution. Dispute resolution in the construction industry including any third party administration is not only a frustrating experience but also a disappointment because of the time and money consuming nature of the procedure in addition to damage to productive completion of projects and relationships (Goodkind 1988, Gebken and Gibson 2006).

Most researchers agreed that conflict resolution and management is gaining importance in construction projects and currently is one of the main topics of interest for both practitioners and researchers. Within this context the main objectives of this thesis is to identify the most effective dispute factors leading to litigation and to develop a statistical model which allows determining the litigation probability of a construction project during bidding stage.

Throughout this study context of the thesis will be discussed in 5 Chapters;

Following chapter, *Chapter 2*, will give general definitions on dispute. Additionally, several dispute reasons will be discussed from literature and dispute resolution methods that are currently in use of construction companies will be explained in detail including their application processes in practice.

Chapter 3 covers the research methodology including potential factors affecting litigation probability of a construction project which also formed the data base that will be used for the analysis.

Chapter 4 comprises brief information on statistical analysis methods used. General overview of the study is introduced together with the detailed results obtained from the analysis.

Chapter 5 presents concluding remarks on prediction of litigation probability during bidding stage of a construction project including prospective benefits and potential shortcomings.

CHAPTER 2

DISPUTES IN CONSTRUCTION INDUSTRY

2.1. Dispute and Claim

In previous years, before construction became such a great international industry probably construction projects and contractual agreements were much simpler compared to current ones. Most likely engineer or architect employed by the owner and it was the engineer parties' duty to make ready the design and the specifications, and then contractors' responsibility began to execute the project. The relationship between the parties was bases on trust and there was no need for long contractual clauses to allege as a pretext. The responsible party did not try to escape from obligations such as appropriate time extensions, necessary liquidated damages, and perhaps disputes were negotiated without the need of a third party (Treacy 1995).

Construction Management deals with all parties of a contract of an on-going project and construction contract is the key to form the risk allocation structure between the contract parties involved; owner, contractor, engineer. However, even with an active and effective management, presence of problems can cause friction between any of the parties due to the complex nature of construction.

The word "dispute" indicates controversy and conflict. Conflicts occur in every construction project (Bramble and Cipollini 1995, Zack 1995, Fenn *et al.* 1997, Pinnell 1999, Carsmen 2000, Harmon 2003). Claim, can also be named as

“Request for Equitable Adjustment” is basically disturbance to the original contract by one of the parties, however, the word “claim” has a legal recognition by most of the organizations. Dispute defined in several resources such as;

- *Dictionary of Modern Legal Usage* (Garner 1995) gives the definition of “to take or demand as one’s right” for claim.
- *American Institute of Architects* (1987) defined claim as “a demand or assertion by one of the parties seeking, as a matter of right, adjustment or interpretation of contract terms, payment of money, extension of time or other relief with respect to the terms of the contract”.

Additionally, most of the time construction claims arise under a specific contract of a project and generally called as “contractual claims” (Powell Smith et. al 1999). Claims can be originated by any of the contract parties, however in common practice; claim denotes any application of the contractor to request additional money or time other than the ordinary.

2.2. Factors Leading to Disputes

Disputes are caused by a variety of reasons or combination of them. According to Diekmann and Nelson (1985) most common cause for a contract claim is design errors. Due to their study covering contracts values between \$200,000-\$20,000,000 among 427 claims, 46% of all claims were because of design errors, meaning deficiencies and uncertainties found in the plans or specifications and 26% of all claims were due to either discretionary or mandatory changes.

In literature there are several studies attempted to specify the causes of disputes, and authors introduced different categorizations to the possible claims.

Concerning prediction of disputes Diekmann *et al.* (1995) addressed three major issues: *People* associates with the management capabilities of key personnel, effectiveness of the responsibility structure, past experience and success with similar type of project, interpersonal skills of organizations and motivation of people; *Project* regarding several internal and external factors including; environmental issues site limitations and design; and *Process* pertain planning of scope, financial planning and contractual obligations. Similarly, Molenaar *et al.* concentrates on the three categories: people issue, process issue and project issues.

Other than Sykes (1996) tried to classify controversies due to their nature of inception such as; misunderstandings and unpredictability most of the researchers stressed the most common reasons of conflict between parties some of which are listed by Fenn (2006);

- Possible delay causes; poor design, change orders, weather, site conditions, late delivery, economic conditions, and increase in quantity (Al Momani 2000).
- Potential ten causes of claim; increase in scope of work, inadequate bid information, faulty and/or late owner-supplied equipment and material, inferior quality of drawings and/or specifications, insufficient time for bid preparation, Stop-and-go operations, work in congested areas and overcrowding, acceleration to regain schedule, inadequate investigation before bidding, unbalanced bidding and underestimation (Jergeas and Hartman 1994).
- Strikes, rework, poor organization, material shortage, equipment failure, change orders, act of God are the main sources according to Alkass *et al.*(1996).

- Five sources defined by Bristow and Vasilopoulous (1995) include; unrealistic expectations, contract documents, communication lack of team spirit and change.
- Colin *et al.* (1996) claims in six areas as; payment, performance, delay, negligence, quality and administration.
- Heath *et al.* (1994) chose to define conflict in seven areas; contract terms, payment, variation, time nomination, re-nomination and information.
- According to Hewit (1991) six conflict areas are; change of scope and conditions, delay, disruption, acceleration and termination.
- Kululanga *et al.* (2001) specified four sources for disputes; errors, defects and omissions in the contract documents; underestimating the real cost of the project in the beginning; changed conditions; and stakeholders involved in the project.
- Madden's (2005) three categories are legal, technical and quantum.
- Ten conflict driving areas according to Rhys Jones (1994) are management, culture, communications, design, economics, tendering pressures, lay, unrealistic expectations, contracts and workmanship.
- Semple *et al.* (1994) identified acceleration, site access, weather, and changes are the four main causes of conflicts.
- Kilian and Gibson (2005) defined the driving factors behind the claim; owner-caused delays, performing extra work not included in original tender documents, contract and/or design, inadequate design, differing site conditions, change orders. Kilian and Gibson also covered root causes from Government and Contractors point of views. Government perspective includes; project management procedure, communication, design errors and contracting officer actions; while main Contractor root

causes are; contracting practices, project management, bid development errors, communication.

Assaf *et al.* (1995) elaborated below listed reasons for delay and claims in large building construction projects under the materials, manpower, equipment, financing, changes, government relations, scheduling and controlling, environment and contractual relationships categories;

- shortage of construction material
- changes in types and specifications during construction,
- slow delivery of materials,
- damage in storage,
- delay in the special manufacture,
- shortage of labour,
- labour skills,
- nationality of labourers,
- equipment failure,
- equipment shortage,
- unskilled operators,
- slow delivery of equipment,
- poor productivity of equipments,
- financing by contractor during construction,
- delays in contractor's progress payment by owner,
- cash problems during construction,
- design changes by owner or his agent during construction,
- design errors made by designers,
- foundation conditions encountered in the field,
- mistake in soil investigation,
- water table conditions on site,
- geological problems on site,
- errors committed during field construction on site,
- obtaining permits from municipality,
- obtaining permits for labourers,

- excessive bureaucracy in project owner operation,
- building code used in the design of the project,
- preparation and approval of shop drawings,
- waiting for sample material approval,
- preparation of scheduling networks and revisions,
- lack of training personnel and management support,
- lack of database in estimating activity duration and resources,
- poor judgment of experience in estimating time and resources,
- inadequate planning,
- inspections and testing procedures,
- quality control applications
- traffic control regulations on site,
- accidents during construction,
- hot weather effect on construction activities,
- rain effects on construction activities,
- insufficient available utilities on site,
- social and cultural factors,
- the relationship between different subcontractor's schedule,
- conflict between the consultant and contractor,
- uncooperative owners,
- slowness of the owner's decision making process,
- joint ownership of the project,
- poor organization,
- coordination between parties,
- insufficient communication between owner and designer at the design phase,
- unavailability of professional construction management,
- controlling subcontractors by general Contractors in the execution of the works,
- unavailability of financial incentives for Contractor to finish ahead of schedule,
- negotiations and obtaining of contracts,
- legal disputes between various parties,
- project delivery system.

Kumaraswamy (1997) developed a different approach and tried to identify root causes and proximate causes of disputes based on a survey conducted on 61 construction project. Figure 1 shows the summary of the root causes and the proximate causes.

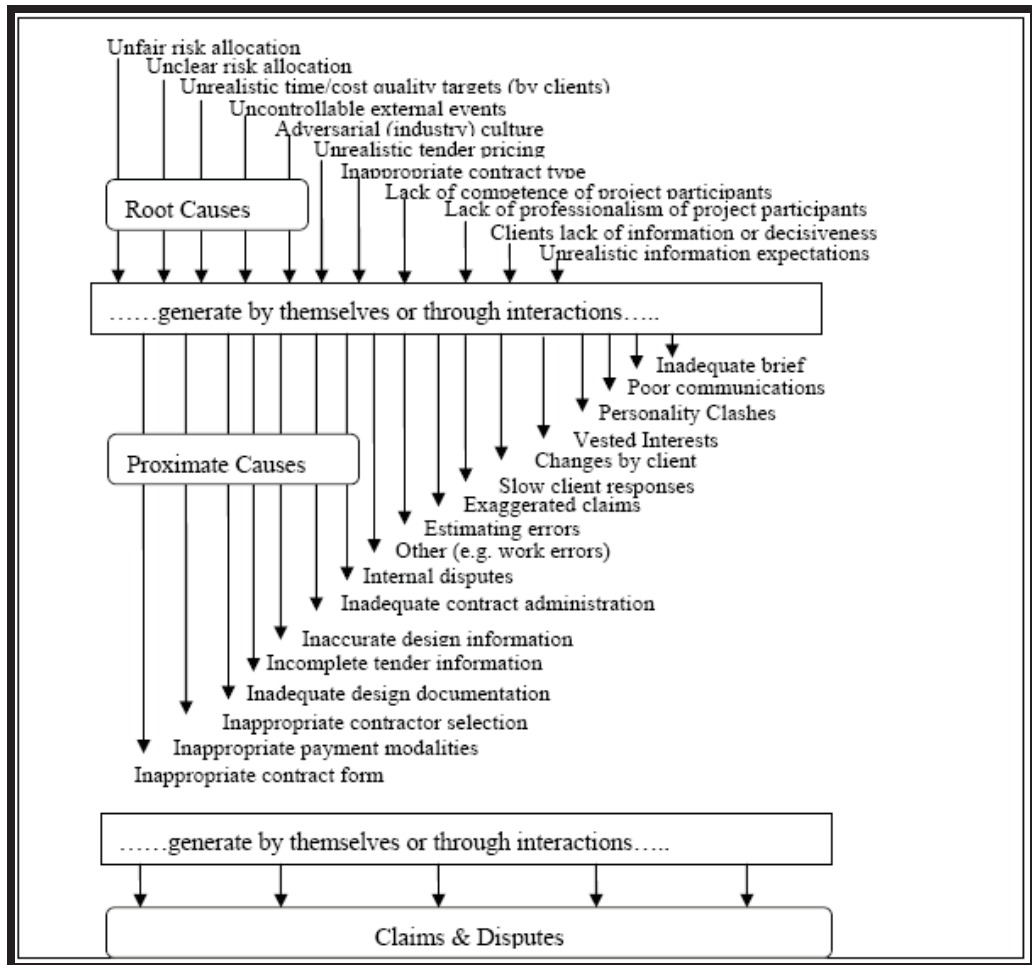


Figure 1 – Root and Proximate Causes (Kumaraswamy 1997)

2.3. Dispute Resolutions

The construction industry displays an oppositional behavior (Rhys Jones 1994, Cheung *et al.* 2006). Conflicts are a reality in every project because of the fact that construction projects tends to coordinate a wide variety of individuals with different, aim, goal, objective, viewpoints, approach and perception and there is always a possibility that what may start as even a minor misunderstanding decay and grow into a dispute. In addition, changes during construction, any disturbance to the project and delays resulting from disputes create basis for new conflicts and disputes in an increasing manner can be called as "spiral of conflict" (Groton, 1997).

Disputes are originated from disagreements between parties. Simply, disagreement arises when an assertion by one party is opposed by another. However, this disagreement does not necessarily be named as a dispute, unless one of the contract parties accepts the consequences of controversy and seeks a resolution. Resolving dispute became a routine part of almost every construction project (Cheung and Yiu 2007).

Probably negotiation is usually the first attempt to resolve a conflict. Then, litigation and arbitration step in to the scene with lawyers, consultants, experts which costs considerable amount of time and money. Today dispute resolution methods varies from litigation and arbitration called traditional techniques to alternative dispute resolution (ADR) methods including mediation, mini-trial, adjudication, dispute resolution board, dispute resolution adviser, and negotiation. It is management's role to perceive any possible dispute, if it has developed, to resolve it as early as possible.

Traditional resolution techniques are well developed over the years and have enforcement among the parties, yet the over-long processes and extensive costs of the traditional methods necessitated alternatives and some private ADR methods developed. Figure 2 is the stair step chart showing the dispute

resolution methods presently in use in construction industry adapted from Cheung (1999).

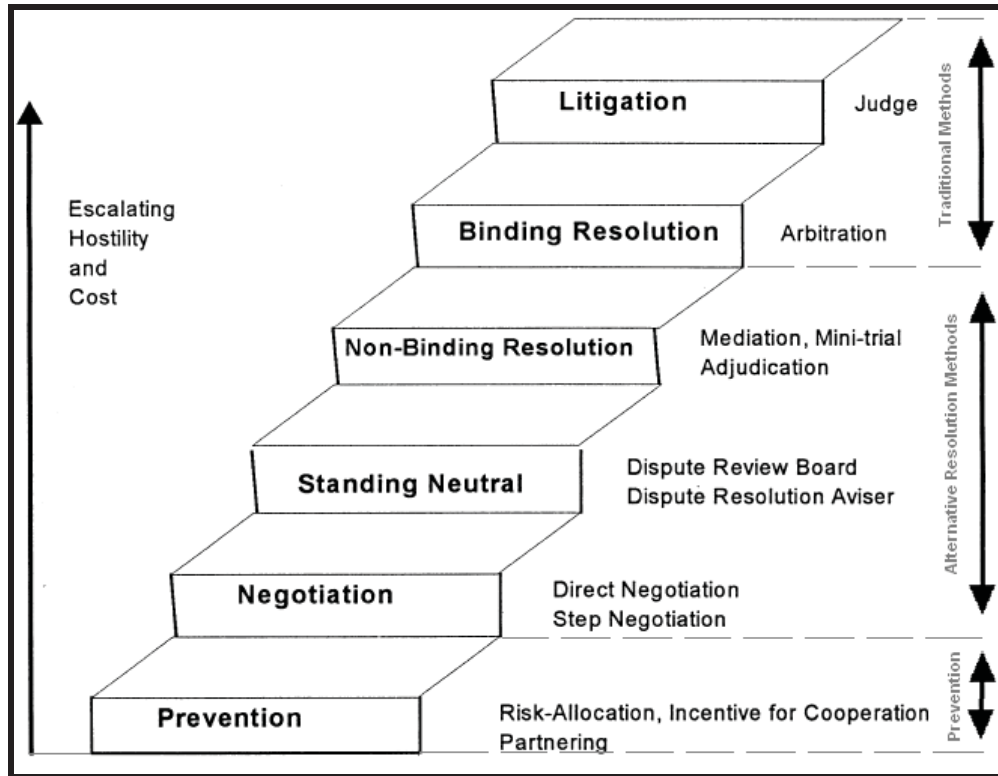


Figure 2 – Dispute Resolution Steps

2.3.1. Traditional Dispute Resolution Methods

2.3.1.1. Litigation

By definition litigation is the act of carrying on a legal proceeding. The litigation or legal process is most common in civil lawsuits. In litigation, there is a plaintiff (one who brings the charge) and a defendant (one against whom the charge is brought). A legal proceeding connotes the resolution by a judicial tribunal of an issue between two parties. In construction industry basically litigation covers the controversy lawsuits.

