A MODEL FOR EVALUATING THE POTENTIAL OF LITIGATION DUE TO CONTRACT AMBIGUITY IN INTERNATIONAL CONSTRUCTION PROJECTS

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ABSTRACT

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Disputes are unavoidable due to the unique interests of the parties and the challenging, complex and oppositional nature of the industry in the construction sector. For this reason, many researchers have conducted studies on disputes and dispute resolution in construction projects. Litigation, which is the last resort of disputes, is an unwelcomed process for all parties causing loss of time, money and reputation. In this respect, both the owner and the contractor require to prevent the factors that cause disputes which may result in litigation. The aim of this study is to develop a model for evaluating the potential of litigation due to contract ambiguity in international construction projects. The model will enable the evaluation of the potential of litigation due to contract ambiguity and will assist the owner to reduce and eliminate the factors that are increasing the contract ambiguity for decreasing the litigation potential. The model developed is an instrument to be used for evaluating the effects of ambiguity to potential of litigation rather than a prediction of litigation.

The ultimate model established disclosed the importance of the effect of the ambiguity in the contract and its annexes on the disputes and litigation processes. Thanks to the model developed by determining the factors that constitute ambiguity in the contract and specifying the statistically significant ones among them, an analytical relationship with relatively high prediction performance has been provided between contract ambiguity and litigation.

In this study, it is revealed that the notion of ambiguity with a holistic approach should be taken into account when determining and studying the reasons for disputes. Both contractors and owners may have the opportunity to develop their own risk and contingency strategies and project management approaches in the contract preparation and bidding stages, thanks to this developed model.

Keywords: Ambiguity, Dispute, Logistic Regression, Neural Network, Support Vector Machine

ÖZ

ULUSLARARASI İNŞAAT PROJELERİNDE SÖZLEŞME BELİRSİZLİĞİ SEBEBİYLE ORTAYA ÇIKAN DAVA POTANSİYELİNİ DEĞERLENDİREN MODEL

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İnşaat sektöründe tarafların kendine mahsus çıkarları ve sektörün zorlu, karmaşık ve çekişmeli doğası nedeniyle uyuşmazlıklar kaçınılmazdır. Bu nedenle birçok araştırmacı inşaat projelerinde uyuşmazlıklar ve uyuşmazlıkların çözümü konusunda çalışmalar yapmıştır. Uyuşmazlıkların son durağı olan dava, tüm taraflar için hoş karşılanmayan, zaman, para ve itibar kaybına neden olan bir süreçtir. Bu itibarla hem işveren hem de müteahhit, dava ile sonuçlanabilecek ihtilafların sebeplerinin önlenmesine ihtiyaç duymaktadır. Bu çalışmanın amacı, uluslararası inşaat projelerinde sözleşme belirsizliği nedeniyle dava açma potansiyelinin değerlendirilmesi için bir model geliştirmektir. Model, sözleşme belirsizliği nedeniyle dava açma potansiyelinin değerlendirilmesini sağlayacak ve dava açma potansiyelini azaltmak için işverenin sözleşme belirsizliğini artıran faktörleri azaltıp ortadan kaldırmasına yardımcı olacaktır. Model, bir dava tahmininden ziyade, belirsizliğin dava açma potansiyeli üzerindeki etkilerini değerlendirmek için kullanılacak bir araçtır. Oluşturulan nihai model, sözleşme ve eklerindeki belirsizliğin uyuşmazlıklara ve dava süreçlerine etkisinin önemini ortaya koymuştur.

Sözleşmede belirsizlik oluşturan faktörlerin belirlenmesi ve bunlardan istatistiksel olarak anlamlı olanların belirtilmesi ile geliştirilen model sayesinde, sözleşme belirsizliği ile dava arasında göreceli olarak yüksek tahmin performansına sahip analitik bir ilişki sağlanmıştır.

Bu çalışmada, uyuşmazlıkların nedenleri belirlenirken ve incelenirken bütüncül bir yaklaşımla belirsizlik kavramının dikkate alınması gerektiği ortaya konmuştur. Geliştirilen bu model sayesinde hem müteahhitler hem de işverenler, sözleşme hazırlama ve ihale aşamalarında kendi risk ve beklenmedik durum stratejilerini ve proje yönetimi yaklaşımlarını geliştirme fırsatı bulabilirler.

Anahtar Kelimeler: Belirsizlik, Anlaşmazlık, Lojistik Regresyon, Yapay Sinir Ağı, Deskek Vektör Makinesi

To My Family

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INTRODUCTION

In the list of the “World's Top 250 International Contractors” published by ENR-Engineering News Record in 2020, the number of Turkish Contractors ranks second after China with 44 companies. For more than 10 years, the ranking of Turkey in this list has not been changed. In addition, according to the “Construction Sector Analysis” published by the Turkish Contractors Association (TMB) in January 2021, the Turkish construction industry has undertaken 299 projects worth 14,4 billion USD in 2020. It was highlighted in the report that these data are taken from the Republic of Turkey Ministry of Trade statistics. The Russian Federation stands out among these projects with the percentage of 31.9 %, followed by countries such as Kuwait, Romania, and Ukraine with about 5%. Within Turkey, the number of foreign joint ventures or foreign-funded construction projects are not high compared to the projects undertaken by Turkish contractors abroad and although the share of the construction sector in foreign direct investment is around 3.3% as of the end of 2019 according to the report published by the Presidency Investment Office of the Republic of Turkey, there is a foreign presence in the construction sector in the country, especially thanks to the consortiums established in major infrastructure projects and EU / World Bank funded projects.

Under above explained circumstances, in terms of Turkish companies, because of the unfamiliarity of legal regulations, culture, partner companies from that country and because of foreign elements involved in the construction sector in Turkey (companies, funds, etc.) some conflicts, disputes and issues which could be driven to litigation could arise throughout the project. Apart from above-mentioned facts, conflicts and disagreements become inevitable due to the fact that construction projects bring different parties together and the dynamic, variable and complex nature of the construction industry. At this point, the construction contract and its annexes, which reveal the relations between the parties, their liabilities, the legal remedies to be applied, the methods of dispute resolution, the addressing of the disputes that may arise before they arise, in short, the constitution of a construction project, play a critical role.

Findings about construction law in human history date back to Hammurabi laws. The legal rules of Hammurabi, who lived and ruled in 1700s BC, were written on the tablets contained some provisions regarding construction activities. The establishment of construction law and the emergence of construction contracts as we know them today are the result of the need to build infrastructure and industrial facilities that increased after the industrial revolution in nineteenth century. Construction contracts in the 19th century included some basic provisions such as the time to complete the work, specifications, governing price, and basic responsibilities of the parties, and were much simpler contracts than today (R. Thomas and Wright 1993). Construction contracts have become more comprehensive and complex over time due to technological developments, the increase in the population of cities as a result of the industrial revolution, and the need for housing and infrastructure. In the past, construction projects were carried out by relying on a master builder from the conceptual design stage to the completion stage, but after the industrial revolution, specialization and contract freedom emerged, and in this case, staff that are more expert came to the fore. With this development, employers started to make individual contracts in which the roles of the relevant party are determined for each specific area of expertise (Nadar 2019). The current structure of construction contracts has shaped during the 20th century and at the beginning of the 21st century by means of the factors such as making separate contracts with the parties involved in the project according to their areas of expertise, increasing needs, disputes arising in growing and complexing projects, and the development of construction law.

Contract conditions used in construction projects are documents that specify the rights and responsibilities of the contracting parties and in consequence of this role they are very crucial for pre and post contract drafting periods (Mohamad and Madon 2006). If the project is started with an incomplete or uncertain contract and its annexes, it will be inevitable that major problems that may lead to litigation will arise. Construction sector has risks and opponent characteristics by its nature that leads to the construction disputes (Chong and Zin 2010). Due to the inherent characteristics of the construction industry, it is highly likely that disputes and claims which could cause time and money losses between the various parties will arise (Lee et al. 2020). The likelihood of disputes between owner and contractors increases in construction projects that grow and become more complex as they grow (Lu, Zhang, and Zhang 2016). There have been many researchers who have investigated the root causes of these conflicts and revealed these reasons through their studies. Many root causes have been listed in the studies carried out, and the ambiguity, deficiencies and inconsistency in construction contracts and its annexes have an important place. Mohamad and Zulkifli (2006) have justified through their study that level of understanding of contract documentation and clarity of contract documents have high importance to cope with the construction disputes. Clarity of the contract document is of paramount importance for understanding the rules to be applied for the progress of the project and the rights and responsibilities of the parties (Mohamad and Madon 2006). Construction contracts are complicated documents that try to balance the needs of many different parties involved in a project. Contractors face much uncertainty when delivering on their contract responsibilities, so it is important to design contracts that are fair in allocating risk.

While preparing the contracts, a variety of participants contribute and the contract is finalized with a joint effort. This situation can lead to certain inconsistencies and conflicts. In cases where there are conflicting provisions between contract documents, an order of precedence clause should be determined and this order should be defined in the contract in order to decide which document's provisions will apply. Choi (2003) listed the hierarchy, with some exceptions, among contract documents in descending order of priority as follows:

- The Agreement
- General Conditions
- Special conditions
- Amendments
- Technical Specifications
- Design&Drawings

Like other contract types, construction contracts are written legal documents that define the responsibilities/obligations of the parties, project objectives and all processes throughout the project through contract annexes/documents. Construction contracts are somewhat incomplete and uncertain in nature because contract clauses and appendices cannot cope with all possible contingencies.

Ambiguity in the contract may arise from grammar, word or sentence structures, as well as from incompatibility, incompleteness, confusion and interpretations between contract documents. There are many studies in the literature that focus on the notion of ambiguity and point out the factors that constitute ambiguity, especially for construction contracts.

Many researchers accepted that the construction contracts and its annexes have great importance for smooth implementation of the projects and for avoiding the disputes throughout the project which can lead to the litigation process and cause time and money losses for the parties of the contract. Within this framework, the essential goal of this thesis is to develop a model for evaluating the potential of litigation due to contract ambiguity in international construction projects. The model to develop is an instrument to be used for evaluating the effects of ambiguity to potential of litigation rather than a prediction of litigation.

The thesis consists of 5 Chapters in which the context of the study will be discussed;

The next chapter, *Chapter 2*, will cover basic descriptions of construction contracts, dispute/litigation and ambiguity. In addition to that, the relations of contract ambiguity between the disputes/litigation will be discussed. Also, factors affecting the contract completeness and ambiguity will be demonstrated from literature and from real cases.

In *Chapter 3*, research methodology and questionnaire development with the factors affecting the contract ambiguity will be introduced. The statistical analysis method will also be briefed in this chapter.

Chapter 4 covers research findings and discussions of the detailed study results acquired from the analysis.

Section 5 provides conclusions and recommendations for evaluating the potential of a litigation due to contract ambiguity for the construction contract, including possible benefits and potential shortcomings that can be applied during the contract preparation phase of a construction project.

CHAPTER 2

AMBIGUITY IN CONSTRUCTION CONTRACTS AND LITERATURE REVIEW

2.1 Construction Contracts

Construction projects are a complex process includes various parties in which each party works within their own duties and responsibilities and must be acted in cooperation to achieve the targeted result. Contracts is an economic projection process exchange into future (Smyth and Pryke 2008). Contracts are the constitution of a construction project that defines the obligations, areas of responsibility and relationships of the parties involved in the project (Kan and Le 2014), and describes the ways to be followed in possible disputes/conflicts. Contract is an official governance tool as a defense mechanism against the risks inherent in projects (Gao et al. 2018). The basic mechanism that connects and ensures the transfer between the implementation phase of the project and the pre-project work agreement is the contract (Rameezdeen and Rodrigo 2014). Construction contracts are the basis of the relationship between the parties involved in the project (Broome and Hayes 1997). Simply, the verbal or written agreement to which the law will apply is the contract. More specifically, the agreement that includes the commitment of the service provider involved in the project is called the construction contract (Semple, Hartman, and Jergeas 1994). A legally binding agreement between the parties for the exchange of something of value is called a contract. In the construction industry, money is the valuable thing that is received in return for a service provided for a construction activity. In the contract, the parties accept the contractual and legal obligations that are not possible and/or easy to change (Molenaar et al. 2007). Strong contract approaches are thought to be strategies that delegate risk responsibility to enhance comprehensive project targets (Kan and Le 2014). Ensuring that the project achieves its objectives is the main function of a construction contract (Koc and Gurgun 2022).

Although there are many distinct participants involving, contributing and having a role in the successful design and completion of a construction project, commonly 2 parties presented that has a signature in the contract: the owner and the contractor. However, a consultant/designer who has certain roles and responsibilities throughout the project period and is defined in the contract, undertakes the design on behalf of the employer; other parties, such as subcontractors, suppliers, machinery/equipment suppliers, who may be involved in the project with a separate contract by the contractor, are indirectly involved in the contract and the project.

Murdoch and Hughes (2008) structured the responsibilities of the clien/employer, advisor/consultant and the constructor (contractor) in construction project and the structure is presented in Figure1.

Client/ employer	Representative	Client project manager, client's representative, employer's representative/project manager.
	Advisor	Advisory group, feasibility consultant.
	Stakeholder	End-user, general public, tenant, workforce.
	Supplier	Client's direct contractor, Preferred supplier
Advisor/ consultant	Design leadership	Architect (management function), design leader, lead consultant, lead designer.
	Management	Consultant team manager, design manager.
	Design	Architect (design function), architectural designer. Designer, specialist advisor, engineer, consultant (etc).
	Administration	Architect, contract administrator, supervising officer. Planning supervisor, Project administration.
	Site inspector	Clerk of works, Resident engineer.
	Financial	Cost advisor, cost consultant, quantity surveyor.
Constructor	Overall responsibility	Builder, contractor, lead contractor, general contractor, main contractor, principal contractor, design-build contractor, design contractor, management contractor.
	Constructor's staff	Construction manager, construction planner, contract manager, person-in-charge, site agent.
	Partial responsibility	Engineering contractor, package contractor, specialist, specialist contractor, specialist sub-contractor, specialist supplier, specialist trade contractor. Domestic sub-contractor, labour-only sub-contractor, named sub-contractor, nominated sub-contractor, nominated supplier, specialist sub-contractor, supply-only sub-contractor, sub-contractor, trade contractor, works contractor.

Figure 1 - Structure of Responsibilities in Construction Projects (Murdoch and Hughes, 2008)

2.1.1 Contract Parts and Annexes

Construction contracts are not a single document; it is a set of documents created with the participation of different parties. In general, a construction contract consists of the following main parts and annexes:

- The Agreement
- General Conditions
- Special Conditions
- Design & Drawings
- Technical Specifications
- Bill of Quantities (BoQ)

Several authors pointed out that in order to hinder potential disputes, conflicts and unneeded details/information, these documents which is deemed legal should be compiled and adjusted with the utmost care and attention (Choi 2003, Nadar 2019, (Molenaar et al. 2007, Semple, Hartman, and Jergeas 1994). The agreement, general conditions and special conditions, defined as contract forms, that collectively describe how the construction work will be executed and completed, how the payment to the contractor will be made, the project schedule, lashing and insurance requirements, construction management and supervision, compensation procedure and timing, and actions for breach of contract is drafted by the owner. The bidding program, design&drawings and technical specifications are produced by the engineer (consultant) on behalf of the owner (Choi 2003).

The most essential document in the construction contract dossier is the *agreement* document which is signed by the owner and the contractor and it is the basis on which all other specific annexes that form up the contract dossier are built. In this document, the scope, parties and price of the contract are established. In addition, the *agreement* document can be a preprinted, standard ready document, or it can be in a format that can be customized revolving around on the characteristics of the relevant project. In terms of order of precedence, the agreement document takes place above all other documents that form up the contract.

The part of the construction contract that provides the mechanisms/procedures of the project and constitutes the framework of the contract documents are the *general conditions*. The rights, obligations, roles and responsibilities of the parties to the contract are addressed in the *general conditions*. In detail, the procedures of how disputes will be resolved, contract changes, payment processes, and termination are defined in the *general conditions*. *Special conditions* are additions and/or changes made to the sections in the *general conditions*. At this part, the conditions are detailed or modified specific to the relevant projects characteristics and requirements. Conditions of the contract have a decisive aspect in weighing the overall position of a construction contract and contract performance, as it outlines the comprehensive framework of the project and introduces provisions for each part of the contract.