With litigation, project participants stay suspended and are never certain of the outcome until a court decides who is right and who is wrong. Stokes (1977) states that; “A lawsuit is risky. It may be compared to an old western walk – the parties start at opposite ends of the street and meet in the middle with guns blazing. Both may get killed.” Even the consequences of the process can generate new claims or project schedule may be disrupted during the whole court action. Litigation requires legal knowledge and expertise and most of the time requirements cost considerable amount of money and perhaps it is the most absolute and binding way to resolve disputes arising out of an infinite variety of factual circumstances. Litigation for dispute resolution has significant advantages however the two major shortcomings make parties of the contract hesitate to go through the process. First shortcoming is, depending on the authority and complexity of the dispute litigation, process may take two to six years for court to reach a decision and second one is, because of the fact that litigation is a lengthy and elaborated process, it is expensive (Jervis and Levin 1988, Mahfouz and Kandil 2009).

2.3.1.2. Arbitration

By definition arbitration is the process of in which a disagreement between two or more parties is resolved by impartial individuals, called arbitrators. The disinterested third party, a private arbitrator, hears the evidence brought by both sides and makes a decision and commonly that decision is binding on the parties. Arbitration is used in place of litigation in the hope of settling a dispute without the cost and time of going to court. In arbitration the parties decide jointly on the arbitrator in contrary to litigation in which the judge is appointed and the parties have little or no say in the selection.

2.3.1.3. Arbitration vs. Litigation

The below list points out the major differences of arbitration and litigation;

Table 1 – Major Differences between Arbitration and Litigation

	Arbitration	Litigation
Private/Public	Private - between the two parties	Public - in a courtroom
Type of Proceeding	Civil - private	Civil and criminal
Confidentiality	Confidential	Public
Evidence allowed	Limited evidentiary process	Rules of evidence allowed
How arbitrator/judge selected	Parties select arbitrator	Court appoints judge - parties have limited input
Formality	Informal	Formal
Appeal available	Usually binding; no appeal possible	Appeal possible
Use of attorneys	At discretion of parties; limited	Extensive use of attorneys
Waiting time for case to be heard	As soon as arbitrator selected; short	Must wait for case to be scheduled; long
Costs	Fee for arbitrator, attorneys	Court costs, attorney fees; costly

2.3.2. Alternative Dispute Resolution (ADR) Methods

2.3.2.1. Mediation

Mediation process is similar to arbitration, key issue is to employ a neutral third party, however contrary to arbitration, it is usually to employ mediation as a non-binding procedure and on the other hand, mediator does not judge the parties or the case, but helps assist a discussion and eventual resolution of the dispute. The parties are brought together in a neutral environment where they can freely and confidentially present their position in front of a neutral third party who then attempts to limit the issues and put them in perspective. It involves some special tactics of mediator to define both parties' sources of problems and conduce to reach their own solutions by creating a win-win medium (Cheung and Yiu 2007, Goodkind 1988). The mediator deals directly with the people involved in a controversy. Instead of being an authority that renders a verdict, he creates an environment that disputing parties can construct their own agreement (Goodkind 1988). Goodkind (1988) also suggested that "People tend to carry out decisions they have helped to formulate. People do not like to be told what to do. People are more important than disputes". Concordantly, mediation gives opportunity to disputed parties to settle disputes voluntarily and in private conditions while preserving business relationships or reputations to industry (Chau 1992, Hon 2006; Cheeks 2003, Chau 2007, Yiu and Lai 2009). Conflict resolution by mediation is rapid, cost-effective and flexible. Nonetheless, due to the mediator oriented structure of the caucus, mediator selection and skills significantly affect the mediation outcome (Cheung and Yiu 2007). Parties can reach a solution even within days and the mediation process is less expensive due to traditional methods. However, due to the non-binding nature of the process or an insufficient mediator results parties seeking remedy may be frustrated.

Goodkind (1988) explained the mediation process in detail starting from kick off meeting which is named as joint session to the settlement point. Throughout this process the mediator starts with her/his qualifications, her/his mediation experience and continue with the explanations on her/his role in the subject matter of dispute settlement process. Moreover, mediator provides information about the mediation process itself including the differences from other dispute resolution methods. Mediator defines the ground rules regarding presentations and discussions to be held during the process. Also, confidentiality and courtesy in sessions are the some of the topics that mediator point out for in the beginning of the mediation. Following the preliminary descriptions each party present the situation and their point of view for the subject dispute. The aim of the presentations is to provide necessary information to the mediator to evaluate relationships and dynamics between the parties. As the mediation proceed mediator may appeal to get together with the parties in joint or separate sessions to explore alternative solutions and seeks possible tradeoffs. After understanding the situation clearly mediator step in to the next phase of mediation and offer an insight into the matter of conflict by emphasizing the main issues and formalizing the offer. If mediation process succeeds final inclusive agreement is reached between the parties, otherwise, resolution of the dispute may convey to traditional techniques such as arbitration or litigation which will impose sanction to the situation (Goodkind 1988).

2.3.2.2. Minitrial

A mini-trial is not a real trial, but a voluntary, nonbinding resolution method. Aim of the mini-trial is to handle the conflict as a business problem instead of a legal problem (Henry 1988). While either party is free to proceed to a formal trial, regardless of the mini-trial's outcome. Compared to real court actions minitrials take less time while reducing the expenses.

It is not necessary to assign a third party as a neutral adviser, however it is advantageous to have a respected authority that can design and manage the minitrial procedure. Further, adviser can help with the clarifications necessary during the presentations. Certainly the most significant function of the neutral advisor is his advisory opinion upon the request of the parties'. Neutral advisor's opinion tends to reflect a probable outcome of the litigation by observing weaknesses and strengths of both parties (Henry 1988).

According to American Arbitration Association (AAA) neutral advisor should be selected due to certain qualifications including; having no financial or personal interest in the result of the minitrial and shall not reveal prejudice and bias behavior.

Minitrials are most functional in construction conflicts that are heavily fact-oriented and complex and in the mean time contradicting parties are willing to preserve relationships. Flexible, problem-solving and confidential process, time and money saving approach and preservation of business relationships features are the most important advantages of minitrial (Henry 1988).

Additionally, hearing directly from the opponent instead of a consultant during presentations eliminates most of the misunderstandings between parties. However, this may turn into a disadvantage by letting the parties to see each others' hands; their strategies and evidences if case becomes a real trial (Smith 1998).

In practice define by American Law and Legal Information, minitrial starts with assigning representatives having an authority to negotiate a settlement. Also an independent "neutral adviser" should be determined. Before the minitrial parties provide all necessary information materials including records kept to show background of the conflict and this period named as "information exchange". During this period parties present their perspective to the dispute issue with all supporting information. Following the information exchange management representatives try to resolve the dispute according to the revealed

the strengths and weaknesses of each party's case. Representatives may also ask for neutral advisers' opinion during the dispute resolving time period. If an agreement is reached it is specified in writing and signed by the representatives forming a legally binding agreement on the parties. If the parties cannot manage to settle the dispute, the proceedings will terminate 30 days after the date of the information exchange.

2.3.2.3. Adjudication

Adjudication is a limited binding resolution technique in which a third neutral party (Adjudicator), named in the contract, is responsible for decision making to any matter in dispute. Adjudicator's decision shall be binding until the dispute is finally determined by legal proceedings. Additionally, the parties have the right to challenge the decision through arbitration or litigation (Chau 2007).

This is a process in which the disputants present their cases to an independent expert who then evaluates the evidence according to the relevant law, rules, contract and practice that is applied appropriately in the dispute and gives a confidential opinion on the likely outcome of the case if it were to go to court or arbitration. The disputants agree beforehand that they will be bound by the opinion of the expert and that this decision is binding on the parties in the interim, until a further decision by a court of law or arbitration is reached.

According to Housing Grants Construction and Regeneration Act of 1996 (HGCR Act 1996) adjudication process starts with the referring party's Referral Notice submission to the Adjudicator within 7 days of the Notice of Adjudication. The Referral Notice is required to set out the basis of the Referring Party's remedy seek and to include the evidence it intends to rely upon.

It is for the Adjudicator to decide the procedure to be followed thereafter, but usually the Responding Party is given 7-10 days to make its Response.

A hearing may be held lasting one day to discuss the matters that are required to be decided and to have the issues explained. In some cases this has involved representation by barristers and legal argument. In other cases the day has involved an investigation of facts.

In most cases there are interrogatories in the form of written questions from the Adjudicator answered by the parties and requests for further statements on discrete topics and requests for copies of correspondence referred to in correspondence submitted by the parties.

The Adjudicator gives his decision within 28 days of the Referral Notice.

A reasonable process flow (Figure 3) for dispute resolution is defined by Chau (2007) reflecting the current settings of Hong Kong construction industry which basically starts with de notice of dispute and covers the mediation and adjudication steps and leading to arbitration in case the previous methods fail.

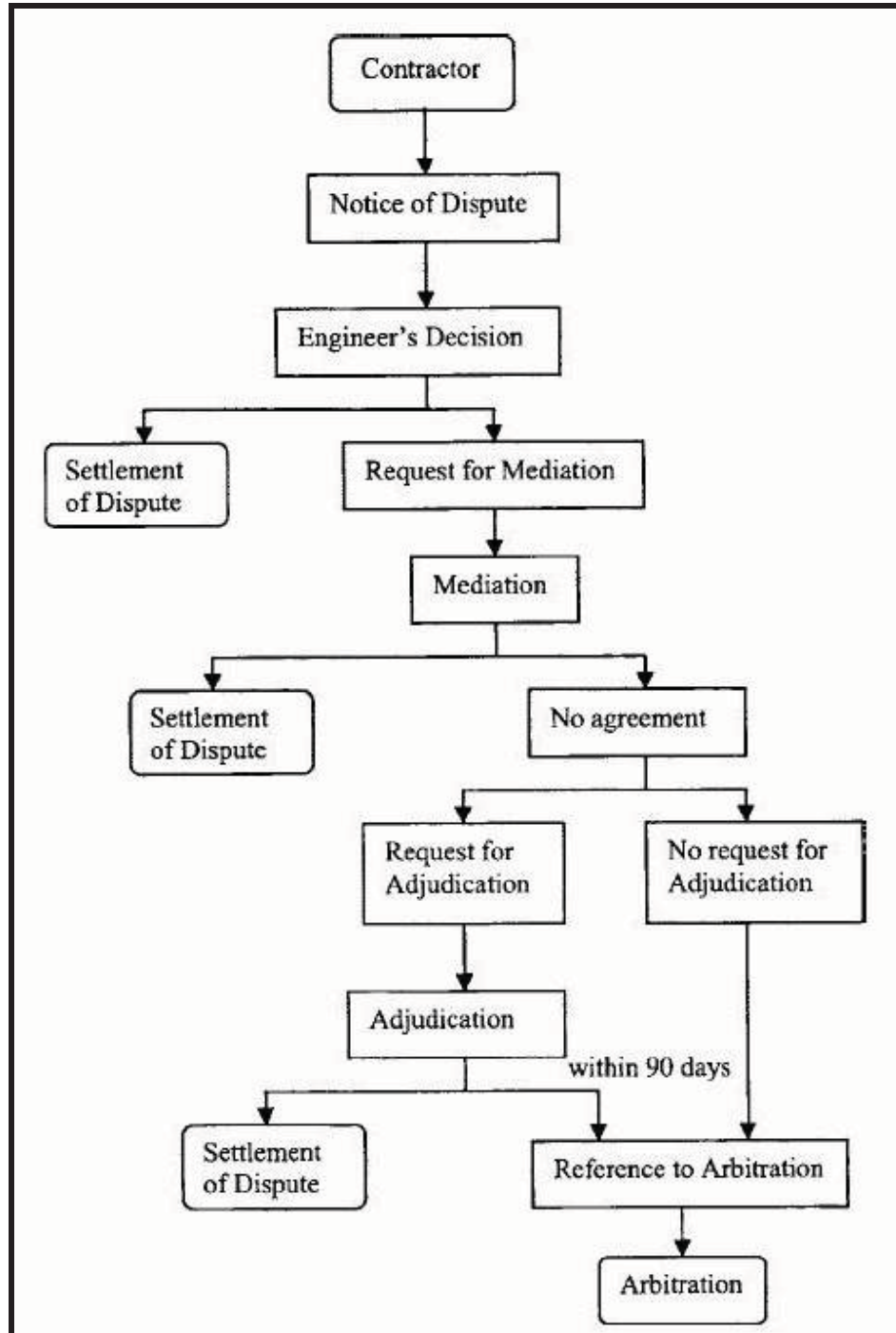


Figure 3 – Framework for Dispute Resolution Process of Hong Kong (Chau 2007)

2.3.2.4. Dispute Review Board (DRB)

Different from other alternative dispute resolution methodologies DRB panel is generally established during the pre-construction phase and unresolved issues are brought before the DRB during the course of the contract, as they arise, not at contract completion. (Harmon 2004)

The owner and contractor each nominate one member to the panel, and each must approve the other's nominee. The two DRB nominees (or the owner and contractor by mutual agreement) select the third member of the DRB. DRB members are compensated by the parties in accordance with a DRB agreement. The contract specifications outline the DRB's role. A DRB only has the authority granted to it by the parties. A DRB usually consists of three members, selected by both the contractor and the owner soon after the award of the contract. With smaller contracts, the panel might be a single person, which may be regarded as equivalent to appointing an expert conciliator or mediator for the duration of the contract.

Contract documents may list the requirements of Dispute Resolution Advisors (DRA) such as years of experience in their respective professions and substantial experience in the type of construction involved in the contract, as well as experienced in contract interpretation and construction claims. DRA, who are normally highly experienced in the field, help the parties to identify contractual issues early and processes them through to agreed conditions. The DRA needs to display some mediation skills. The benefits include fewer disputes, less cost issues and foreseeable cash flow for the parties from beginning to the end of the contractual agreement (Fisher and Ury 1991).

The DRB members are provided with the contract plans and specifications, become familiar with the project procedures and the participants, and are kept aligned with the job progress and developments. Typically, DRB members make periodic visits to the construction site and become familiar with the

parties and the project. In this manner, they have the chance to observe the problems at the time they occur and, based on their own construction experience, understand the technical details and contractual consequences. This enables the parties to bring conflicts to the board while the project is ongoing.

The DRB's output is a written non-binding recommendation for resolution of a conflict. The report includes an explanation of the DRB's evaluation of the facts and the contract provisions and the reasoning that led to its conclusions. Acceptance by the parties is facilitated by their confidence in the DRB member's expertise, first hand understanding of the project conditions, and practical judgment. Basic principles of DRB are first, prevent problems to intensify into disputes and second, prevent any disagreement to escalate into litigation (Vorster, 1993).

2.3.2.5. Negotiation

Negotiation is the most common form of dispute avoidance and resolution and probably the first step before considering other methods (Cheung *et al.* 2006). Basically, Negotiation is a process of making joint decisions when parties involved have different opinions. It is a voluntary, private, confidential and an amorphous process agreed by both parties. It is usually the cheapest method and is usually tried first. According to Fisher and Ury (1991), direct negotiation is a common dispute resolution process in which parties try to resolve the dispute without involving any independent third party. Negotiation is a process of persuasion where each side tries to influence the other to accept its point of view. The problem with negotiation is that it is rare for disagreements and disputes that are resolved by this method (Cheung *et al.* 2009). The bargaining power of the parties usually plays a significant part as well.

Negotiation is voluntary in the sense that negotiations can be broken off at any time by simply refusing to continue, and no one can strain an unwilling party to negotiate. Amicable tactics are key issue in keeping negotiators at the negotiation table (Ren *et al.* 2001), because, if the relationship between the parties has broken down beyond this point then negotiation will not be possible. This makes negotiation non-determinative, as there is no guarantee that it will end in an agreement that resolves the issue. Therefore, it is also non-binding up to the point agreement is reached. Negotiation can take many forms ranging from an informal chat or a telephone conversation between the parties or their lawyers to a highly structured and complex process taking place over an extended period.

The great benefits of negotiation, from the parties' view point, are firstly that the parties can do it on their own, thus reducing costs, and secondly they remain aware of the dispute and the process. They may not succeed with this method, but an imposed resolution they find unacceptable will not be a straining issue also, as is possible with the traditional and binding methods. It is important that the parties involved show regard to the agreement.