The *design&drawings* produced prior to the commencement of the construction activities by the consultant (the Engineer) assigned/authorized by the owner depending on the project delivery method, both provide an overview of the project and present the details of what will be built and how. Every construction project incorporates a set of drawings and plans and can be modified and updated with revisions throughout the project implementation period. The *design&drawings*, jointly with the conditions of the contract and technical specifications, constitute the ground of the contractor's projections and estimations and are the physical aspect of the relevant construction project. The design consultant who produces the drawings is expected to be familiar with the contract conditions, specifications and project requirements so that the drawings and other parts of the contract can be consistent. In addition, accurately, properly drafted designs maintain contractors to save time spent for description of tasks.

Technical specification is a document that defines all technical data, performance requirements, material details, quality standards, workmanship and equipment details and it is developed by professionals from each discipline. The *technical* *specification* contains definitions for each task and the desired ultimate product is specified. As in other parts of the contract, the specifications should be developed with good care and diligence. A defective and incomplete specification may cause problems for contractors and this may cause additional costs to the owner. During the implementation phase, the specifications can be modified subject to owners approval. At the same time, deviation limits should be fixed in the technical specification. According to the *Water Environment Federation and American Society of Civil Engineers* (1992), technical specifications have 3 inclusive categories:

- Material and workmanship standards that specify the contractor's responsibilities that will come to a conclusion of a structure of the desired characteristics.

- General performance characteristics that can be measured by tests for the intended end product; these specifications are often used for mechanical works.

- Specifications for construction works for selection of proprietary products from the available market. The manufacturer of the proprietary product in the market is not specified, the features can only describe the intended product and quality/performance tests can be defined.

The *Bill of Quantities (BoQ)* list provided to bidders/participants during the tender process is a detailed list of work items, materials, labor, quantities, unit or lump sum prices and it becomes part of the contract after tender process. A quantity surveyor or building estimator directly appointed by the employer prepares this list. It is essential that this document, which constitutes the basis for the cost and risk estimates of the bidders, is consistent with the other parts of the contract, specifically with the drawings, in order to restrain troublesome situations such as changes (variations), cost deviations, time extensions that may arise during the implementation phase.

In addition to these main parts of the contract, the supplementary annexes such as *work programme and schedule*, *insurances* and *bonds* bring to completion the contract dossier and they are fundamental for a complete, consistent contract dossier.

2.1.2 Standard Construction Contracts

Pollock (1950) defined a contract as a guarantee or set of guarantees to be enforced by law. In other words, there is a reciprocity between the guaranteed and the guarantor commitment. In the contract, the rights and obligations are established by the agreement between the parties to the contract. In many works, agreements are made with small contracts of a few pages, regardless of the size of the work, but in cases such as budget exceeding, delays, failure to meet the desired quality standards; simple, undetailed contracts pose a risk in terms of disputes. This is a troublesome position for both parties of the contract and if the terms are not clearly established, small disputes can grow later and cause big losses, litigation processes can begin. For this reason, simple contracts that emerged in the 19th century evolved over time into standard construction contracts, which were used for years and developed by testing with various cases. It is recommended to employ standard contracts in many projects, thanks to its adaptability corresponding to the characteristics of the projects. Standard contract forms can reduce the risk of claims and disputes by helping to minimize misunderstanding of language and terms (E. E. Chan, Nik-Bakht, and Han 2021).

Standard contracts issued by various professional institutions are crucial for design and construction works for numerous reasons (Ndekugri and Rycroft 2000; Pollock 1950; Sweet 1989; Broome and Hayes 1997).

First, there is a consensus on the allocation of risks and responsibilities, the methods of addressing problems, and administrative dispositions.

Second, they enhance the efficiency of negotiation processes and minimize possible loss of money and time.

Finally, they develop binding mechanisms for the parties involved in the project to achieve their goals.

Ndekugri and Rycroft (2000) claimed the critical features of a standard contracts as;

- An apparatus for designating contingent risk whilst conserving time and facilitating dealing at arms-length.
- A mechanism that does not require typing terms for every activity.
- Maintaining recognition and familiarity by practical experience.
- The protection of merely one party's interest is not possible by discussing independent bodies.
- Elimination of undesirable discretion by individuals through a negotiation approach.
- Providing the risk distribution in the cases envisaged and provided in the calculations.
- Providing a recognizable framework for processes such as payment, work changes and dispute resolution.

While the use of standard contract forms is generally recommended and accepted, in some specific cases and projects, the parties may prefer for contracts that are customized or drafted from scratch to look after their own interests. In such cases, in order to establish the administrative issues and to protect against the negative and unfamiliar conditions of the country where the project will be carried out, standard contract forms are preferred and the contract can be modified to a large extent with special conditions and various annexes.

Many local and international organizations in the construction industry publish standard contract forms. Among them, the most frequently used are:

- New Engineering Contract (NEC)
- Fédération Internationale des Ingéniurs Conseils (FIDIC)
- International Chamber of Commerce (ICC)
- Association of Consulting Architects (ACA)
- Association of Consulting Engineers (ACE)
- American Institute of Architects (AIA)
- Institution of Civil Engineers (ICE)

2.1.3 Types of Construction Contracts and Project Delivery Methods

Due to the unique nature of construction projects and the fact that no two projects are alike, various types of construction contracts are developed to meet the needs of the project parties. Diversity in contract types helps in determining which type of contract is most suitable for the project, correct distribution and management of risks, smooth progress of payments and dispute resolution process. An accurately adopted contract type ensures that expectations are clear from the commencement, eliminating unnecessary risk and responsibility sharing and unexpected problems. In this way, both the contractor and the employer will be protected.

Basically, there are 3 main types of construction contracts defined according to the calculation mechanism of payments:

- Lump Sum
- Unit Price (Re-measurement)
- Cost Plus

The types differ in terms of who bears the risks involved, who bears the excess costs, and how the savings are valued. Apart from these 3 main types, customized forms of cost plus type (*cost plus fixed fee, cost plus percentage*), *time and material, guaranteed maximum price (GMP)* and are among the construction contract types.

A *lump sum contract* is a contract where there is a fixed price set for all activities to be performed in the project. These contracts are also called “fixed price contracts”. In *lump sum contracts*, the fixed price generally includes all labor, materials, project overhead, company overhead, and contractors’ profit, and the contractor acknowledges to perform the stipulated work in exchange for this fixed Money (Gordon 1994).

Contracts in which separate prices are determined for each work item, material and labor are called *unit price contracts*.

Contracts in which all costs and project expenses are paid for the works done in the project and the profit of the contractor is added with a determined method are called *cost plus contracts*. The amount payable on top of the costs may be a fixed percentage or amount.

When it comes to low complexity, performance of the project is best obtained using Lump Sum followed by Cost Plus and Unit Price is the worst. With the increase in complexity, the performance will decrease in implementing Lump Sum, but will increase if Cost Plus and Unit Price are used. At high complexity, project performance is highest at Unit Price, followed by Cost Plus and Lump Sum is the worst (Kan and Le 2014).

In Table 1, the mostly referred and discussed advantages and disadvantages of main 3 types of construction contracts are displayed. As it can be traced from the Table 1, what is an advantage for one contract type may be a disadvantage for another and vice versa.

Table 1 - Advantages and Disadvantages of Main 3 Types of Construction Contracts

	Advantages	Disadvantages
Lump Sum	• Owners protects himself from unexpected costs • Contractors have an explicit outlook of the scope • Useful for the projects that the scope is well-defined (Broome and Hayes 1997)	• If the project exceeds the specified scope, it may result in lost profits for the contractor (Nadar 2019) • Budget constraint may inhibit the planned output. • Lower project performance in case of complex projects (Kan and Le 2014)
Unit Price	• Easy to evaluate costs by breakdowns • Possibility to reassess prices in response to scope change • Effective in high complexity (Kan and Le 2014)	• Cost estimation is difficult for large projects • The final cost is not precisely determined at the beginning of the project.
Cost Plus	• The project is more likely to be accomplished as projected. • The risk for contractors is low (Nadar 2019) • It is useful when labor, materials and equipment cannot be precisely determined (Nadar 2019)	• When limits are not enforced, project can extend beyond scope • Challenging to supervise and monitor (Nadar 2019)

In supplement to determining the contract type, the proper choice of the project delivery method is a very significant step before the design, as it determines the communication and payment processes. Project delivery is described by Project Management Institute (PMI) as “the structure of the parties’ relationships, the roles and responsibilities of the parties, and the overall set of activities required to deliver the project”. Project delivery methods set the contractual relations between the project parties and the timing of the official participation of the participants in the project (Mollaoglu-Korkmaz, Swarup, and Riley 2013). None of the project delivery methods is perfect and contains positive and negative aspects according to the characteristics of the project. There are certain things to consider before determining the delivery method: budget, scope, risks, schedule and experiences belong to previous projects. Considering these factors, the most appropriate delivery method for the project is determined, and in this way, general risks, budget and time can be managed more accurately.