The features that contribute to the success of direct negotiation are flexibility and solution seeking behavior, which meet the needs and interest of both parties (Fisher and Ury 1991). However, the success of negotiation depends on interpersonal communication skills of the parties during the entire process (Cheung *et al.* 2009). In negotiations, parties approach each other for discussions to find a mutually acceptable outcome to the dispute.

Negotiations may, or may not, involve advocacy. However, key point is each party needs to explain its own interests, and listen carefully to the other party. A conscious effort is needed to avoid premature judgment, while multiple options for settlement are quietly explored. This does not only require patience, self-control and courtesy, but also a commitment to and trusts in the negotiation process.

There are two perceptible strategies employed in negotiation, depending on how strong a bargaining position a party feels it is in. These are known as positional bargaining and principled negotiation. In positional bargaining the parties adopt extreme positions at the start and trade concessions to try to reach a resolution somewhere in the middle. This strategy suits the tough one in a dominant position, who may often achieve some undeserved results against particularly weak opponents. On the other hand, it is too easy for this approach to fail if the parties become entrenched, and the weaker party is not as compliant as the dominant party expects.

Parties should pay attention to the preparation period also. The listed matters may give a good perspective to a party preparing for negotiations;

- study decently on the issue including determination estimations and findings on affects of the dispute
- allow parties sufficient time,
- identify the interests of the other party,
- plan negotiation process,
- define realistic goals,
- inform negotiator properly and honestly
- listen the other party carefully

2.3.2.6. Suggestions

Cheung *et al.* (2002) listed the expert suggestions by means of the several attributes of the ADR processes and preparation for them.

Table 2 – Suggestions for Dispute Resolution (Cheung *et al.* 2002)

Attributes/means	Suggestions by experts
Voluntariness	<ul style="list-style-type: none"> * Parties' willingness to settle * Use ADR process instead of litigation * Neutrals make parties fully aware of consequences if dispute was to be resolved by traditional court process * Neutrals explain to parties the benefits of using ADR process
Confidentiality	<ul style="list-style-type: none"> * Written agreement between parties * Keep the process and related materials strictly confidential * Allow only the parties involved in a dispute to participate the process
Neutrality/fairness	<ul style="list-style-type: none"> * Improve competence and judicial quality of neutrals, continuing professional development * Maintain pool of experienced mediators and arbitrators * Neutrals to make mandate statement declaring any conflict of interest * Careful selection of neutrals by parties, study neutral's track records
Consensus agreement	<ul style="list-style-type: none"> * Neutrals help to consolidate differences * Parties' willingness to adopt dispute resolution * Neutrals advise most appropriate contract provision * Neutrals make sure parties understand critical issues of dispute * Neutrals ensure process is conducted in no adversarial manner
Knowledge in construction	<ul style="list-style-type: none"> * Continuing professional development * Promotion of ADR workshops
Creative agreement	<ul style="list-style-type: none"> * Neutrals should explore alternative settlement options * Careful selection of neutrals, those with good all around experience in various dispute resolution strategies and ability to critically analyze disputes and come up with creative answer that can satisfy parties

Table 2 continued

Table 2 – Suggestions for Dispute Resolution (Cheung *et al.* 2002)

Attributes/means	Suggestions by experts
Enforceability	<ul style="list-style-type: none"> * Selecting neutrals with competence in drawing up agreement/award * Signed agreement between parties * Parties are committed to settle
Speed	<ul style="list-style-type: none"> * Neutrals keep close eye on process * Parties' willingness to cooperate * Documents-only process—avoid unnecessary procedures * Use ADR as opposed to arbitration and litigation * Make sure parties are thoroughly briefed about all facts * Focus on key issues * Good time management—don't waste time on things that do not matter
Cost	<ul style="list-style-type: none"> * If nature of dispute allows, avoid involvement of lawyer * Limiting discoveries * Good time management—set time limit for hearing * Neutrals explain to parties importance of time and implications if dispute drags on without resolution * Documents-only process * Proactive neutrals—neutrals are given authority/teeth to control process * Less legal input and more parties' involvement * Focus on major issues and not be caught up by minor details
Preservation of business relationship	<ul style="list-style-type: none"> * Parties' willingness to adopt dispute resolution scheme * Parties are willing to accommodate differences * Emphasis on consensus through ADR, avoid going to arbitration and litigation * Parties show respect for each other * Avoid heated confrontation—emphasize win/win solution * Don't take issues personally * Neutrals encourage open and honest discussion

2.4. Prediction of Disputes from Literature

Several methods of dispute resolution are explained in previous sections of this chapter. The methods having different confidentiality, formality etc. characteristics are discussed as well as different time and money consuming behaviors. However, the best way of dealing with disputes between the contract parties is to predict and avoid them while possible. In fact, several researchers tried to develop methods to forecast the possible disputes in a construction project. Diekmann and Girard (1995) tried to clarify if some of the project characteristics has significant role to trigger disputes and if those disputes can be distinguished even before the project start. Boosted Decision Tree (BDT) which works as learning algorithm on various distributions over the training data is used for prediction of disputes revealing that people is the related issues are the key to forecast disputes (Diekmann and Girard 1995). Shin and Molenaar (2000) focused on the characteristics of the contract clauses rather than the human interactions and proposed dispute prediction concept given in Figure 4 which accept dispute identification as an intrinsic part of construction project process.

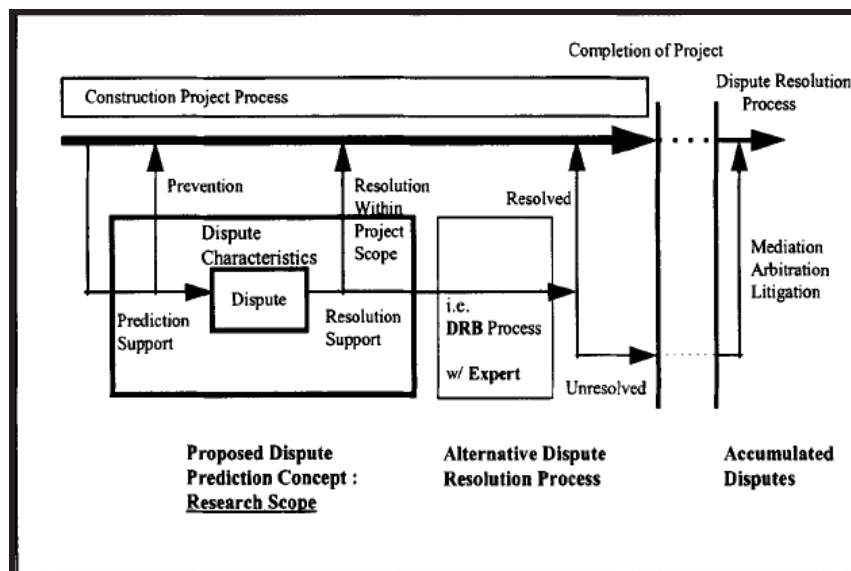


Figure 4 – Dispute Prediction Concept (Shin and Molenaar 2000)

The critical characteristics of disputes are defined for dispute prediction purposes under the headings regarding Change, Design/Specification, Contract Condition, Work ,Time/Cost, Completion and the study revealed disputes need to be considered as a source of additional information for decision making in the construction process (Shin and Molenaar 2000). In addition, Mitropoulos and Howell (2001) carried out comparative analyses over 24 disputes from 14 projects and proposed preventive actions to minimize the occurrence of frustrating claims regarding construction projects including; reducing project uncertainty, contractual problems and opportunistic behavior while increasing the project organization's problem-solving ability, and use of ADR.

2.5. Prediction of Outcomes of Dispute Resolution

No matter what method is followed for dispute resolution the main concern is the outcome of the procedure, especially if the final decision expresses a binding feature such as in litigation or arbitration. Since litigation has a time consuming and expensive nature, prediction of the outcome may affect decision making on whether or not to go through litigation process while reducing the frequency and severity of construction projects. Considering the increasing number of litigation regarding construction projects researchers attempted to develop artificial intelligence based models to predict the outcome of litigation. Arditi *et al.* (1998) performed artificial neural networks (ANN) analysis on 132 Illinois court cases and obtained 66,7 % prediction performance. Arditi and Tokdemir (1999) applied case-based reasoning (CBR) using the same 132 cases for the same purpose and reached 83,3 % prediction rate. Another study carried out with the 132 Illinois court cases by Arditi and Pulket (2005) by using BDT which revealed 89,6 % prediction performance. Pulket and Arditi (2009) developed another prediction model which supports settlements out of court, called Universal Prediction Model (UPM). The proposed framework of the UPM is presented in Figure 5. Additionally process is explained as “First, the

dataset is appropriately consolidated by using several algorithms and methods. This step is performed to ensure the appropriate data format required for a particular learning scheme. Next, the attribute selection process searches the space of attribute subsets and selects the most relevant attributes in the dataset Pulket and Arditi (2009)".

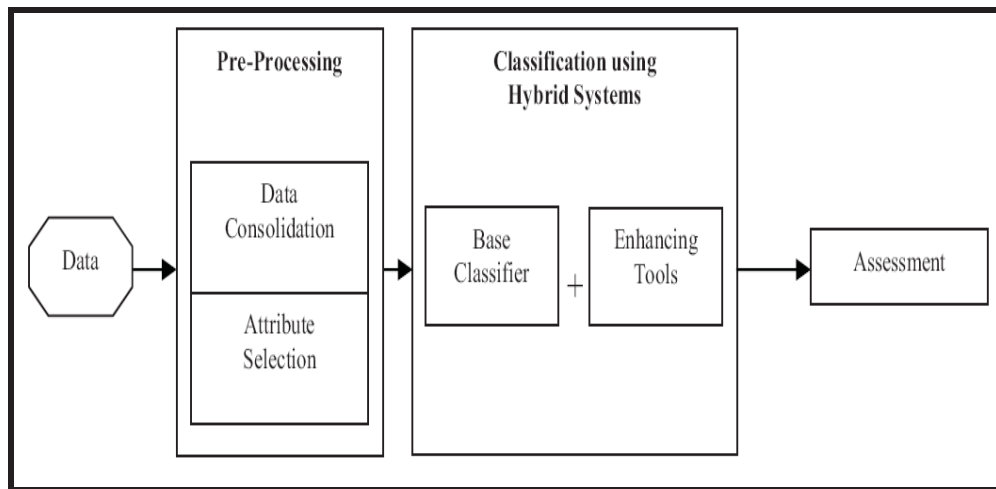


Figure 5 – Framework of the UPM (Pulket and Arditi 2009)

UPM was applied to two data sets. First one is the same data set used in previous studies including 132 Illinois court cases that displayed 90, 9% prediction performance. UPM was run with an augmented dataset including 151 court cases and showed 96,0 % prediction rate. UPM performances of two separate data sets support the idea that increase in the number of cases used in the model improves the prediction performance.

CHAPTER 3

RESEARCH METHODOLOGY AND QUESTIONNAIRE DEVELOPMENT

3.1. Research Methodology

Litigation is probably the most intimidating process for contractors to deal with during any construction project. However, if a different resolution method is not stated in contract, disputes are resolved in courts. As emphasized several times litigation is a time and money consuming process that contractors endeavor to eliminate the risk of any possible litigation. Hence, the main objective of this thesis is to develop a tool for predicting potential litigation in a construction project as early as possible. In conformity with this prediction purpose, the research is structured based on an information collection form composed of several questions to integrate practitioners' experiences to this study.

The questionnaire form which is given in Appendix A is constituted of two main parts. PART I aimed to gather general information related to the contractor company and the subject project that contractor undertook, while PART II proposed a list of factors might have affect on disputes leading to litigation for the subject project.

The initial questioner form was developed according to several studies in literature tried to specify the causes of conflicts that most of them are listed in

‘2.2 Factors Leading to Disputes’. The questionnaire form is developed to reveal the problematic issues which may be the leading causes for dispute specifically litigation in an international construction project. However, since the aim of the study is to develop a prediction model capable of forecasting the litigation probability during “bidding stage”, the possible effective factors defined in the PART II of the questionnaire should only include the ones that the contractors are capable of estimating during bidding stage. The effective factors elaborated under the listed subdivisions.

- Experience of contract parties,
- Factors related to tender preparation stage,
- Engineering related factors,
- Factors related to resources,
- Construction related factors,
- Schedule and coordination related factors,
- Contractual factors,
- Host country related factors.

The preliminary questionnaire form was shared with 6 individuals including not only academicians, but also professionals working in managerial positions and in tender preparation departments of the construction companies. Evidently, with the feedback of these experts on the survey form the final body of the questionnaire form (Appendix A) was generated.

3.2. Application of the Research

Final questionnaire form distributed to several Turkish construction companies and individuals conversant with the bid stages of the projects that are believed to have experience in international construction business.

PART I included total number of 26 questions. In the first section of PART I contributors are asked about the experience of the company in construction business as well as the value of their experience in both local and international industry. Further, companies' labour force and partnership structure of the company are objects of interest. The second section of PART I, questions are related to project information including type and location of the project, contractual obligations such as project duration, performance and advance payment bond amounts, financing structure and bidding type and evaluation criteria for the project. Furthermore, it is asked in this section if the project subjected to a litigation process.

The second part of the questionnaire, PART II, consists of 51 questions listing possible factors affecting a project to go through litigation process. In this section contributors were expected to state their level of agreements to the situations listed for the subject project during bidding stage. In order to get response to the questions in this section 0-5 scale that is listed in Table 3 is used.

Table 3 – Questionnaire Scale

Scale	Description
0	Not Applicable (N/A)
1	Strongly Disagree
2	Disagree
3	Neither Agree nor Disagree
4	Agree
5	Strongly Agree

According to the scale applied “0-Not applicable” is the choice to be selected if the question is irrelevant to the project or the respondent does not have information on the issue. Otherwise, one of the five levels of agreement shall be selected.

In brief, the factors listed in questionnaire were believed to have critical affect on prediction of litigation probability in addition to serving the appropriate configuration for the statistical analysis.

3.3. Objectives of the Research

The main purposes of the data analysis are;

1. To determine the factors affecting litigation occurrence in international construction projects and determining the level of influence of these factors,
2. To develop a statistical model for predicting the probability of litigation during bidding stage for international construction projects using Linear Regression and Logistic Regression analysis techniques.

CHAPTER 4

RESEARCH FINDINGS AND DISCUSSION

The questionnaire developed was sent to 25 companies that are members of Turkish Contractors Association and have international construction experience, 3 firms working as claim and contract consultants, and more than 100 individuals who have experience in international construction management. Our aim was to contact with professionals who had previous experience as a key personnel in international construction projects, or performed work during bidding stages or conflict resolution processes of the projects. In the introduction part of the questionnaire form the aim of the study and our requirements from individuals explained in detail and total 34 professionals responded and returned forms. For this thesis definition of international construction project stands for a project carried out outside Turkey, or a project carried out in Turkey with an international partner or an international owner.

4.1. General Overview

At the end of the information collection phase of this study total number of 34 project data was reached. The data set includes “12” projects subjected to litigation and “22” projects completed without any dispute or manage to resolve disputes by any appropriate ADR method. First part of the questionnaire requests information related to company performed the project starting with the

years of experience. Levels of experiences of the companies which are the durations in years that the company is active in construction business are listed in Table 4. According to the data provided 29 of the 34 companies have at least 10 years of experience, and 24 of 34 projects meaning 71 % of the projects had performed by the companies having experience more than 20 years in construction industry. In construction industry most of the companies' long-term objectives include international trade and marketing activities. Consequently, the results of this study reveals companies having 10 to 20 years of experience in business manage to step into the international construction business.

Table 4 – Experience Years of Contractors

Company Experience in Construction (years)	# of Company
0-9	1
10-19	5
20-29	8
30-39	4
40-49	7
50-59	5
Unknown	4
Total	34

Another determinant for the strength of the contractor companies are the value of the projects completed by them. In the given Figure 6 and Figure 7 pie charts are present the level of previous performance of the companies in foreign countries and in local market. The results revealed no significant difference between litigated and non-litigated projects' contractors total completed work values performed in abroad or in Turkey.