Selecting the appropriate project delivery method is a challenging task due to presence of alternatives available, criteria to consider and the risks/uncertainties involved in the decision making process (Bypaneni, Tran, and Nguyen 2018). The criteria having utmost importance is listed by Murdoch and Hughes (2008);

- Client's (Owner's) involvement in the construction process
- Design and management separation
- Protecting right of altering the specification in terms of client (owner)
- Precision of client's (owner's) remedying of contract
- Project complexity
- Desired speed of project completion
- Price accuracy

Gordon (1994) structured a flowchart (Figure 2) for selecting the appropriate project delivery method and defined basic steps as use project drivers, use owner drivers, use market drivers, use risk allocation drivers, use commodity vs. service analysis and use judgement/experience.

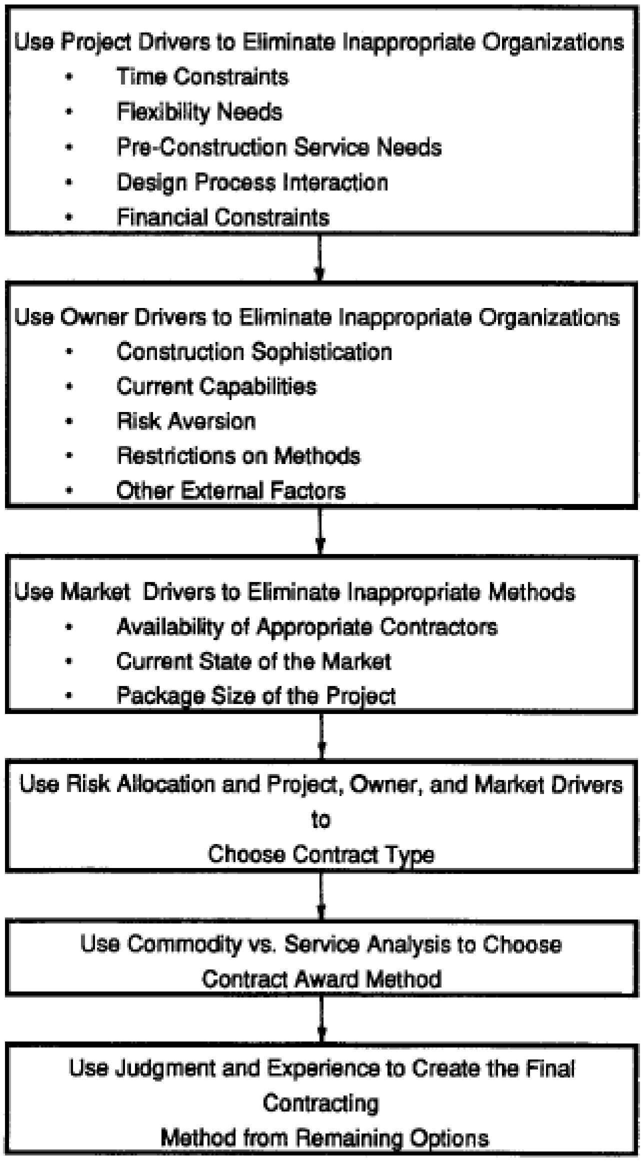

Figure 2 - Project Delivery Method Selection Flowchart (Gordon 1994)

A breakdown of the four most common types of project delivery methods is as;

- Design Bid Build (DBB)
- Design Build (DB)
- Construction Manager at Risk (CMAR)
- Integrated Project Delivery (IPD)

Design Bid Build (DBB), also called the “traditional method”, distinctly separates the design and construction processes (Mollaoglu-Korkmaz, Swarup, and Riley 2013; Hale et al. 2009; Christopher Gordon 1994; Nadar 2019; Ibbs et al. 2003). Design bid build is a project delivery method in which the owner enters into a separate contract, corresponding to his needs, with an architect/engineer who provides design services (Hale et al. 2009). In *DBB*, where the project is divided into 2 as design and construction, construction begins after the design is completed with two well-defined different stages and the drawings become the basis of the tender documents. Lump sum contracts are preferred in *DBB* as the owner is confident of the completed design (Ibbs et al. 2003). The contractual relationships in *DBB* is demontrated by Murdoch and Hughes (2008) as can be observed in Figure 3.

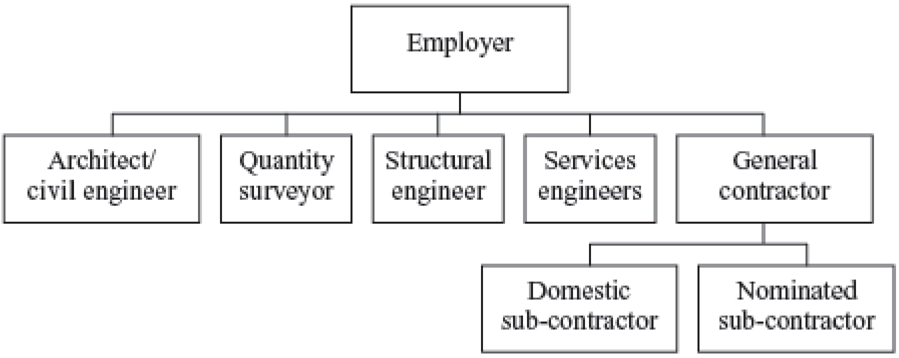

Figure 3 - Contractual Relationships in Design Bid Build (Murdoch and Hughes 2008)

Design Build (DB) is a project delivery method in which a contract is made between the owner and a single company to carry out both the design and the construction from a single source (Mollaoglu-Korkmaz, Swarup, and Riley 2013). In *DB*, the design is carried in accordance with the requirements after the award of the contract, giving the contractor broad ground to be more efficient. The contract is based on performance requirements and the main purpose is not to identify how to do, but what is needed (Nadar 2019). *DB* also includes the *Engineering Procurement Construction (EPC/Turnkey)* type project delivery method. In EPC/Turnkey, there is a single focus of responsibility; it is used in projects where the final cost and certainty of time is very important to the owner. The contractual relationships in *DB* is demontrated by Murdoch and Hughes (2008) as can be observed in Figure 4.

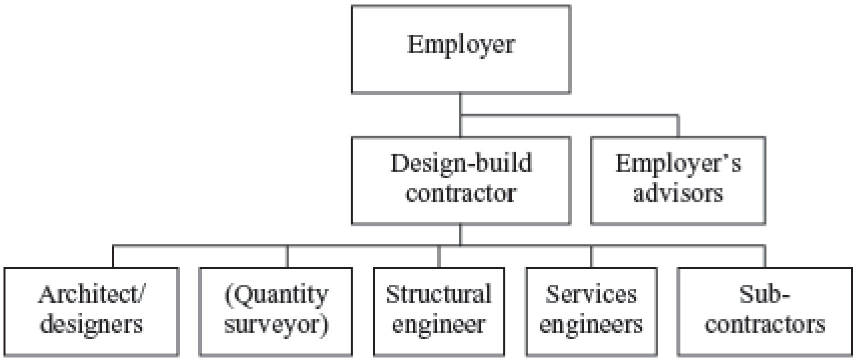

Figure 4 - Contractual Relationships in Design Build (Murdoch and Hughes 2008)

The *Construction Manager at Risk (CMAR)* method can be defined as a derivative of the design bid build method (Mollaoglu-Korkmaz, Swarup, and Riley 2013; Bypaneni, Tran, and Nguyen 2018), in which a construction manager (CM) commits to finishing the project with a guaranteed maximum price. Unlike DBB, the design process and supervision of the construction are undertaken by the construction manager (CM) designated by the owner, rather than a separate designer. The construction manager acts as the employer's representative during both the design and construction phases. In CMAR, the design is completed within the framework of the employer's contract with a design company. The employer selects two separate contractors for the construction management services and for the construction works to be completed in accordance with the contract. CM also overlooks the design phase and usually guarantees a maximum price for construction (Mollaoglu-Korkmaz, Swarup, and Riley 2013).

In the *Integrated Project Delivery (IDP)* method, the entire project team works under a single contract and it is a relatively new method. Before launching the design, all team members are determined and take part from design to the end of construction. IDP suggests teamwork and collaboration are at the forefront. The main purpose of IDP is to distribute responsibilities and risk/rewards among stakeholders. Since the contractor's participation in the project would be at an early stage, considerable time and money can be saved, efficiency is at the forefront. At the same time, the design is produced in a more refined way. IDP is the most compatible delivery method with the lean construction management concept, which aims to make all activities in the project more effective and efficient. Team integration in the delivery method provides optimized results for early collaboration, communication management/timing and chemistry between stakeholders (Mollaoglu-Korkmaz, Swarup, and Riley 2013).

Apart from the 4 main methods that are commonly used, there are such delivery methods employed in construction industry as, *Public Private Partnership (PPP),* where a partnership between a private company and a government-affiliated agency is established, the private company manages the construction and the government agency provides funding basically, *Job Order Contracting (JOC),* where more than one project is completed under a single contract, *Multiprime (MP)*, where the owner takes the role of general contractor and carries out the project with sub-contracts with different major trade contractors.

Murdoch and Hughes (2008) illustrated 3 main delivery methods in Figure 5 to 11 in terms of the most important delivery method selection criteria. In the figures, GC stands for general contracting which means design bid build, DB stands for design build and CM stands for contract manager which means construction management which is almost same delivery methods with construction manager at risk. Since the integrated project delivery method is a rather new method and has nearly same approaches, it can be evaluated that it has similar strengths and weaknesses with design build.

Figure 5 - Level of Involvement of the Owner (Murdoch and Hughes 2008)

Figure 6 - Separation Design from Management (Murdoch and Hughes 2008)

Figure 7 - Capacity of Variations (Murdoch and Hughes 2008)

Figure 8- Clarity of Owner’s Contractual Remedies (Murdoch and Hughes 2008)

Figure 9 - Complexity of Projects (Murdoch and Hughes 2008)

Figure 10 - Speed from the Inception to Completion (Murdoch and Hughes 2008)

Figure 11 - Certainty of Price (Murdoch and Hughes 2008)

In the literature, several authors studied the advantages and disadvantages of most widely used DBB and DB project delivery methods. Gordon (1994) and Ibbs et al. (2003) highlighted that the owners control and dominance on the design is higher in DBB. Gordon (1994) claimed the DBB is useful if project scope is clearly definable and if time is not a constraint, the design become complete and detailed in DBB. An another advantage of DBB method is defined by Ibbs et al. (2003) as higher productivity. Each method has disadvantages as well as benefits, and Gordon (1994) indicated that DBB bears high possibility of variations due to separate designer and the contractor. Accordingly, cost changes in DBB are relatively high as pointed out by Ibbs et al. (2003) and Hale at al. (2009) as well. Team integration is less in DBB as remarked by Mollaoglu-Korkmaz et al. (2013).

For DBB and DB, which are the 2 methods most widely used in the construction industry, a disadvantage for one can be an advantage for the other or vice versa. Nadar (2009), Ibbs et al. (2003) and Hale et al. (2009) specified that relatively short project durations could be achieved in DB. Gordon (1994), Murdoch and Hughes (2008) presented that the DB is flexible for changes in construction phase. Mollaoglu-Korkmaz et al. (2013) studied the DB with respect to sustainability aspect and it was concluded that the DB has better chance to achieve sustainability goals. It was claimed by Gordon (1994) and Korkmaz et al (2013), as opposed to DBB, the level of team integration is higher in DB. Ibbs et al. (2003), Hale et al. (2009), Murdoch and Hughes (2008) noted that better cost savings can be achieved in DB. Contractor’s being responsible for everything is the most important advantage of DB, particularly in cases where the owner is not competent and willing to figure out between a design error and a workmanship error (Murdoch and Hughes 2008). Productivity is relatively less in DB (Ibbs et al. 2003). Since other delivery methods are newly applied and/or not widely used, there are not many studies on these methods in the literature.

Apart from the project delivery method adopted, some other delivery attributes, such as owner commitment, collaboration, skills of the project management team, timing of participants entry to the team and experience of the contractor carries higher impacts on project performance than the delivery method used (Mollaoglu-Korkmaz et al. 2013, Kan and Le 2014, Hale et al. 2009).

2.2 Ambiguity in Construction Contracts

Ambiguity can be described as understanding something in two or more ways (Zeni et al. 2007). The definition of ambiguity in Merriam Webster English Dictionary is the quality or state of being ambiguous especially in meaning, an ambiguous word or expression or uncertainty. Berry et al. (2003) categorized the ambiguities under four types:

1. Lexical ambiguity: It implies a word that may have more than one meaning.
2. Syntactic ambiguity: It appears when a sequence of words or phrases has more than one grammatical structure, with different meanings and also called as structural ambiguity.
3. Semantic ambiguity: It is commonly referred in predicate logic and it emerges when a sentence has more than one way of reading, with regard to logical form.
4. Pragmatic ambiguity: It defines the relation between language and the context of the text.

In construction contracts, different interpretations due to the complex language structure, legal/technical terms, and ambiguity in contract terms can lead to conflicts, claims, disputes that can endanger the achievement of the project's objectives (Koc and Gurgun 2022). The lack of clarity in the tender documents is the main reason for the claims and conflicts at the contract stage (Laryea 2011). In construction contracts, ambiguity can be occurs in terms of language, as well as conflicts between contract provisions or contract documents, certainty, interpretation and order of precedence of the contract documents. Reasonable offers and reduced risk of conflict would be achieved by clearer and more precise tender documents, a reasonable bidding time and clarification of what the owner needs (Laryea 2011).

One of the main responsibilities of the contract drafters, managers and contract parties is the interpretation of the contract. Words with multiple meanings and/or details in the contract may be meaningful to the contractor but not to the employer, or vice versa, which may lead to discussions about the claim processes (Oyegoke 2006; Acharya, Dai Lee, and Man im 2006). Therefore, interpretation is particularly important in the contract and the ambiguous wording, roles, responsibilities and rights need to be revealed. Contractual obligations will be suspect if the terms are not understood and the content of the contract documents is not interpreted properly (Mohamad et al. 2008).

Chaong and Zin (2010) highlighted that an approach of improvement of clarity in construction contract documents would facilitate to prevent conflicts, disputes and in their study, they approached the notion of ambiguity in terms of grammar and listed the clarity problems in a construction contract as follows:

- Too long sentences
- Too many passive voices
- Word repetition
- Complex noun phrases
- Too many use of “shall”
- Negative language
- Poor explanations
- Controversial legal terms
- Ambiguous words or sentences with more than one meaning
- Poor grammar

Many authors have studied and identified the factors that constitute ambiguity in construction contracts. Besaiso *et al*. (2018) specified that unclear risk allocation and unclear force majeure sources constitutes ambiguity in construction contracts. Incompatibility with other contracts in the project, expressions and sentences with multiple meanings, unbalanced risk allocation and interest protection are the ambiguity factors identified by Broome and Hayes (1997). According to Murphy *et al.* (2014), unclear performance requirements and inconsistencies between contract clauses creates ambiguity. Ibbs and Ashley (1987) listed the ambiguity factors as uncertain project goals and performance needs, bill of quantities (BoQ) related uncertainties, lack of supporting documents and details, ambiguous third-party liabilities, unclear provisions for defects, ambiguous penalty provisions and uncertain conditions for performance measurements. Ambiguous enforceability including extreme claims is an ambiguity source according to Maemura *et al.* (2018). Three factors indicated by Schuhmann and Eichhorn (2017) as enforceability, insufficient details for implementation and focus of focal points and lack of clearly defined scope. Acharya *et al.* (2006) claimed three case that creates ambiguity: undefined scope, ambiguity stemmed from excessive changes in BoQ, unclear words and sentences. Thomas *et al.* (1994) focused on three ambiguity factors: inadequacies of implementation details, lack of provisions for using electricity, transportation, water etc. and ambiguous provisions of insurances. Unclarity of parties responsibilities, ambiguity stemmed from scope change needs, ambiguous unforeseen conditions and unclear penalty provisions are the factors creating ambiguity in construction contracts according to Artan İlter and Bakioğlu (2018). Ashmawi *et al*. (2018) specified five ambiguity factors as complication of responsibilities of the parties, ambiguous payment details, unclear third-party liabilities, ambiguous provisions of defects and ambiguous practice code for undocumented changes. Mahler (2007) defined inconsistencies in contract clauses as ambiguity factor. Three sources of ambiguity described by Youssef *et al*. (2018); unclarity of scope changes, ambiguity of unforeseen conditions and ambiguity in commencement/delays/suspension provisions. According to Hassanein and Afify