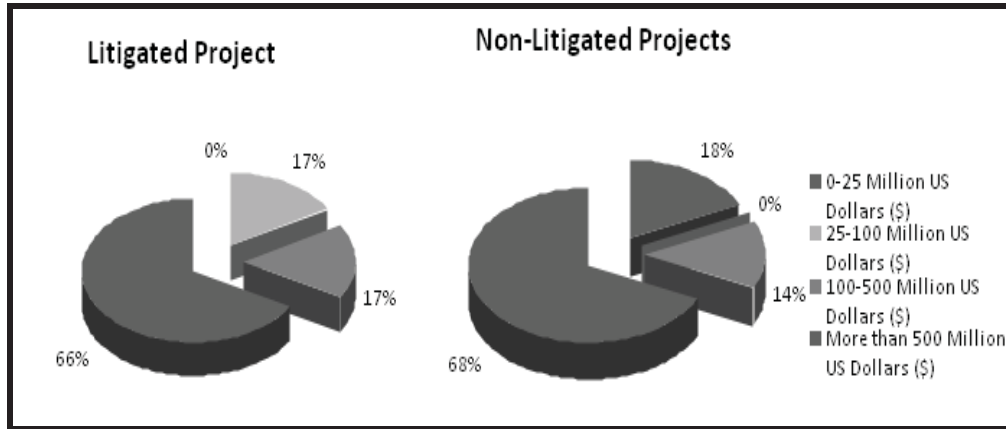


Figure 6 – Total Value of Completed Works in Abroad

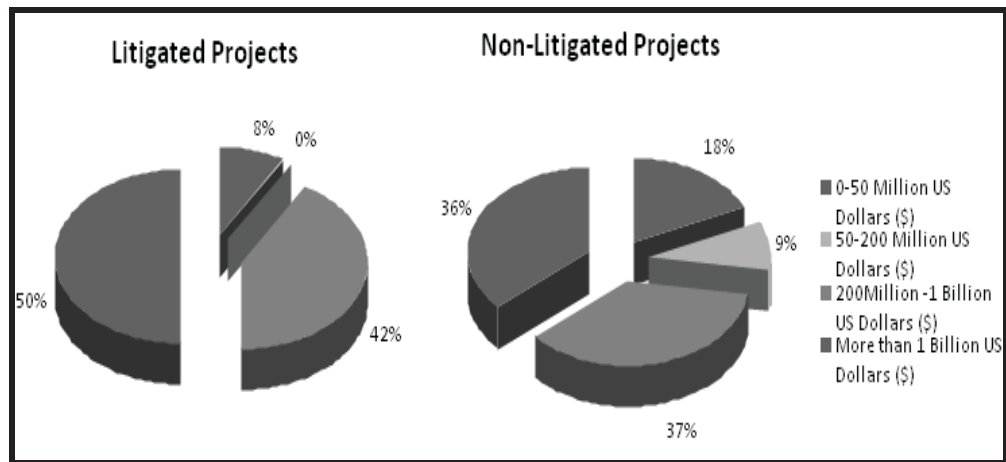


Figure 7 – Total Value of Completed Works in Turkey

It is seen that 68 % of the projects are performed by companies having limited liability partnership structure and also a few sole proprietorship and public limited company partnerships observed. Additionally, work forces of the responsible companies for litigated and non-litigated projects do not differ significantly from each other.

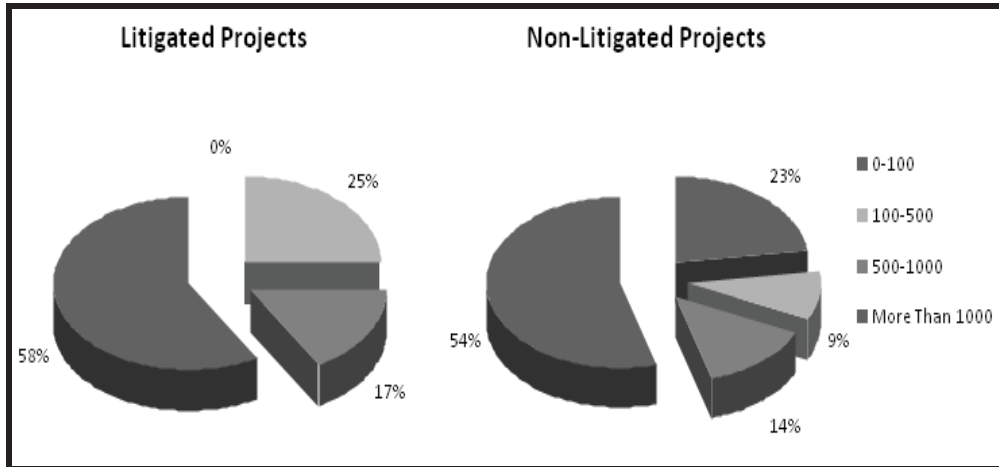


Figure 8 – Total Number of Employees in the Company

The information related to companies in the questionnaire form decided not to use in the in the statistical analysis steps because there is no important difference noticed between litigated and non-litigated projects.

Following the company related questions the survey asked the respondents general characteristics of the projects. The survey reached project data of several types of international construction projects. However, the types of the projects are dominated by building projects serving variety of needs including hospital, shopping mall, army buildings etc. Table 9 shows numbers of the project types and the percentages of them in the overall data set for both litigated and non-litigated projects.

Table 9 – Type of Construction

Status	Type of Construction	# of Company	Percentage
Litigated	Infrastructure	1	8,33%
	Transportation	0	0,00%
	Industrial Plants	2	16,67%
	Pipeline	0	0,00%
	Building	7	58,33%
	Dam	1	8,33%
	Residential	1	8,33%
	Power Plant	0	0,00%
	Total	12	100,00%
	Non-litigated	Infrastructure	2
Transportation		1	4,55%
Industrial Plants		6	27,27%
Pipeline		1	4,55%
Building		11	50,00%
Dam		0	0,00%
Residential		0	0,00%
Power Plant		1	4,55%
Total		22	100,00%

According to the data set the 34 projects were performed in different locations including Afghanistan, Azerbaijan, Bulgaria, Germany, Iraq, Ireland, Jordan, Libya, Russia, Saudi Arabia, Turkey and United Kingdom alphabetically. And, total value of the projects contributed to this study changes from 3.000.000 \$ to 430.000.000 \$.

Mainly, the official tender packages released by authorities appoint the type of bidding, the attendees may be restricted by some clauses or it may be open to any company. There are three most commonly used bidding types which are *Invitational bid*, *Open Bid with Pre-Qualification* step required and *Open Bid without Pre-Qualification*. For the subject data set distribution of the bidding type over the litigated and non-litigated projects are given in the Figure 9.

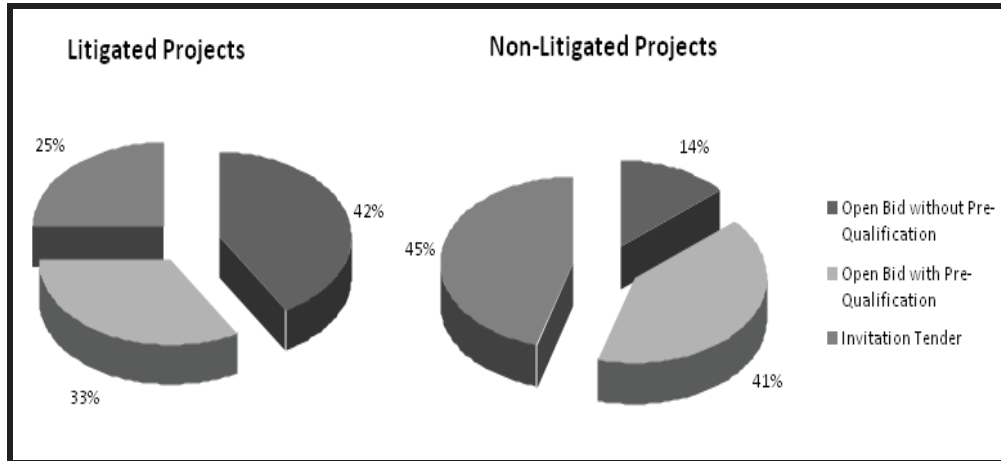


Figure 9 – Type of bidding

Other than the type of bidding the survey questionnaire asked for the bidding evaluation criteria also. Generally, two evaluation methods are used by the owner for tender evaluation. First one is the quantitative method based on the *Lowest Price* proposed for a subject project while second one, called *Best Value*, depends on qualitative judgment of criteria defined by the request for proposal documents and bidders should satisfy both the specified standards and at the same time minimize the price. According to the observation in the data set majority of the projects are evaluated due to best value criteria and the distribution is in Figure 10.

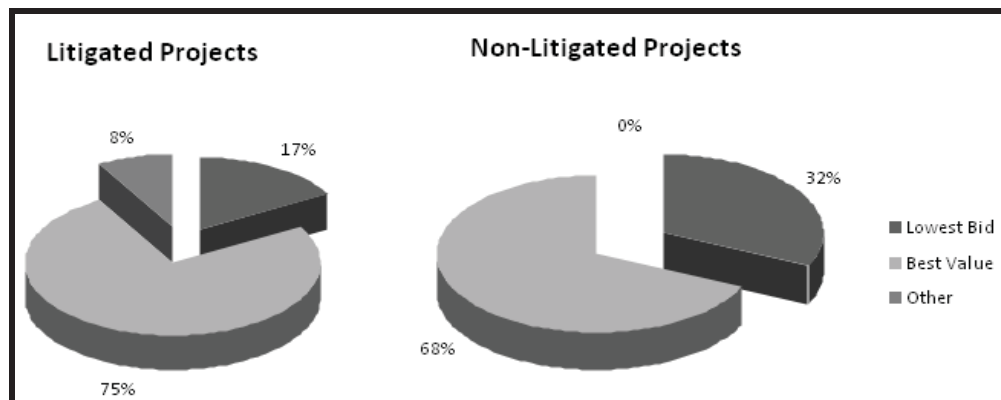


Figure 10 – Bid evaluation Criteria

The last results will be discussed in this section is contract type. Contract type is one of the basic indicators of risk allocation between the parties. Three contract types are used in the data set are; *Lump Sum* in which contractor performs the work in an agreed budget and undertakes full responsibility for the performance costs and resulting profit or loss, *Unit Price* in which contract is signed due to an agreed to rate for the performance of specified work and the overall price is proportional to the quantity of the work and at last *Cost Plus* contract that is used when project is not suitable to estimate the contract value accurately and this type of contract provides incurred expenses and profit at a fixed rate or value, while charging all the risk to the owner party. The presented values in Figure 11 are the contract type observations over the litigated and non-litigated projects.

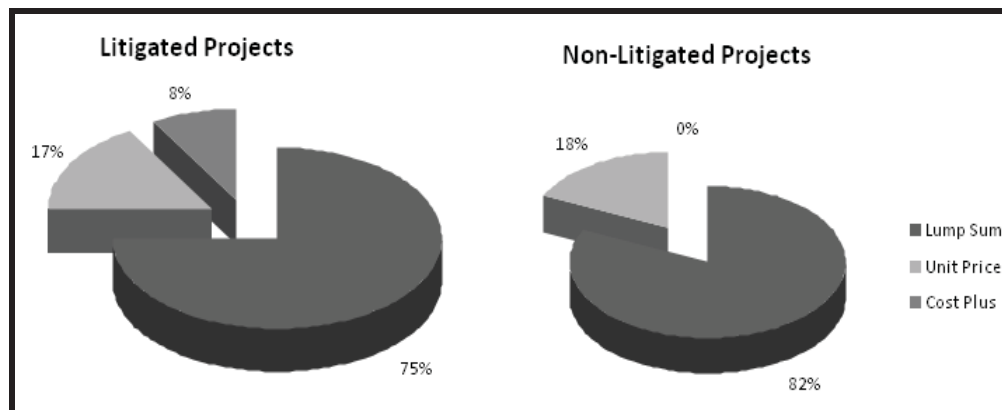


Figure 11 – Contract Type

4.2. Determination of Factors Affecting Litigation Probability

4.2.1. Use of *t-test*

Basically *t-test* is used to compare the mean values of litigated and non-litigated projects. In this manner *t-test* is used for testing a hypothesis on the basis of a difference between sample means. Especially, the *t-test* provides the information whether the means of two groups are statistically different from each other (Ott 1992).

Properties of the Student *t* distribution can be listed as (Calkins 2005);

1. The Student *t* distribution is different for different sample sizes. Generally, the sampling distribution is moderately skewed, unimodal, without outliers, and the sample size is between 16 and 40
2. The Student *t* distribution is usually bell-shaped, but with smaller sample sizes shows increased variability and as the sample size increases, the distribution approaches a normal distribution.
3. The mean is zero,
4. The distribution is symmetrical about the mean,
5. The variance is greater than one, but approaches one from above as the sample size increases,
6. Population standard deviation is unknown.

It can be observed for bell-shaped distributions that two groups with high variability might have the same difference in means as two groups with low variability. Moreover analysis can conclude that in spite of the similarity in mean differences, the two groups with low variability show more difference from the groups with high variability. The difference between scores for two

groups can be understood by distribution curves and it is possible to judge the difference between their means relative to the spread of the score.

Suppose a simple random sample of size “ n ” drawn from a Normal population with mean “ μ ” and standard deviation “ σ ”. Let “ \bar{x} ” denote the sample mean and “ s ”, the sample standard deviation. Equation of “ t ” is;

$$t = \frac{\bar{x} - \mu}{s / \sqrt{n}} \quad (1)$$

Population standard deviation is defined by;

$$s^2 = \frac{1}{n - 1} \sum_{i=1}^n (x_i - \bar{x})^2 \quad (2)$$

Most commonly *t-test* is used in three different purposes (Moore and McCabe 2006);

1. Comparing mean of a single variable to a fixed (known) number or a gold standard, called one sample *t-test*,
2. Comparing two independent samples’ mean values from two population, known as two sample *t-test*,
3. Comparing two samples which are paired in some way, called paired *t-test*.

In this thesis MS Excel 2003 is used for analyzing the critical “ t ” values and “ $P(T \leq t)$ one-tail” value is used to determine the significance of the test results under the below assumptions and procedures. As defined in MS Excel Help *t-test* can be used for three different purposes in Excel;

“The Two-Sample *t-test* analysis tools test for equality of the population means underlying each sample. The three tools employ different assumptions: that the population variances are equal, that the population variances are not equal, and that the two samples represent before treatment and after treatment observations on the same subjects.

For all three tools below, a *t-statistic* value, *t*, is computed and shown as “t Stat” in the output tables. Depending on the data, this value, *t*, can be negative or non-negative. Under the assumption of equal underlying population means, if $t < 0$, “P(T ≤ *t*) one-tail” gives the probability that a value of the *t-statistic* would be observed that is more negative than *t*. If $t \geq 0$, “P(T ≤ *t*) one-tail” gives the probability that a value of the *t-statistic* would be observed that is more positive than *t*. “t Critical one-tail” gives the cutoff value so that the probability of observing a value of the *t-statistic* greater than or equal to “t Critical one-tail” is Alpha.”

In the significance calculations for the factors affecting litigation probability unequal variance approach is taken into consideration and simply applied in Excel by the choice of “*t-test: Two-Sample Assuming Unequal Variances*” under the “Data Analysis” menu of the software. As the name implies, this analysis tool assumes the subject two independent data sets are from distribution having unequal variances and quoted as “heteroscedastic *t-test*”. The aim of the test is again to detect if the two samples have equal mean values. The following formula is used the statistic value *t* determination;

$$t' = \frac{\bar{x} - \bar{y} - \Delta_0}{\sqrt{\frac{s_1^2}{n} + \frac{s_2^2}{n}}} \quad (3)$$

Additionally, the below mentioned formula is used for calculation of degrees of freedom;

$$t = \frac{\left(\frac{s_1^2}{m} + \frac{s_2^2}{n} \right)^{1/2}}{\frac{(s_1^2/m)^{1/2}}{m-1} + \frac{(s_2^2/n)^{1/2}}{n-1}} \quad (4)$$

In this study two sample *t-test* is used to test the significance of the factors affecting litigation based on the questionnaire form responses. The first part of the analysis is based on detecting whether one mean is larger than the other, therefore, it is chosen to perform a one-tailed (sometimes called one-sided) *t-test*. The aim of this study is to investigate if mean values' are significantly differing for litigated and non-litigated projects for each factor affecting litigation probability of a construction project. The hypotheses this scenario became the following:

H0: $\mu_1 = \mu_2$ (the population means of the two groups are the same).