(2007), formce majeur clauses uncertainty, ambiguous payments details, lack of clarity in procurement details and lack of definition of commissioning process are the ambiguity factors. Cheung *et al.* (2006) specified incompatibility with other contracts in the project, Martin (1993) specified ambiguity in commencement/delays/payments, Lumineau and Malhotra (2010) indicated lack of supporting documents and technical details as ambiguity factors. Procurement definition's unclarity and ambiguous test, quality control and performance measurement processes are the ambiguity factors pointed by Bubshait and Al-Atiq (1999). Wells and Hawkins (2011) and Donkoh (2015) specified the ambiguous clauses regarding occupational health and safety as ambiguity factor. The two factors highlighted by Berry *et al.* (2003) is ambiguous provisions of use of electricity, water, transportation etc. and unclear insurance clauses. Ambiguity related to unit prices and its definition is referred ambiguity factor by Oyegoke (2006).

Chan et al. (2021) proposed a fishbone model for ambiguity in construction contracts (Figure 12).

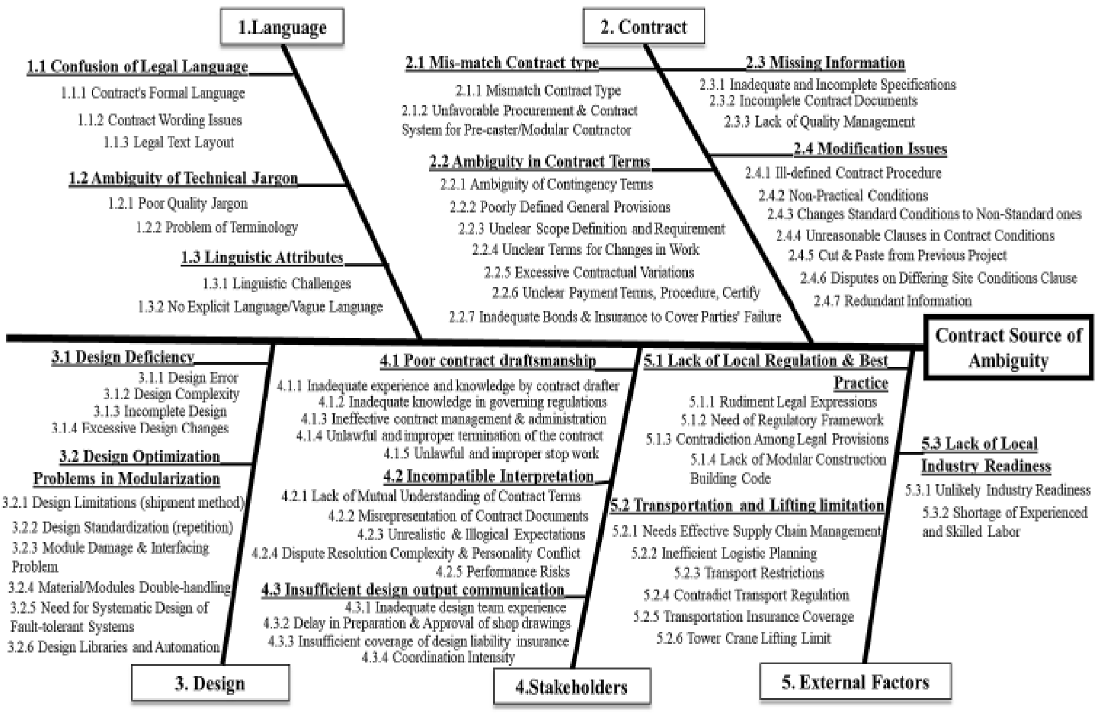

Figure 12 - Fishbone Model of Ambiguity in Construction Contracts (Chan et al. 2021)

The diagram (Figure 12) proposed by Chan et al. (2021) illustrated the contractual sources of ambiguity by dividing it into 5 main groups. These are *language, contract, design, stakeholders,* and *external factors*. In addition, the sub-fractions of each main source are indicated in the diagram and the root causes of ambiguity are elaborated.

2.3 Dispute and Litigation

The concept of dispute and dispute resolution processes have an essential place in construction project management. Conflicts arise frequently between the parties to the project/contract on issues such as duties, responsibilities and risk allocation, and if these conflicts are not resolved at an early stage, disputes may arise. Dispute is described as disagreement arised between large number of participants due to the conflicting interests and referred as ”epidemic” by Cheung and Yiu (2006). In order for an emerging conflict to become a dispute, a claim requested by one of the parties should not be admitted by the other party and the conflict should not attain to a resolution. A dispute does not occur until a claim has been submitted and later turned down. Claim is defined by *American Institute of Architects* (1987) 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, and extension of time or other relief with respect to the terms of the contract”. Semple *et al.* (1994) described claim as “assertation to the right to remedy, relief, or property” by referring *Canadian Law Dictionary*. Conflict is serious disagreement or discussion about an issue of importance; in other words, it can also be defined as a serious difference between ideas, beliefs or interests (Kumaraswamy 1997). In Figure 13, basic relationships between conflict, claim and dispute phenomena are presented by Kumaraswamy (1997).

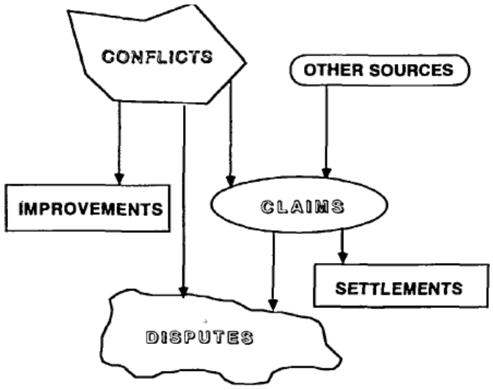

Figure 13 - Basic relationships between conflicts, claims and disputes (Kumaraswamy 1997)

In the case of an unresolved dispute, the process commonly continues to court and the litigation process commences. Litigation, by definition, is the process of initiating or appealing a legal action in court to resolve a dispute. In court, the rights or obligations of a party can be determined. There are two parties in court: the plaintiff (who brought the case) and the defendant (who defends the accusation).

In the construction industry, litigation is not uncommon due to its controversial nature and conflict-prone processes. Disputes are resolved through litigation in complex projects, unless a specific customized resolution method is specified in the contract (Mahfouz and Kandil 2009). Litigation is preferred between the parties if the execution of the decision is required (E. H. W. Chan et al. 2006) and calls for legal knowledge and expertise.

With regard to dispute resolution, litigation is often regarded as the highest quality decision-making mechanism and judgements made are binding. In addition, it involves defined appeals in possible erroneous judgments. Alongside of advantages it contains, litigation basically has 2 major drawbacks: first, it takes 2 to 6 years for a complex dispute to reach court; secondly, the process is very expensive due to the exploration process of the case (Mahfouz and Kandil 2009). Thus, many disputes arising out of construction contracts are subject to clauses that enable the parties to seek arbitration as an alternative means to dispute resolution.

As an alternative to the litigation, another traditional method of dispute resolution is arbitration. Arbitration is a specialized form of contractual dispute resolution. A third arbitrator or arbitral tribunal is designated by the parties to the dispute. Disputes are tried to be resolved with material facts, documents and applicable legal principles.

In arbitration, the entire process is administered by an arbitrator, subject to the rules of the contract and regulations framed by local courts. The right of appeal is limited and costs are usually paid to the winning party. The arbitration process, although being less formal, the arbitrator being impartial and involving a facilitating third party, is highly regulated by rules and the arbitrator carries out the process (E. H. W. Chan et al. 2006).

The differences between litigation and arbitration is presented in Table 2.

Table 2 - Litigation vs. Arbitration (S.-O. Cheung, Suen, and Lam 2002; Treacy 1995; Chau 2007)

Litigation	**Arbitration**
Legal process and the court decides the outcome.	Resolution arrived by a neutral third party and decision is binding.
Public procedure	Confidential and private procedure
Longer process	Speedier resolution
Open to appeal	Decision is final and binding, and can not be appealed except particular cases.
Court appoints the judge	Parties chooses the arbitrator
More expensive	Less costly
Rules of evidence allowed	Limited evidence

2.3.1 Factors leading to Dispute

Disputes and conflicts that lead to disputes have varied reasons. In the broadest sense, according to determination made by Chan *et al.* (2006), disputes arises from 2 main reasons: nonhomogeneous knowledge and experiences of the parties in construction law and inability to work towards a common goal due to the fact that each party has their own goals and objectives.

In the literature, there are various researchers and studies that work on the causes of disputes. In the related studies, the reasons for the dispute are divided into categories and more general and/or more specific reasons are specified as factors. Kumawarasmy (1997) demonstrated the common sources of the disputes as in Figure 14 by dividing the causes as root causes and proximate causes. Root causes are identified as unclear and unfair risk allocation, unrealistic targets, uncontrollable external events, adversarial culture of industry, unrealistic tender pricing, inappropriate contract type, lack of projects participants and clients adequate characteristics and unrealistic expectations. The proximate causes which are stemming from the root causes are identified as more specific and detailed forms of root causes, for example slow client response, inappropriate contract form. This grouping of dispute causes allows proximate causes to be traced and making it possible to control them. At the same time, this classification allows us to see which cause is emerged by external effects and which reason arises from internal dynamics of the project.

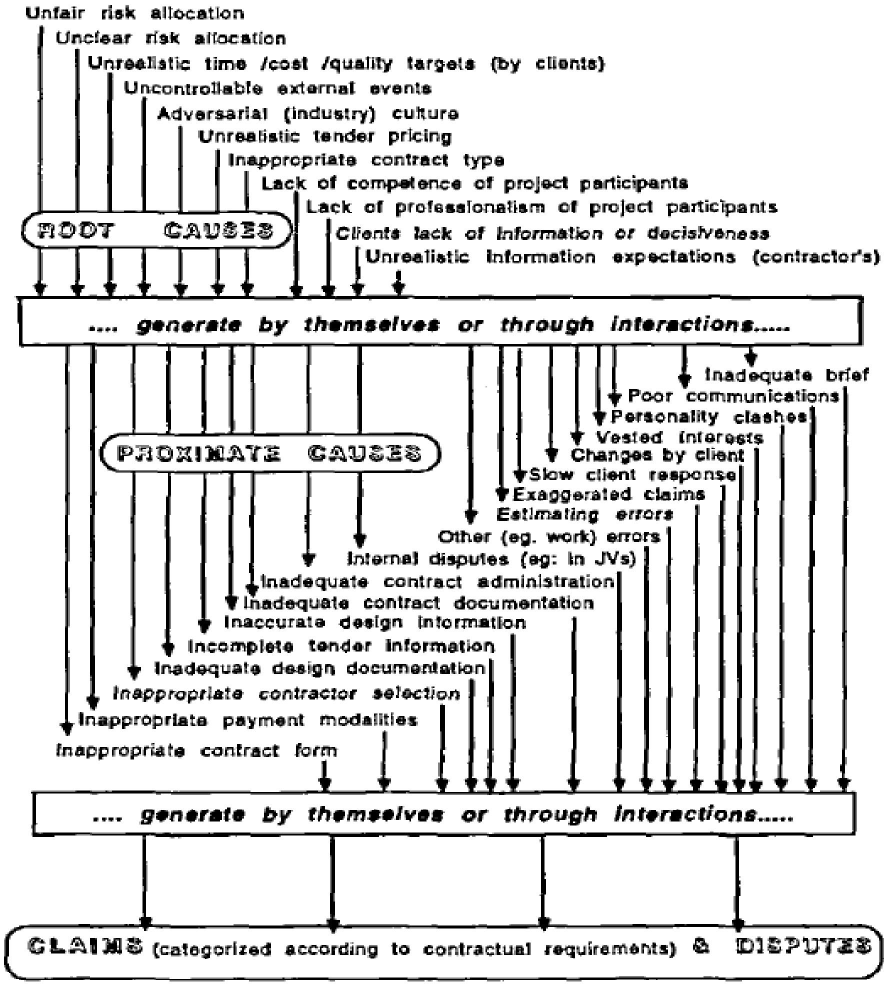

Figure 14 - Common sources of disputes (Kumawarasmy 1997)

Diekmann and Nelson (1985) categorized the claim causes of which lead to the disputes into 5 main areas: design error, changes, differing site conditions, weather and strikes. Jagannathan and Delhi (2020) classified the claim sources as change orders, cost overruns, delays and conflicts.

In the literature review carried out by Fenn (2006), the authors and factors that reveal the causes of conflicts between the parties were listed as;

- Poor design, change orders, weather and site conditions, late delivery, economic conditions, quantity increase (Al Momani 2000).

- Strikes, rework, poor organization, material shortage, equipment failure, change orders, act of God (Alkass et al. 1996).

- Scope increase, inadequate bid information, faulty or late equipment and material supplied by owner, poor qualified design and specifications, insufficient time for bidding, stop and go operations, congested areas works, acceleration to regain schedule, inadequate investigation before bidding, unbalanced bidding and underestimation (Jargeas and Hartman 1994).

- 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 2005).

- Errors, defects and omissions in contract documents, underestimating the real cost, changed conditions and stakeholders. (Kululanga et al. 2001)

- Acceleration, site access, weather and changes (Semple et al. 1994)

2.3.2 Alternative Dispute Resolutions

As a substitute to traditional dispute resolution methods, the method that expresses disputes without court is called Alternative Dispute Resolution (ADR). In ADR, conflict resolution processes and techniques are grouped without an authority and/or a state. As a result of the weaknesses and disadvantages of litigation and arbitration, such as cost, delays and oppositional relations, the rapid growth and escalation of alternative dispute resolution methods, namely conciliation, mediation, adjudication and other hybrid processes, was encouraged (S.-O. Cheung, Suen, and Lam 2002). Frustration with the litigation and arbitration processes has led to attempts to find other processes called alternative dispute resolution (ADR), which are intended to bring faster resolution to disputes(Treacy 1995).

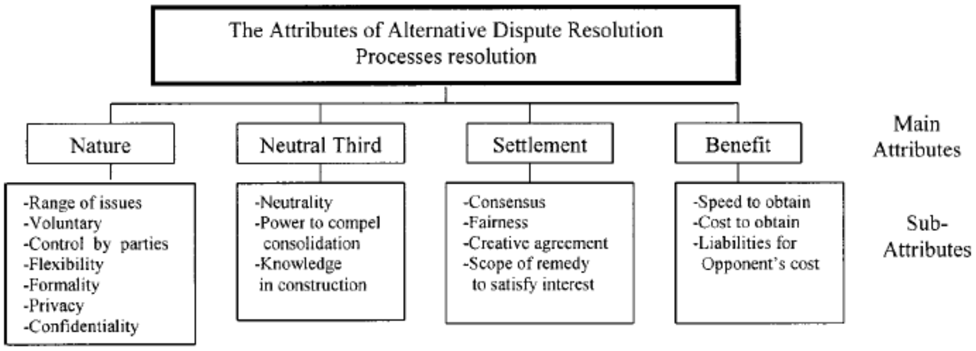

Figure 15 - Attributes of Alternative Dispute Resolution Processes (Cheung et al. 2002)

Cheung et al. (2002) defined the attributes of alternative dispute resolution processes as main attributes and sub-attributes as illustrated in Figure 15.

Mediation, which is a consent-based dispute resolution process, is a process in which a third mediator determined by the parties to the dispute tries to reach a solution through negotiation. It is similar to arbitration in that the parties employs an impartial third party and the third party manages the process. However, unlike arbitration, the appointed third party's decision is not binding and the parties to the dispute are not judged and the arbitrator but merely assists the parties during negotiations with the intention of maintaining a settlement. The mediator carries out the process through various specialized methods to disclose the source of the dispute and to reveal the win-win position (Goodkind 1988; S. O. Cheung and Yiu 2007). Through mediation, the parties protect their business relations and reputation in the industry and the mediation provides a voluntary resolution opportunity to resolve disputes (Yi and Fhkis n.d.; K.-W. Chau 1992; Cheeks 2003; K. W. Chau 2007; Yiu and Lai 2009). Cheung and Yiu (2007) suggested that the mediation is fast, cost-efficient and flexible. However, choice of the mediator is crucial for the outcome owing to the process is mediator aligned.