Ha: $\mu_2 > \mu_1$ (the population mean of the second group is larger than the population mean of the first group).

There are two version of *t-test* based on the assumption of population variances; one is equal variance assumption and the second is unequal variance assumption. Most statistics packages are capable to compute both versions of the *t-statistic*. In this study the simple conservative approach is used as stated by Moore and McCabe (2006). Basically, conservative approach is to always use the *t-test* that does not assume equal variances unless there is evidence that the two variances are equal. This conservative approach and is based on studies that have shown that tests to determine equality of variances are often unreliable.

Additionally, the risk level, which is called the alpha level, set at 90 % meaning that 90 times out of one hundred you could find a statistically significant difference between the means by chance.

Software calculates the degrees of freedom (df), according to related Formula (4). Inserted the alpha level, t value, and df, the critical value table is formed by Excel allowing determination of whether the t value is large enough to be significant leading to a conclusion that the difference between the means for the two groups is statistically significant or not.

4.2.2. *t*-test Results

In the data base formed by 34 project information there are total number of 77 questions, including 26 PART I questions related to general information on company and subject project and, 51 PART II questions listing possible factors affecting a project to go through litigation process. Since, MS Excel needs numerical notations to perform the statistical analysis PART I of the data set is reorganized. 1 & 0 is used to define litigated and non-litigated projects respectively. Also, for categorical information such as; type of bidding (*Open Bid without Pre-Qualification, Open Bid with Pre-Qualification, Invitational Bid*), bid evaluation criteria (*Lowest Price, Best Value*), contract type (*Lump Sum, Unit Price, Cost Plus*), type of project delivery (*Turnkey Contract, Design-Build, Design-Bid-Build, Build-Operate-Transfer, Construction Management*) etc., variable number increased for each factor and 1 is used if the category is valid for the project otherwise 0 is applied for the item. Part II questions target to understand the level of agreement of the experts to the expressions listed using a 1 to 5 scale. In the analysis 1 to 5 scale of the factors configured as -2 to 2 respectively. Additionally, PART I questions designated by initial “G” for “General Information” from 1 to 12 (G01, G02,, F12) and PART II questions are designated by initial “F” for “Factors Affecting Litigation” from 1 to 51 (F01, F02,, F51) in the statistical analysis. Then, in order to determine the most effective factors the variables subjected to *t*-test in Excel one by one and reached 18 significant variables due to 10 % P-values. The significant variables are listed in Table 6.

Table 6 – Significant Variables

No.	Notation	Description
1	G03	Advance Payment Amount
2	G05	Type of Bidding (Open without Pre-Qualification or not)
3	G07	Tender Preparation Period
4	F04	Acquaintance of Owner and Contractor from previous projects
5	F29	Security conditions at site
6	F34	Effectiveness of risk management plan
7	F35	Validity of project control and reporting mechanism
8	F40	Realistic contractual obligations of the contractor
9	F41	Clarity of scope of the parties
10	F43	Level of contractual requirements on health and safety
11	F03	Level of experience in the host country
12	F17	Availability of skilled labour in the host country
13	F18	Availability of construction materials in the host country
14	F24	Level of experience of project management team
15	F36	Level of time consuming bureaucratic procedures
16	F38	Level of detail on dispute resolution processes in the contract
17	F46	Fluctuations in the exchange rate
18	F50	Contractor's unfamiliarity to the laws and regulations of the host country

In the following tables from Table 7 to Table 24 presents the mean and variance values of the projects litigated and non-litigated in the data set for each variable and probability values of random error. However, in order to illustrate the significant difference between the means of the two samples a box plot analysis is carried out in Statistical Package for Social Sciences (SPSS) for only the first variable *G3 – Advance Payment* and shown in Figure 12. This graphical comparison visualizes the distributions of the two samples, allows one to see if there exists overlap between the two distributions.

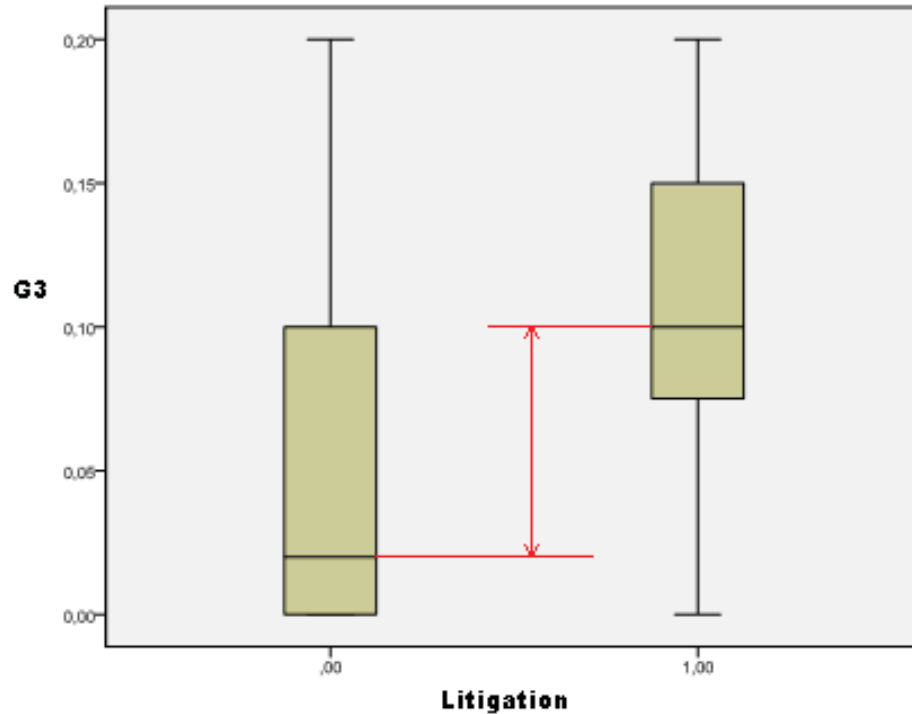


Figure 12 – Box Plot for Variable *G3* – *Advance Payment Amount*

Advanced payment is the lump sum amount of money paid to the contractor during the commencement of the work over a specified percent from overall contract amount. In the first *t-test* result values given in the Table 7 indicates a significant difference between the litigated and non-litigated groups' mean values for the variable *G03* - *Advance Payment Amount*. Advanced Payment Amount is classified quantitative variable having values between 0 % and 20 % according to the participants' answers to the related question, and calculated p-value $0,025449413 \leq 0,10$ verifies there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 7 – *t*-test Results for Variable G3 - Advance Payment Amount

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	0,108333333	0,058095238
Variance	0,004469697	0,00472619
Observations	12	21
df	24	
t Stat	2,05519382	
P(T<=t) one-tail	0,025449413	
t Critical one-tail	1,710882067	

In the second *t*-test results presented in the Table 8 displays a significant difference between the litigated and non-litigated groups' mean values for the variable G05 - *Type of Bidding* (Open without Pre-Qualification or not). Type of Bidding is classified as categorical variable having values either “1” if the bidding type is open bid without pre-qualification or “0” otherwise, and calculated p-value $0,001160293 \leq 0,10$ indicates there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 8 – *t*-test Results for Variable G5 - Type of bidding (Open without Pre-Qualification or not)

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	0	0,363636364
Variance	0	0,242424242
Observations	12	22
df	21	
t Stat	-3,464101615	
P(T<=t) one-tail	0,001160293	
t Critical one-tail	1,720742871	

In order to bid a potential projects all important decisions has to be made during tender preparation time which is generally a tight scheduled period. Contractor companies should consider all cost and management related factors including cost estimate, availability of resources, bid mark-up, risk level, level of competition, country related factors etc. in this period. In fact, in the third *t-test* results shown in the Table 9 stress the importance of available time in this period having a significant difference between the litigated and non-litigated groups' mean values for the variable *G07 - Tender Preparation Period*. Tender Preparation Period is also classified as quantitative and the data is collected for this variable in days. Calculated p-value $0,026692666 \leq 0,10$ indicates there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 9 – *t-test* Results for Variable *G7 - Tender Preparation Period*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	91,36363636	44,95238095
Variance	2865,454545	5613,047619
Observations	11	21
df	27	
t Stat	2,020204192	
P(T<=t) one-tail	0,026692666	
t Critical one-tail	1,703288423	

Familiarity between the owner and contractor most of the time considered as a strength during bid preparation and in the fourth *t-test* results given in the Table 10 points out a significant difference between the litigated and non-litigated groups' mean values for the variable *F04 - Acquaintance of Owner and Contractor from previous projects*. Owner and contractor familiarity to each other is classified as ordinal values represented by -2 to 2 intrinsic ranking and

the data collected for this variable shows the level of agreement. Calculated p-value $0,02386614 \leq 0,10$ indicates there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 10 – *t*-test Results for Variable F04 - Acquaintance of Owner and Contractor from Previous Projects

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	-0,818181818	0,19047619
Variance	1,163636364	2,761904762
Observations	11	21
df	28	
t Stat	-2,070575387	
P(T<=t) one-tail	0,02386614	
t Critical one-tail	1,701130908	

Unsecured environments increase the risk of encountering an unexpected situation and in the same manner, the fifth *t*-test results presented in the Table 11 shows a significant difference between the litigated and non-litigated groups' mean values for the variable F29 - Security Conditions at Site. Security conditions at Site is classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,04989614 \leq 0,10$ indicates there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 11 – *t-test* Results for Variable *F29 - Security Conditions at Site*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	-1,090909091	-0,333333333
Variance	1,290909091	1,633333333
Observations	11	21
df	23	
t Stat	-1,714985851	
P(T<=t) one-tail	0,04989614	
t Critical one-tail	1,713871517	

Application of an effective risk management provides the contractor readiness to occurrence of unexpected events in the mean time let the contractor act fast if a situation arises. In the sixth *t-test* results presented in the Table 12 demonstrates a significant difference between the litigated and non-litigated groups' mean values for the variable *F34 - Effectiveness of Risk Management Plan* meaning that utilization of an effective risk management plan before bidding has significant effects on litigation probability of the project. This variable is also classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,015375418 \leq 0,10$ shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 12 – *t*-test Results for Variable F34 - Effectiveness of Risk Management Plan

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	-1,4	-0,619047619
Variance	0,488888889	1,447619048
Observations	10	21
df	28	
t Stat	-2,275146029	
P(T<=t) one-tail	0,015375418	
t Critical one-tail	1,701130908	

Project control and reporting mechanism is important in an organization not to lose the monitoring capability, consequently enable contractor follow up the process leading to any dispute and in the seventh *t*-test results presented in the Table 13 points out a significant difference between the litigated and non-litigated groups' mean values for the variable *F35 - Validity of Project Control and Reporting Mechanism*. This variable is also classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,014626807 \leq 0,10$ shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 13 – *t*-test Results for Variable F35 - Validity of Project Control and Reporting Mechanism

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	-0,363636364	0,545454545
Variance	1,054545455	1,212121212
Observations	11	22
df	21	
t Stat	-2,339754807	
P(T<=t) one-tail	0,014626807	
t Critical one-tail	1,720742871	

Nobody can perform miracles and the binding agreement between the parties should explain the conditions and requirement in detail mean while contract should prepare a realistic and sound medium for execution of the project. In the eighth *t-test* results given in the Table 14 displays a significant difference between the litigated and non-litigated groups' mean values for the variable *F40 - Realistic Contractual Obligations of the Contractor*. This variable is again classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,025937642 \leq 0,10$ shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 14 – *t-test* Results for Variable *F40 - Realistic Contractual Obligations of the Contractor*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	-0,25	0,619047619
Variance	1,477272727	1,147619048
Observations	12	21
df	21	
t Stat	-2,061261854	
P(T<=t) one-tail	0,025937642	
t Critical one-tail	1,720742871	

Parallel with the previous factor scope of the parties should be well defined. Likewise, in the ninth *t-test* results given in the Table 15 displays a significant difference between the litigated and non-litigated groups' mean values for the variable *F41 - Clarity of Scope of the Parties*. This variable is classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,047036524 \leq$

0,10 shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 15 – *t-test* Results for Variable *F41 - Clarity of Scope of the Parties*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	0,166666667	0,954545455
Variance	1,787878788	1,093073593
Observations	12	22
df	18	
t Stat	-1,767615207	
P(T<=t) one-tail	0,047036524	
t Critical one-tail	1,734063592	

Construction is one of the most dangerous industries. Employment security and better protection of workers' health is one of the inevitable aspects of construction projects. However, not all the projects give same importance to health and safety requirements and generally Turkish contractors overlook the requirements in high standard which cause disputes. In the tenth *t-test* results given in the Table 16 displays a significant difference between the litigated and non-litigated groups' mean values for the variable *F43 - Level of Contractual Requirements on Health and Safety*. This variable is classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,024263414 \leq 0,10$ shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 16 – *t*-test Results for Variable *F43 - Level of Contractual Requirements on Health and Safety*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	0,166666667	1,045454545
Variance	1,424242424	1,283549784
Observations	12	22
df	22	
t Stat	-2,088625488	
P(T<=t) one-tail	0,024263414	
t Critical one-tail	1,717144335	

Host country conditions certainly affect contractor’s performance in a project and familiarity to the project location reduces the risk level of the project. In the eleventh *t*-test results given in the Table 17 displays a significant difference between the litigated and non-litigated groups’ mean values for the variable *F03 - Level of Experience in the Host Country*. This variable is classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,070411913 \leq 0,10$ shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 17 – *t*-test Results for Variable *F03 - Level of Experience in the Host Country*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	0,636363636	1,409090909
Variance	2,054545455	1,396103896
Observations	11	22
df	17	
t Stat	-1,544725213	
P(T<=t) one-tail	0,070411913	
t Critical one-tail	1,739606716	

In the twelfth *t-test* results given in the Table 18 displays a significant difference between the litigated and non-litigated groups' mean values for the variable *F17 - Availability of Skilled Labour in the Host Country*. This variable is classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,084009883 \leq 0,10$ shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 18 – *t-test* Results for Variable *F17 - Availability of Skilled Labour in the Host Country*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	0,666666667	0
Variance	1,696969697	1,714285714
Observations	12	22
df	23	
t Stat	1,423487193	
P(T<=t) one-tail	0,084009883	
t Critical one-tail	1,713871517	

In the thirteenth *t-test* results given in the Table 19 displays a significant difference between the litigated and non-litigated groups' mean values for the variable *F18 - Availability of Construction Materials in the Host Country*. This variable is also classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,081821729 \leq 0,10$ shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 19 – *t-test* Results for Variable *F18 - Availability of Construction Materials in the Host Country*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	0,75	0,136363636
Variance	1,295454545	1,647186147
Observations	12	22
df	25	
t Stat	1,435130337	
P(T<=t) one-tail	0,081821729	
t Critical one-tail	1,708140745	

In the fourteenth *t-test* results given in the Table 20 displays a significant difference between the litigated and non-litigated groups' mean values for the variable *F24 - Level of Experience of Project Management Team*. This variable is classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,058215112 \leq 0,10$ shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 20 – *t-test* Results for Variable *F24 - Level of Experience of Project Management Team*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	0,083333333	0,863636364
Variance	2,083333333	1,075757576
Observations	12	22
df	17	
t Stat	-1,654204981	
P(T<=t) one-tail	0,058215112	
t Critical one-tail	1,739606716	

Results of the fourteenth *t-test* revealed that project management is a key for project success and to overcome the complex structure of the construction level of experience is a critical factor.

In the fifteenth *t-test* results given in the Table 21 displays a significant difference between the litigated and non-litigated groups' mean values for the variable *F36 - Level of Time Consuming Bureaucratic Procedures*. This variable is classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,097815879 \leq 0,10$ shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 21 – *t-test* Results for Variable *F36 - Level of Time Consuming Bureaucratic Procedures*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	0,727272727	0,095238095
Variance	1,618181818	1,59047619
Observations	11	21
df	20	
t Stat	1,338874943	
P(T<=t) one-tail	0,097815879	
t Critical one-tail	1,724718218	

As well as project or country related factors detailed information on the dispute resolution method provides substantial guidance on preventing occurrence of any major conflict between the parties of contract which may lead to litigation. In the sixteenth *t-test* results given in the Table 22 displays a significant difference between the litigated and non-litigated groups' mean values for the variable *F38 - Level of Detail on Dispute Resolution Processes in the Contract*. This variable is classified as ordinal values represented by -2 to 2 intrinsic

ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,065529737 \leq 0,10$ reveals there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 22 – *t-test* Results for Variable F38 - Level of Detail on Dispute Resolution Processes in the Contract

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	-0,363636364	0,523809524
Variance	2,654545455	1,461904762
Observations	11	21
df	16	
t Stat	-1,591496912	
P(T<=t) one-tail	0,065529737	
t Critical one-tail	1,745883669	

Economical risk of a project mostly related with the alteration in the currency exchange rates of the contractor’s native country’s currency and the currency in which the progress payments are made. In the seventeenth *t-test* results given in the Table 23 displays a significant difference between the litigated and non-litigated groups’ mean values for the variable F46 - *Fluctuations in the Exchange Rate*. This variable is classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,083165099 \leq 0,10$ shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 23 – *t-test* Results for Variable *F46 - Fluctuations in the Exchange Rate*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	0,272727273	-0,571428571
Variance	3,018181818	1,257142857
Observations	11	21
df	14	
t Stat	1,460127395	
P(T<=t) one-tail	0,083165099	
t Critical one-tail	1,761310115	

And the last *t-test* results given in the Table 24 indicates a significant difference between the litigated and non-litigated groups' mean values for the variable *F50 - Contractor's unfamiliarity to the laws and regulations of the host country*. This variable is classified as ordinal values represented by -2 to 2 intrinsic ranking and the data collected for this variable shows the level of agreement. Calculated p-value $0,07381134 \leq 0,10$ shows there is enough evidence to reject the null hypothesis, which is the equality of mean values of the sample groups, in favor of the alternative.

Table 24 – *t-test* Results for Variable *F50 - Contractor's Unfamiliarity to the Laws and Regulations of the Host Country*

t-Test: Two-Sample Assuming Unequal Variances		
	<i>Litigated</i>	<i>Non-Litigated</i>
Mean	-0,166666667	-1
Variance	3,060606061	0,9
Observations	12	21
df	15	
t Stat	1,526785152	
P(T<=t) one-tail	0,07381134	
t Critical one-tail	1,753050325	

During *t-test* results revealed some relations which may be presumed non-logical such it is observed that projects having higher advanced payment amount and longer tender preparation period subjected to litigation. It is possible that lack of time and money for this cases compensated by higher contingency. On the other hand availability of material and skilled labor in the projects is higher in litigated projects which may be according to the limited data set of the study.

4.3. Prediction Model Development

4.3.1. Linear Regression

Regression analysis is a statistical technique that attempts to evaluate and model the relationship between two or more variables by fitting a linear equation to observed data. One variable is considered to be a dependent variable (y) while others are considered to be independent variables ($x_1, x_2, x_3, \dots, x_n$) (Ott 1992). The aim of linear regression analysis is to arrange the values of slope and intercept to find the line that best anticipates y from $x_1, x_2, x_3, \dots, x_n$.

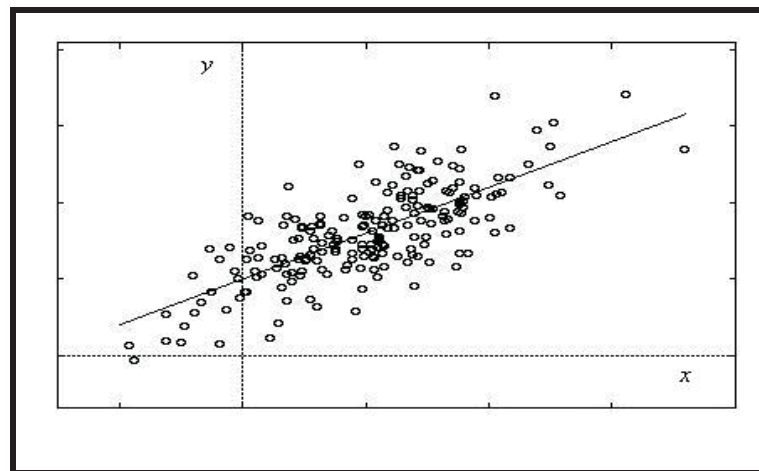


Figure 13 – Linear Regression Plot for Sample Variable

This method is used for cases independent variable information is easier to obtain than dependent variable (Groß 2003). The representation of a dependent variable (y_i) one independent variable (x_i) should be;

$$y_i = \beta_0 + \beta_1 x_i + u_i \quad (5)$$

Figure 14 shows the graphical representation of the model.

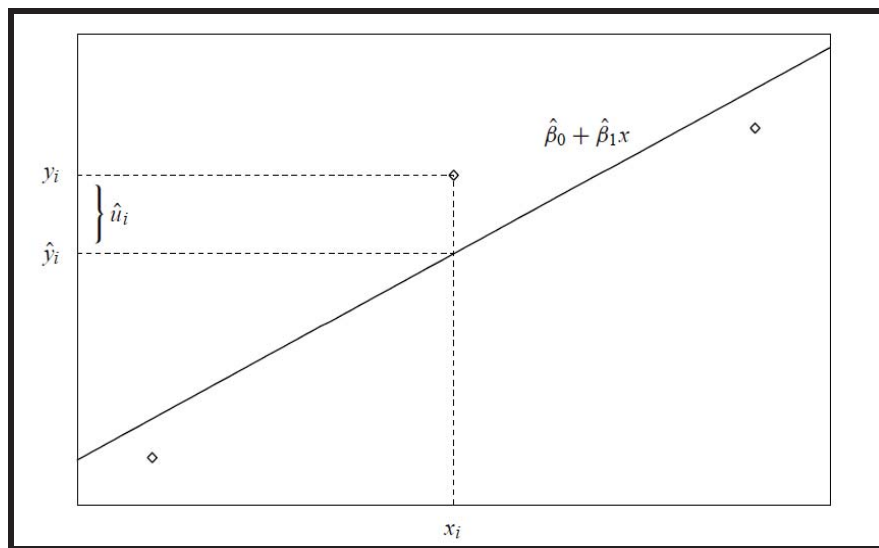


Figure 14 – Graphical Representation of Linear Regression

The error term u describes the factors are not included in the equation and the aim of the regression analysis is to minimize the error square terms. The final form of the estimated equation will be;

$$\hat{y}_i = \hat{\beta}_0 + \hat{\beta}_1 x \quad (6)$$

Shortly, regression analysis attempt to minimize the distance between the measured values and the plotted line. Although, there are several methods most common method used is Ordinary Least Squares (OLS). OLS simple calculates

sum of the square values of the vertical distances of the measured values to the plot line (Schroeder *et al.* 1986). Expression for this method is;

$$SSR = \sum_{i=1}^n (y_i - \hat{y}_i)^2 \quad (7)$$

Values for $\hat{\beta}_0$ and $\hat{\beta}_1$ are defined therefore the sum of squared residuals (SRR) will be minimized. Obviously, the more SSR gets smaller the data fits better to the model. However, SRR is sensitive to the units of measurement of the dependent variable to overcome this issue; a more standardized representation, R^2 , is used to measure the goodness of fit. The formula for R^2 is given as the Equation (7) and can be explained as the proportion of the variation in y_i around mean value (μ_y) for the model (Schroeder *et al.* 1986).

$$R^2 = 1 - \frac{SRR}{\sum (y_i - \mu_y)^2} \quad (8)$$

Value of the R^2 differs from 0 to 1 meaning $R^2=1$ is perfect fit and $R^2=0$ is lousy fit. Least squares regression can be used to fit the data with any function of the form;

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n \quad (9)$$

Formula (8) means that each independent variable has an unknown multiplier coefficient and summation of these products and intercept gives the final dependent variable value.

4.3.2. Elimination Process

This thesis is seeking the simplest adequate model which is practical and also exhibits a good prediction performance. There are two commonly used stepwise procedures to determine the satisfactory regression model. These methods are; forward selection (adds variables), and backwards elimination (removes variables). In forward selection, variables are progressively increased one by one at each step to form the final model, whereas backward elimination starts with the set of all variables and progressively eliminates the least favorable ones. In this study backward elimination techniques is used.

The backward elimination procedure is a consecutive significance testing course for independent variables. Starting from the first formed model that includes all previously listed factors variables will be removed from the equation according to the predefined condition.

The traditional version of the backward elimination procedure used in practice can be defined as, the variable with the highest P-value in the regression model will be specified as insignificant and will be eliminated from the model, according to the conditioned on the P-value being bigger than 10 %. The analysis will be carried out with the remaining independent variables until all variables in model satisfies the $P\text{-value} \leq 10\%$ meaning no variables can be removed from equation.

The theory behind the traditional technique is *F-statistics*. Backward elimination procedure adopted from Mason *et al.* (2003).

Step 1. Best fit model developed with all independent predictor variables

Step 2. Calculate *F-statistics* and using a predetermined significant level, in this study significant level is set 0,10, test the importance of the factors. In fact, $t^2 = F$, where both are the statistics computed for the same coefficient for the partial test.

Some computer packages report the *F-statistic*, and some the *t-test*, but the P-values for the two tests are identical.

Step 3. The null hypothesis here is that there is not a general relationship between the response (dependent) variable and one or more of the predictor (independent) variables ($H_0: \beta_i = 0$), and the alternative hypothesis is that there is one ($H_a: \beta_i \neq 0$).

$$F = \left(\frac{\hat{\beta}_i^2}{Se_{\beta_i}^2} \right) \quad (10)$$

A *small F-value* indicates that there is no relationship between the response and predictors, meaning that the null hypothesis should be accepted.

Step 4. End the process if all the variables are significant. Otherwise, select the least significant factor and drop it, and return to Step 3. Form the convenient model with the reduced variables from previous step. Calculate *F-statistic* test for significance for the remaining factors.

4.3.3. Linear Regression Models

The first linear regression model is developed with the 18 independent variables revealed as significant factors in the *t-test* results in section 4.2.2 for prediction of litigation probability of a construction project during bidding stage and 26 project data out of 34 is used for the first trial because regression analysis was not able to use 8 project data due to missing information of several variables.

The first variable to drop from the regression model is F18 representing the construction material availability with a p-value of 0,9593. Table 25 presents the results of the first trial.

Table 25 – P-values for Linear Regression Model 1

Notation	Description	P-value
(Constant)	Intercept	0,3682
F03	Level of experience in the host country	0,5376
F04	Acquaintance of Owner and Contractor from previous projects	0,3587
F17	Availability of skilled labour in the host country	0,0718
F18	Availability of construction materials in the host country	0,9593
F24	Level of experience of project management team	0,9252
F29	Security conditions at site	0,9078
F34	Effectiveness of risk management plan	0,0914
F35	Validity of project control and reporting mechanism	0,2040
F36	Level of time consuming bureaucratic procedures	0,1794
F38	Level of detail on dispute resolution processes in the contract	0,3048
F40	Realistic contractual obligations of the contractor	0,2798
F41	Clarity of scope of the parties	0,8990
F43	Level of contractual requirements on health and safety	0,7202
F46	Fluctuations in the exchange rate	0,4402
F50	Contractor's unfamiliarity to the laws and regulations of the host country	0,8664
G03	Advance Payment Amount	0,3552
G05	Type of Bidding (Open without Pre-Qualification or not)	0,3329
G07	Tender Preparation Period	0,3366

The second regression model run with 17 variables of 26 project data collected from the questionnaires distributed and the next highest p-value 0,9276 belongs to the factor reflecting level of experience of the project management team, resulting in deleting F24 from the model.

Table 26 – P-values for Linear Regression Model 2

Notation	Description	<i>P-value</i>
(Constant)	Intercept	0,3345
F03	Level of experience in the host country	0,5064
F04	Acquaintance of Owner and Contractor from previous projects	0,3244
F17	Availability of skilled labour in the host country	0,0263
F24	Level of experience of project management team	0,9279
F29	Security conditions at site	0,8909
F34	Effectiveness of risk management plan	0,0677
F35	Validity of project control and reporting mechanism	0,1679
F36	Level of time consuming bureaucratic procedures	0,1449
F38	Level of detail on dispute resolution processes in the contract	0,2405
F40	Realistic contractual obligations of the contractor	0,1887
F41	Clarity of scope of the parties	0,9001
F43	Level of contractual requirements on health and safety	0,6875
F46	Fluctuations in the exchange rate	0,3733
F50	Contractor's unfamiliarity to the laws and regulations of the host country	0,8582
G03	Advance Payment Amount	0,3191
G05	Type of Bidding (Open without Pre-Qualification or not)	0,2726
G07	Tender Preparation Period	0,3028

The third trial is carried out with the remaining 16 variables and the next eliminated variable is determined as F29 corresponding to security conditions of the projects having a p-value of 0,8910.

Table 27 – P-values for Linear Regression Model 3

Notation	Description	<i>P-value</i>
(Constant)	Intercept	0,1660
F03	Level of experience in the host country	0,4530
F04	Acquaintance of Owner and Contractor from previous projects	0,2822
F17	Availability of skilled labour in the host country	0,0181
F29	Security conditions at site	0,8910
F34	Effectiveness of risk management plan	0,0421
F35	Validity of project control and reporting mechanism	0,1381
F36	Level of time consuming bureaucratic procedures	0,1180
F38	Level of detail on dispute resolution processes in the contract	0,1603
F40	Realistic contractual obligations of the contractor	0,1628
F41	Clarity of scope of the parties	0,8424
F43	Level of contractual requirements on health and safety	0,6668
F46	Fluctuations in the exchange rate	0,3453
F50	Contractor's unfamiliarity to the laws and regulations of the host country	0,7491
G03	Advance Payment Amount	0,2885
G05	Type of Bidding (Open without Pre-Qualification or not)	0,2417
G07	Tender Preparation Period	0,1261

In the fifth trial is tested with the 15 independent variables finding the factor F41 insignificant for the regression model with a p-value of 0,8231.

Table 28 – P-values for Linear Regression Model 4

Notation	Description	<i>P-value</i>
(Constant)	Intercept	0,1363
F03	Level of experience in the host country	0,2652
F04	Acquaintance of Owner and Contractor from previous projects	0,2571
F17	Availability of skilled labour in the host country	0,0117
F34	Effectiveness of risk management plan	0,0301
F35	Validity of project control and reporting mechanism	0,1179
F36	Level of time consuming bureaucratic procedures	0,0838
F38	Level of detail on dispute resolution processes in the contract	0,1396
F40	Realistic contractual obligations of the contractor	0,1416
F41	Clarity of scope of the parties	0,8231
F43	Level of contractual requirements on health and safety	0,6560
F46	Fluctuations in the exchange rate	0,2107
F50	Contractor's unfamiliarity to the laws and regulations of the host country	0,6945
G03	Advance Payment Amount	0,2457
G05	Type of Bidding (Open without Pre-Qualification or not)	0,1654
G07	Tender Preparation Period	0,0985

The fifth trial run with 14 variables and eliminated the most insignificant variable F50 having a p-value of 0,7300. Meanwhile, it is observed that the p-values of the variables are slightly decreasing compared to the first five trials.

Table 29 – P-values for Linear Regression Model 5

Notation	Description	<i>P-value</i>
(Constant)	Intercept	0,0402
F03	Level of experience in the host country	0,2427
F04	Acquaintance of Owner and Contractor from previous projects	0,1849
F17	Availability of skilled labour in the host country	0,0072
F34	Effectiveness of risk management plan	0,0176
F35	Validity of project control and reporting mechanism	0,0987
F36	Level of time consuming bureaucratic procedures	0,0671
F38	Level of detail on dispute resolution processes in the contract	0,1004
F40	Realistic contractual obligations of the contractor	0,1206
F43	Level of contractual requirements on health and safety	0,6631
F46	Fluctuations in the exchange rate	0,1898
F50	Contractor's unfamiliarity to the laws and regulations of the host country	0,7300
G03	Advance Payment Amount	0,1698
G05	Type of Bidding (Open without Pre-Qualification or not)	0,1396
G07	Tender Preparation Period	0,0488

The sixth trial for prediction model run with the 13 variables left, disclose F43 health and safety prospects of the contract as the factor to be eliminated with a p-value of 0,6733.

Table 30 – P-values for Linear Regression Model 6

Notation	Description	P-value
(Constant)	Intercept	0,0343
F03	Level of experience in the host country	0,2242
F04	Acquaintance of Owner and Contractor from previous projects	0,1786
F17	Availability of skilled labour in the host country	0,0039
F34	Effectiveness of risk management plan	0,0140
F35	Validity of project control and reporting mechanism	0,0905
F36	Level of time consuming bureaucratic procedures	0,0346
F38	Level of detail on dispute resolution processes in the contract	0,0863
F40	Realistic contractual obligations of the contractor	0,1026
F43	Level of contractual requirements on health and safety	0,6733
F46	Fluctuations in the exchange rate	0,1856
G03	Advance Payment Amount	0,1644
G05	Type of Bidding (Open without Pre-Qualification or not)	0,1328
G07	Tender Preparation Period	0,0423

The following variable to be dropped from the model is displayed as F03 having a p-value 0,2074 reflecting the level of experience in the host country out of the 12 independent variables used to develop the seventh model.

Table 31 – P-values for Linear Regression Model 7

Notation	Description	<i>P-value</i>
(Constant)	Intercept	0,0199
F03	Level of experience in the host country	0,2074
F04	Acquaintance of Owner and Contractor from previous projects	0,0666
F17	Availability of skilled labour in the host country	0,0013
F34	Effectiveness of risk management plan	0,0110
F35	Validity of project control and reporting mechanism	0,0639
F36	Level of time consuming bureaucratic procedures	0,0282
F38	Level of detail on dispute resolution processes in the contract	0,0324
F40	Realistic contractual obligations of the contractor	0,0421
F46	Fluctuations in the exchange rate	0,0442
G03	Advance Payment Amount	0,0960
G05	Type of Bidding (Open without Pre-Qualification or not)	0,1271
G07	Tender Preparation Period	0,0136

After elimination of the factor F03 project # 23 information data became available for the remaining variables therefore the data set increased by 1 project. In the next and the eighth trial linear regression analysis performed with 11 independent variables and the results are presented in Table 32. The variable G03 with a p-value 0,9887 deleted from the model.

Table 32 – P-values for Linear Regression Model 8

Notation	Description	P-value
(Constant)	Intercept	0,0676
F04	Acquaintance of Owner and Contractor from previous projects	0,3873
F17	Availability of skilled labour in the host country	0,0264
F34	Effectiveness of risk management plan	0,2209
F35	Validity of project control and reporting mechanism	0,9841
F36	Level of time consuming bureaucratic procedures	0,5432
F38	Level of detail on dispute resolution processes in the contract	0,2537
F40	Realistic contractual obligations of the contractor	0,0798
F46	Fluctuations in the exchange rate	0,2064
G03	Advance Payment Amount	0,9887
G05	Type of Bidding (Open without Pre-Qualification or not)	0,3290
G07	Tender Preparation Period	0,1514

The ninth regression model consists of 10 variables and the next highest p-value 0,9747 shows the insignificance of F35 to the prediction model.

Table 33 – P-values for Linear Regression Model 9

Notation	Description	P-value
(Constant)	Intercept	0,0246
F04	Acquaintance of Owner and Contractor from previous projects	0,2293
F17	Availability of skilled labour in the host country	0,0173
F34	Effectiveness of risk management plan	0,1953
F35	Validity of project control and reporting mechanism	0,9747
F36	Level of time consuming bureaucratic procedures	0,4744
F38	Level of detail on dispute resolution processes in the contract	0,2264
F40	Realistic contractual obligations of the contractor	0,0457
F46	Fluctuations in the exchange rate	0,1793
G05	Type of Bidding (Open without Pre-Qualification or not)	0,3093
G07	Tender Preparation Period	0,1281

The regression analysis continued with the tenth one enabling to see the following variable to be dropped from the model will be bureaucratic delays notated by F36 having a p-value of 0,4592.

Table 34 – P-values for Linear Regression Model 10

Notation	Description	<i>P-value</i>
(Constant)	Intercept	0,0178
F04	Acquaintance of Owner and Contractor from previous projects	0,2109
F17	Availability of skilled labour in the host country	0,0129
F34	Effectiveness of risk management plan	0,1508
F36	Level of time consuming bureaucratic procedures	0,4592
F38	Level of detail on dispute resolution processes in the contract	0,1520
F40	Realistic contractual obligations of the contractor	0,0359
F46	Fluctuations in the exchange rate	0,1581
G05	Type of Bidding (Open without Pre-Qualification or not)	0,2926
G07	Tender Preparation Period	0,1158

The eleventh trial is carried out with the remaining 8 variables and result in eliminating the factor of bidding type G05 with a p-value of 0,2520.

Table 35 – P-values for Linear Regression Model 11

Notation	Description	<i>P-value</i>
(Constant)	Intercept	0,0205
F04	Acquaintance of Owner and Contractor from previous projects	0,2189
F17	Availability of skilled labour in the host country	0,0111
F34	Effectiveness of risk management plan	0,0981
F38	Level of detail on dispute resolution processes in the contract	0,1730
F40	Realistic contractual obligations of the contractor	0,0402
F46	Fluctuations in the exchange rate	0,1986
G05	Type of Bidding (Open without Pre-Qualification or not)	0,2520
G07	Tender Preparation Period	0,1519

The twelfth regression model results containing 7 variables are given in the Table 36. The next variable found insignificant was tender preparation period having a p-value of 0,1561.

Table 36 – P-values for Linear Regression Model 12

Notation	Description	P-value
(Constant)	Intercept	0,0264
F04	Acquaintance of Owner and Contractor from previous projects	0,1484
F17	Availability of skilled labour in the host country	0,0041
F34	Effectiveness of risk management plan	0,1509
F38	Level of detail on dispute resolution processes in the contract	0,1406
F40	Realistic contractual obligations of the contractor	0,0110
F46	Fluctuations in the exchange rate	0,1214
G07	Tender Preparation Period	0,1561

As approaching the relatively smaller p-values the next trial was tested with the 6 independent variables finding the least significant one in the model is F46 reflecting the alteration in the exchange rate with a p-value of 0,2885.

Table 37 – P-values for Linear Regression Model 13

Notation	Description	P-value
(Constant)	Intercept	0,0794
F04	Acquaintance of Owner and Contractor from previous projects	0,1981
F17	Availability of skilled labour in the host country	0,0089
F34	Effectiveness of risk management plan	0,2254
F38	Level of detail on dispute resolution processes in the contract	0,2387
F40	Realistic contractual obligations of the contractor	0,0283
F46	Fluctuations in the exchange rate	0,2885

Elimination of the factor F46 after variables G03, G07 and F50 which are missing variables for project # 31 enables to extend the project information used in regression analysis to 28 projects. The fourteenth step analysis continued

with 5 factors. The P-values of the variables are listed in Table 38 and in this trial F04 representing the familiarity between the contract parties is dropped from the model.

Table 38 – P-values for Linear Regression Model 14

Notation	Description	P-value
(Constant)	Intercept	0,1193
F04	Acquaintance of Owner and Contractor from previous projects	0,1797
F17	Availability of skilled labour in the host country	0,0077
F34	Effectiveness of risk management plan	0,1766
F38	Level of detail on dispute resolution processes in the contract	0,1524
F40	Realistic contractual obligations of the contractor	0,0294

Additionally, eliminated factor F04 allow projects # 21 and # 33 to contribute into the analysis resulting in total number of 30 project information. In the fifteenth trial standard backward elimination procedure concluded by satisfying significance level of 0,10 results shown in the Table 39.

Table 39 – P-values for Linear Regression Model 15

Notation	Description	P-value
(Constant)	Intercept	<u>0,0576</u>
F17	Availability of skilled labour in the host country	<u>0,0089</u>
F34	Effectiveness of risk management plan	<u>0,0454</u>
F38	Level of detail on dispute resolution processes in the contract	<u>0,0931</u>
F40	Realistic contractual obligations of the contractor	<u>0,0207</u>

The coefficients determined according to the fifteenth model are listed in the Table 40.

Table 40 – Linear Regression Coefficients of Model 15

Notation	Coefficients
(Constant)	0,2012
F17	0,1711
F34	-0,1503
F38	-0,0934
F40	-0,1639

According to the last step of the standard backward elimination process analysis the model is formed as;

$$y = 0,2012 + 0,1711 \times F17 - 0,1503 \times F34 - 0,0934 \times F38 - 0,1639 \times F40 \quad (11)$$

Where, y is the litigation probability of a project.

Additionally, the Analysis of Variance (ANOVA) table developed for the Model 15 shown in Table 41.

Table 41 – ANOVA Table of Model 15

<i>Model 15</i>	<i>df</i>	<i>Sum of Squares</i>	<i>Mean Square</i>	<i>F</i>	<i>Significance F</i>
Regression	4	3,0324618	0,758115	5,21514	0,0034
Residual	25	3,6342049	0,145368		
Total	29	6,6666667			

The model exposes statistically significant results but affects of the factors to the litigation probability should also be checked from logical point of view. Since the results of the equation will not give exact numbers 0 or 1 while predicting whether a future project will be subjected to litigation or not, it is presumed that if $y < 0,5$ litigation is not expected and if $y \geq 0,5$ litigation is

expected. Under these evaluation criteria for a project the results of the model shows tendency to decrease the litigation probability;

- if effectiveness of risk management plan applied to project improved
- if level of detail on dispute resolution processes in the contract increases
- if requirements of the contract get approachable and realistic

However, the model display stronger possibility of litigation as the availability of skilled labour in the host country increases which is not a logical or coherent relationship. This may be due to the limited data set or linearity assumption of the model, but anyhow it is decided to drop the variable *F17- Availability of skilled labour in the host country* from the equation. According to this final adjustment, the model managed to avoid the unrealistic relation while conserving the realistic relationships and the ultimate linear regression model became;

$$y = 0,2417 - 0,1334 \times F34 - 0,1005 \times F38 - 0,1022 \times F40 \quad (12)$$

Imaginary sample project values are used to demonstrate the application of the model.

Let; $F34=0$, $F38=1$ and $F40 = 1$

Meaning that the contractual obligations of the project are realistic enough and dispute resolution is defined in the contract also an average risk management plan is applied to the project.

The linear model gives the results as;

$$y = 0,2417 - 0,1334 \times 0 - 0,1005 \times 1 - 0,1022 \times 1 = 0,0390$$

The calculated result of the example project which is $y = 0,0390 < 0,5$ presents litigation is not expected.

4.3.4. Prediction Performance of Linear Regression Model

In this section prediction accuracy of the model is evaluated. Since the dependent variable is a binary variable one of the ways to measure the diversity between a predicted and actual true value of the variable is Mean Square Error (MSE) calculated as in the given Formula (13)

$$MSE = \frac{1}{n} \sum_{i=1}^n (Actual_i - Predicted_i)^2 \tag{13}$$

However, in case of this study the purpose of the model to classify the litigation occurrence in a construction project Percent Correctly Classified (PCC) would be a more appropriate evaluation criteria.

$$PCC = \frac{\text{Number of correct classifications}}{\text{Total number of classifications}} \tag{14}$$

In the first step to measure the closeness of fit for the developed model, the data of the 30 projects used to form the final model subjected to Formula (12) and the predicted values are compared with the actual results for litigation occurrence in a construction project. Error measures are calculated for the developed model in both methods and the results are presented in Table 42.

Table 42 – Closeness of Fit for Linear Model Due to Actual Project Variables

	MSE	PCC
Actual Model	0,1602	80,00%

In fact, a good prediction model should not only classify the projects used to form the model correctly but also should have the ability to predict the litigation probability of a newly introduced project. However, all available 30

projects are utilized to develop the linear regression model. In order to overcome this problem cross validation method is used to measure the prediction performance. Basic purpose of cross validation is carrying out the performance measurement by forming training and test samples from the data set available. Correspondingly, it is decided to apply 5 fold cross validation meaning randomly selected 20 % of the data will be used as test sample each time until all the projects are used once. Meanwhile, remaining 80 % of the data set is used to develop the linear regression model at each time and used to evaluate the prediction performance of the randomly selected test samples. The results of the 5 fold cross validation process are summarized in the Table 43.

Table 43 – Prediction Performance of Linear Model Due to Cross Validation

	MSE	PCC
Test Model 1	0,2589	50,00%
Test Model 2	0,1706	83,33%
Test Model 3	0,3185	66,67%
Test Model 4	0,1183	83,33%
Test Model 5	0,2764	50,00%
Average Prediction Performance	0,2285	66,67%

As can be seen from the Table 43 Test models prediction performance changes between 50 % and 83 % and at the average 67 % of the time the linear model predicts correct classifications.

4.3.5. Logistic Regression

Linear analysis gives the opportunity to evaluate if the relationship between two or more variables is linear and gives an idea on the strength of the relationship. Estimated equation tries to predict Y value using the independent variables. Logistic regression is another statistical analysis method described under the generalized linear models including linear regression, multivariate statistics and logistic regression (Nelder and Wedderburn 1972). Usually, the dependent variable is binary, such as male/female or success/failure. In this study logistic regression will be used to determine whether a project will be subjected to a litigation process or not using one of the advantages of the logistic regression enabling to predict a discrete outcome, such as group membership, from a set of variables that may be continuous, binary, ordinal, or a mix of any of all three (Nelder and Wedderburn 1972). Most of the time prediction results of the logistic regression are practical and functional, even if the model being fitted is not logistic and it is a preferable method (Strauss 1992).

Variables can be defined as dependent variable Y and independent variables X with the below mentioned properties;

$Y_i = 1$ if the trait is present in observation i , in this case presence of litigation

$Y_i = 0$ if the trait is not present in observation i

$X = (X_1, X_2, \dots, X_k)$ be a set of explanatory variables which can continuous, binary, ordinal, or a combination of those while x_i is the observed value of the explanatory variables for observation i .

The logistic regression model is expressed by the equation;

$$Y = \frac{e^{(\alpha + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_j x_j)}}{1 + e^{(\alpha + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_j x_j)}} = \frac{1}{1 + e^{-(\alpha + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_j x_j)}} \quad (13)$$

or,

$$\text{logit}[Y(x)] = \log \left[\frac{Y(x)}{1-Y(x)} \right] = \alpha + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_i x_i \quad (14)$$

Additionally, graphical representation of the function is given in Figure 15.

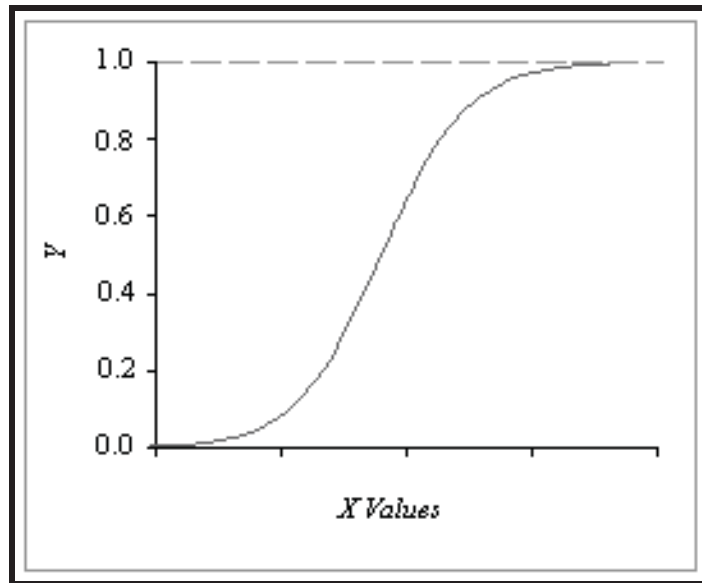


Figure 15 – Graphical Representation of Logistic Regression

The model is developed under the assumptions listed (Menard 2001);

- the data Y_1, Y_2, \dots, Y_n are independently distributed
- dependent variable does not need to be normally distributed; software typically assumes a distribution from an exponential function (e.g. Binomial, Poisson, Multinomial, Normal,...)
- logistic regression does not assume a linear relationship between the dependent variable and the independent variables, but it does assume linear relationship between the logit of the response and the explanatory variables meaning; $\text{logit}[\theta(x)] = \beta_0 + \beta X$

- nonlinear transformations of the original independent variables can be used
- variance does not need to be homogeneous
- independent error terms does not need normally distributed
- maximum likelihood estimation (MLE) rather than ordinary least squares (OLS) approach

4.3.6. Logistic Regression Model

In this thesis logistic regression is applied to see if the logistic relation reveals better fit to the model. Logistic Regression model is developed by using SPSS Statistics 17.0 software with the factors of the final linear regression model. Therefore, the three independent variables classified as ordinal by -2 to 2 intrinsic ranking used are;

- Effectiveness of risk management plan (F34)
- Level of detail on dispute resolution processes in the contract (F38)
- Realistic contractual obligations of the contract (F40)

Dependent variable is the binary variable litigation probability (Y). The results of the analysis performed in SPSS are given in Table 44.

Table 44 – Binary Logistic Regression Model Results

		Variables in the Equation					
		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1 ^a	F34	-,784	,520	2,270	1	,132	,457
	F38	-,578	,356	2,631	1	,105	,561
	F40	-,558	,414	1,813	1	,178	,572
	Constant	-1,430	,735	3,785	1	,052	,239

The formula representing the logistic relation is formed as given in Formula (15).

$$Y = \frac{e^{(-1,430 + -0,784 \times F_{34} - 0,578 \times F_{38} - 0,558 \times F_{40})}}{1 + e^{(-1,430 + -0,784 \times F_{34} - 0,578 \times F_{38} - 0,558 \times F_{40})}} \quad (15)$$

In order to illustrate the practical application of the logistic regression model an imaginary sample project values are used.

Let; $F_{34}=0$, $F_{38}=1$ and $F_{40} = 1$

Meaning that the contractual obligations of the project are realistic enough and dispute resolution is defined in the contract also an average risk management plan is applied to the project.

The logistic model gives the results as;

$$Y = \frac{e^{(-1,430 + -0,784 \times 0 - 0,578 \times 1 - 0,558 \times 1)}}{1 + e^{(-1,430 + -0,784 \times 0 - 0,578 \times 1 - 0,558 \times 1)}} = 0,0714$$

The calculated result of the example project which is $Y = 0,0714 < 0,5$ presents litigation is not expected.

4.3.7. Prediction Performance of Logistic Regression Model

In order to compare the results and the prediction performances of the linear and logistic regression models MSE and PCC are calculated as given in the Formulas 13 and 14 for logistic regression model also. Calculated closeness of fit measures are given in Table 45 for the actual model using all the project variables.

Table 45 – Closeness of Fit for Logistic Regression Model Due to Actual Project Variables

	MSE	PCC
Actual Model	0,1496	80,00%

As explained in 4.3.4. section 5 fold cross validation method is used for the logistic regression model also to investigate the prediction performance of the model for newly introduced project. The results of the 5 fold cross validation process are summarized in the Table 46.

Table 46 – Prediction Performance of Logistic Regression Model Due to Cross Validation

	MSE	PCC
Test Model 1	0,2479	66,67%
Test Model 2	0,1601	83,33%
Test Model 3	0,2076	83,33%
Test Model 4	0,1115	83,33%
Test Model 5	0,2697	66,67%
Average Prediction Performance	0,1994	76,67%

As revealed from the results in Table 46 test models prediction performance changes between 67 % and 83 % and at the average 77 % of the time the linear model predicts correct classifications.

4.3.8. Comparison of the Prediction Performances of Linear and Logistic Regression Models

When the prediction performances of the linear and logistic regression relation assumptions for prediction of litigation probability during bidding stage are observed it is clearly noticed from Table 47 that; even though the both models show 80 % correct classification when closeness of fit is concerned, logistic regression model displays more accurate prediction performance.

Table 47 – Comparison of Prediction Performances of Linear and Models

	Linear Model PCC	Logistic Regression Model PCC
Actual Model	80,00%	80,00%
Average Prediction Performance	66,67%	76,67%

Therefore, in this thesis it is concluded to use the logistic regression model for prediction of litigation probability of international construction projects during bidding stage. Hence, Equation (15) is recommended for prediction of probability of litigation in international construction projects.

CHAPTER 5

CONCLUSION

Construction Management deals with several parties and individuals having different objective and viewpoints during a construction project. Due to the dynamic and complex nature of construction and uniqueness of each project, friction between any of the parties is inevitable. This thesis is focused on investigating the factors that are the main sources of litigations on international construction projects and propose a model to predict the potential litigation occurrence during bidding stage. International project interprets for this study in the manner of a project carried out outside Turkey, or a project carried out in Turkey with an international partner or an international owner.

There are several studies in literature tried to explain reasons of disputes and a few studies tend to predict the result of a dispute resolution process. However, this thesis is the first study proposing a model to forecast the litigation probability in the bidding stage of an international construction project. If construction court actions can be predicted with accuracy and reliability by using this approach, parties involved in the construction process can manage to save considerable amount of money, time. If disputes cannot be avoided low cost resolution methods may be taken into consideration.

In order to give reader the opportunity to see the overall concept of conflict and resolution of conflict, several definition and information was congregated allowing to compare the dispute resolution techniques currently in use.

Throughout this thesis, substantial number of previous studies from literature was reviewed which had been the basis for the comprehensive list of factors that formed the questionnaire form. The responses to the questionnaire form initiated the analysis by gathering the necessary information and constituting the data base. Following the data collection from 12 litigated and 22 non-litigated international projects, the factors affecting litigation probability in the final model were analyzed one by one according to statistical significance of them. The most significant 18 factors are subjected to backward elimination process to form the prediction models with linear regression and logistic regression approaches. The logical relations of independent variables with the dependent variable are also taken into consideration as well as the statistical significance of the factors to achieve the most efficient prediction model. Additionally, prediction performances of the linear and logistic regression models investigated by using cross validation technique.

Disputes are caused by a variety of reasons or combination of them. This study verified the importance of the several dispute reasons affecting litigation probability of an international construction project. Since, there is no possible way to computerize the real human reasoning there is no perfect model to predict any future happening. However, the final prediction model constructed this study transform into a simple approach after several analysis steps while displaying satisfactory results. The final prediction model reveals that contractual awareness and consciousness of risk factors is the key to predict litigation probability.

The accuracy of the output of the model is largely dependent on the quality of the training cases. In order to improve the accuracy of the model, the data base used should be expanded.

From professional point of view the developed model shall be used to avoid the occurrence of a possible litigation. The result of the model may contribute to the risk level of a future project and support the “bid/not bid” decision of a

company. Furthermore, the potential factors affecting litigation probability determined may assist companies to develop risk allocation structures such as partnering or use of preventive contractual clauses considering any future project.

Determination of potential impacts of the factors affecting litigation probability would allow the companies to realize the cost and time increases during a project. Therefore, this study may also contribute to contingency estimation for an international construction project.

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APPENDIX A

SAMPLE QUESTIONNAIRE FORM

PREDICTION OF LITIGATION PROBABILITY FOR INTERNATIONAL CONSTRUCTION PROJECTS DURING BIDDING STAGE

Dynamic nature of construction and uniqueness of each project may lead parties of contract to go through a litigation process for conflict or dispute resolution. The purpose of this study is to investigate the factors that are the main sources of litigations on international construction projects and propose a model to predict the potential litigation occurrence during bidding stage.

The following questionnaire consists of two main parts and both parts shall be filled for an “international” construction project which has been completed. Our definition for an international project is a project carried out outside Turkey, or a project carried out in Turkey with an international partner or an international owner. There is only a single questionnaire and it applies to all of the projects including; the projects without any disputes, the projects with disputes that did not results with a litigation, and the projects resulted with litigation. If you wish to provide information of several projects, for each project please fill a separate questionnaire.

- **PART I** questions cover the general information related with the company and the subject project.
- **PART II** of the questionnaire is a list of factors might have affect on disputes leading to litigation. Considering the conditions of the subject international construction project for each situation please state your level of agreement using a scale of 1-5, by simply marking the related box with an “x”. If given situation is not applicable (N/A) for the subject project please mark N/A column.

Completion of this survey will take approximately 10-15 minutes. Your survey responses will be strictly confidential and data from this research will only be used for academic purposes.

If you are interested we will be glad to share the results of the study. Thank you very much for your time and support.

PART I/A - GENERAL INFORMATION ABOUT COMPANY	
Total Company Experience in Construction	years
Total Value of Completed Works (Abroad)	<input type="checkbox"/> 0-25 Million US Dollars (\$) <input type="checkbox"/> 25-100 Million US Dollars (\$) <input type="checkbox"/> 100-500 Million US Dollars (\$) <input type="checkbox"/> More than 500 Million US Dollars (\$)
Total Value of Completed Works (Turkey)	<input type="checkbox"/> 0-50 Million US Dollars (\$) <input type="checkbox"/> 50-200 Million US Dollars (\$) <input type="checkbox"/> 200 Million-1Billion US Dollars (\$) <input type="checkbox"/> More than 1Billion US Dollars (\$)
Type of Companies Partnership	<input type="checkbox"/> Sole proprietorship <input type="checkbox"/> General Partnership <input type="checkbox"/> Limited Partnership <input type="checkbox"/> Public Limited company <input type="checkbox"/> Limited Liability Partnership (LLP) <input type="checkbox"/> Other, please specify
Total Number of Employees in the Company	<input type="checkbox"/> 0-100 <input type="checkbox"/> 100-500 <input type="checkbox"/> 500-1000 <input type="checkbox"/> More Than 1000

PART I/B - GENERAL INFORMATION ABOUT PROJECT	
Project Type	<input type="checkbox"/> Infrastructure <input type="checkbox"/> Transportation <input type="checkbox"/> Industrial Plants (Refinery, Factory etc.) <input type="checkbox"/> Pipeline <input type="checkbox"/> Building (Hospital, Hotel etc.) <input type="checkbox"/> Dam <input type="checkbox"/> Residential <input type="checkbox"/> Power Plant <input type="checkbox"/> Coastal Structures <input type="checkbox"/> Other, please specify
Project Location (Country)	
Total Project Budget	
Progress Payment Currency	<input type="checkbox"/> Turkish lira (TRY) <input type="checkbox"/> US Dollar (\$) <input type="checkbox"/> Euro (€) <input type="checkbox"/> Russian Ruble (RUB) <input type="checkbox"/> Pound (£) <input type="checkbox"/> Other, please specify
Advance Payment Amount (% of Contract Amount)	
Performance Bond Amount (% of Contract Amount)	
Scheduled Project Duration	months
Project Start Date (month, year)	
Tender Preparation Period	days
Type of Bidding	<input type="checkbox"/> Open Bid without Pre-Qualification <input type="checkbox"/> Open with Pre-Qualification <input type="checkbox"/> Invitational Bid <input type="checkbox"/> Other, please specify

Bid Evaluation Criteria	<input type="checkbox"/> Lowest Bid Amount <input type="checkbox"/> Best value (Combination of Technical and Price Proposal Reviews) <input type="checkbox"/> Other, please specify
Contract Type	<input type="checkbox"/> Lump Sum <input type="checkbox"/> Unit Price <input type="checkbox"/> Cost Plus <input type="checkbox"/> Other, please specify
Type of Project Delivery	<input type="checkbox"/> Turnkey Contract (Design - Build) <input type="checkbox"/> Design - Bid - Build (DBB) <input type="checkbox"/> Build - Operate - Transfer (BOT) <input type="checkbox"/> Construction Management <input type="checkbox"/> Other, please specify
Type of Financing	<input type="checkbox"/> Finance Organizations - Banks <input type="checkbox"/> Contractor Financed <input type="checkbox"/> Owner Financed <input type="checkbox"/> Other, please specify
Role of the Company	<input type="checkbox"/> Main Contractor <input type="checkbox"/> Joint Venture (JV) Partner (Percentage %) <input type="checkbox"/> Consortium Partner (Percentage %) <input type="checkbox"/> Sub-contractor <input type="checkbox"/> Other, please specify
Owner's Origin	
Other Partners' (if any) Origin	1- 2- 3-
SIMPLY DESCRIBE THE CAUSE OF LITIGATION	
DISPUTE RESOLUTION	<input type="checkbox"/> There had been no dispute between the parties <input type="checkbox"/> Disputes settled without litigation (Please specify dispute resolution method) <input type="checkbox"/> Parties went through the litigation process (Please specify the court)
LITIGATION PROCESS	<input type="checkbox"/> Process is still ongoing <input type="checkbox"/> Court reached to a decision
WHAT IS THE OUTCOME OF LITIGATION	

PART II - FACTORS AFFECTING PROJECT TO GO THROUGH LITIGATION							
No	Description	(0) N/A	(1) Strongly Disagree	(2) Disagree	(3) Neither Agree Nor Disagree	(4) Agree	(5) Strongly Agree
1	Contractor had previous experience with similar type of projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Owner's (Director/Client) organization had previous experience with similar type of projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Contractor had previous experience in the host country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Owner (Director/Client) and contractor known each other from previous projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Partners (if any) known each other from previous projects	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Contractor chose to go through the litigation process in previous projects for dispute resolution	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	Owner (Director/Client) chose to go through the litigation process in previous projects for dispute resolution	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	Bidding amount was optimistic	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9	The contractor had detailed information about the project conditions during bidding stage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10	The contractor had spent sufficient amount of effort for preparation for the bid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11	Request for proposal information was inadequate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12	Possible stop and go operations in project were identified during bid stage	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13	Time was insufficient for tender preparation.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14	Designer was competence (capable) enough for required design effort	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15	Design was very complex for the project	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16	Design was applicable and constructible	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17	Required skilled labor were available in the host country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18	Construction materials were available in the host country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

19	Required machinery and equipments were available in the host country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20	Relevant subcontractors were available in host country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21	There were sufficient material suppliers available in the host country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22	Supervisor and control staff were adequate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23	Logistics and Procurement staff were adequate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24	Level of experience of project management team was adequate	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25	Owner (Director/Client) furnished materials had critical importance to construction process	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26	Sufficient amount of funding was available for the project	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27	Construction technique was complex	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
28	Construction site was crowded	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
29	Construction site was not secure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
30	Access to the site was difficult	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
31	The responsibilities of the project team (contractor) was clearly defined and established through a detailed organization chart	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
32	Responsibilities of the partners (if any) were well defined	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
33	Owner (Director/Client) and contractor responsibility structures were clearly defined	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
34	An effective risk management plan applied for the project	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
35	Project control and reporting mechanism was well established	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
36	Bureaucratic procedures for obtaining necessary permits took too much time	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
37	The project schedule was realistic	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
38	Dispute and arbitration resolution processes were well defined in the contract	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
39	Project risk was allocated properly between the parties (owner-contractor) in the contract	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
40	Contractual obligations of the contractor were realistic	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
41	Scope of the parties were well defined in the contract	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
42	Quality requirements of the contract was in high standards	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
43	Health and safety requirements of the contract was in high standards	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

44	Environmental management requirements of the contract was in high standards	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
45	The host country was not politically stable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
46	There are significant fluctuations in the progress payment exchange rate in which the progress payments are made	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
47	The host country was not economically stable	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
48	There were certain limitations to foreign companies in the host country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
49	Money transfer from/to host country was difficult	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
50	Contractor was not familiar with the laws and regulations of the host country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
51	Attitude towards the foreign companies was negative in the host country	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Thank you for your participation and support on our survey. If you wish you can fill this form for other projects.