Adjudication involves a third independent individual (Adjudicator) who evaluates the claims of the parties to the dispute and comes to a decision. The judge is an expert on the subject of the dispute and has a questioning attitude. Decisions made are is limited binding and not final. The decision is binding until one of the parties objects through arbitration and/or litigation (Chau 2007).

Chau (2007) introduced the framework of construction disputes resolution structure in Hong Kong. As can be followed in Figure 16, the resolution process commences with mediation and proceeds with adjudication and arbitration if a settlement is not reached.

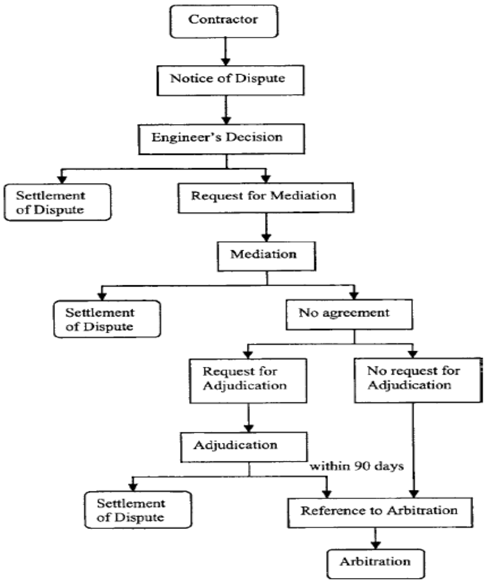

Figure 16 - Framework of Construction Dispute Resolution Processes in Hong Kong (Chau 2007)

Negotiation, in which the parties or their legal representatives try to reach a settlement through a written agreement or a meeting with the participation of all parties, conciliation, which is tried to reach an amicable settlement with the help of an independent third party, and mini-trial which is a small version of real hearing and non-binding, are the other ADR methods employed in the industry.

Apart from these, as a substitute to alternative dispute resolution methods, the dispute review board (DRB) process established during the pre-construction period is also utilized in the industry. As soon as conflicts arise, they arrive the board and a solution is sought. The owner and the contractor appoint a representative to the board, and these two representatives elect a separate 3rd individual and the board is formed. The process is governed by the protocol established.

2.3.3 Prediction of Disputes and Dispute Ambiguity Correlation

In construction projects, after the emergence of disputes, various methods of resolution, as introduced in the previous sections, have been developed and applied. These methods and tools are evaluated in terms of different characters, degrees of confidentiality, time and cost perspectives. However, the mechanisms of controlling and resolving conflicts during construction operations are limited. In addition, no matter how ideal solution is raised, the process after the dispute arises causes significant losses for the parties. Therefore, the best approach for dealing with conflicts is to anticipate and prevent conflict before it arises. In the literature, there are few researchers who move on the prediction and avoidance approach before a conflict arises. Diekmann and Girard (1995) highlighted that The Dispute Prevention and Resolution Task Force of the Construction Industry Institute (CII) introduced the approach for contract dispute prevention and resolution as “start right” and “stay right”. Start right means the use of proper contract language and the definition of an appropriate alternative dispute resolution procedure. Stay right means resolving the dispute before it becomes a complex legal issue. In addition, in their study, they tried to identify the project characteristics that could trigger conflicts and to address these characteristics before the project started. With the algorithm they developed (Boosted Decision Tree), they figured out that the category of “people”, which means organization and individuals of the major contractual parties, plays a key role in predicting disputes. Shin and Molenaar (2000) studied contract clauses by offering dispute determination as a separate part of the construction project process. The topics that evaluated critical in predicting conflicts are Change, Design/Specifications, Conditions of Contract, Works, Time/Cost, and Completion. 24 dispute files occurred in 14 projects were reviewed by Mitropoulos and Howell (2001) with an aim of revealing the actions to be taken for minimizing contractual claims and recommendations were presented as, decreasing project uncertainty, increasing organization's problem solving ability and employing alternative dispute resolution techniques.

In the previous sections, the reasons for the disputes are described as defined in the literature, and the studies/theories on the solution are introduced. Although the notion of ambiguity and/or uncertainty has been defined as a factor for dispute in many studies, the number of studies evaluating disputes with a wholistic approach over the notion of ambiguity is limited. In the first stage, project uncertainties play an important role in the emergence of a claim and a dispute (Jagannathan and Delhi 2020; S. O. Cheung and Yiu 2006; Mahfouz and Kandil 2009; Koc and Gurgun 2022b). Kumawarasmy (1997) included the "ambiguity in documents" into cost claim categories. Ambiguity in plans and specifications were introduced as entitlement issue which is source and reason of claims by Diekmann and Nelson (1985). An ambiguous word or phrase may be the focal point of the dispute. (Thomas *et al.* 1994). The main category of project uncertainties were acknowledged as root cause of claims/disputes by Jagannathan and Delhi (2020). Role ambiguity of the parties is major contributor of construction dispute(S. O. Cheung and Yiu 2007). Conditions of contracts ambiguity was classified as critical dispute characteristic by Shin and Molenaar (2000). As can be perceived, many factors that are considered as the source of dispute are mainly due to the fact that the relevant contract/project part is not clear and uncertain. The relevant contract/project part/characteristic on which the dispute is based is actually included and defined in the contract and/or project, but is not of the desired integrity and quality. This case displays the need to concentrate on the notion ambiguity.

In the previous studies on the notion of ambiguity in the literature, there is not a certain determination, evidence and/or statistical investigation referring to the contract ambiguity as a reason for dispute and its correlation with litigation. Within the scope of this thesis, a contribution is provided to the gap in the literature and a new perspective is brought to the notion of contract ambiguity.

CHAPTER 3

RESEARCH METHODOLOGY AND QUESTIONNAIRE

3.1 Research Methodology

The notion of ambiguity in construction contracts is an unwelcomed condition for each party in the contract, and the ambiguity in the contract may be a cause of dispute on its own, but also plays a key role in dispute resolution processes. As pointed out in preceding sections, if a dispute arisen between the parties are not resolved amicably, one or all of the parties may bring the dispute to the litigation and may cause considerable losses to the parties in terms of time, money and reputation as an effect of litigation process. Therefore, the litigation process is a process that neither party is willing to apply for construction projects. In this thesis, it was aimed to build a model for evaluating the potential of litigation due to contract ambiguity in international construction projects. The research was carried out by means of information collection questionnaire forms consist of questions on the FIDIC construction contracts applied in Turkey or applied by the Turkish contractors/professionals. The main motivation for shaping and distribution of questionnaire forms was to obtain real projects data rather than the opinions/remarks of individuals. The questionnaire forms were distributed to experts involved in the relevant construction project which was governed by FIDIC type of contracts.

3.2 Questionnaire Format

The questionnaire form is designed with two essential parts as given in Appendix A. General information regarding the construction contract and related project are aimed to obtain in Part I. The factors that might influence contract ambiguity are listed in Part II.

The preliminary study was carried out through examining the studies in literature concerning the notion of uncertainty/ambiguity in construction contracts and causes of the disputes with the purpose of specifying the factors and the features of the project that may arise ambiguity leads to the litigation process in a construction contract. Also, the conditions (particular/general) of the applied FIDIC contracts were reviewed. As a consequence of the preliminary study, the factors and features of the contract that may arise ambiguity in a construction contract were determined as a draft. The draft questionnaire form was finalized as in Annex A with the feedbacks of the interviews carried out with the 3 professionals experienced in the field of construction contracts including an academician, a public sector manager and a contract manager in a consulting company. The factors identified in Part II of the questionnaire are categorized as below listed:

- Factors related to liabilities of the parties
- Factors related to variation/amendment procedures
- Factors related to claim/dispute procedures
- Factors related to contractual obligations/documents
- Factors related to interpretation and grammar
- Factors related to sanctions and termination conditions

3.3 Data Collection and Application of the Research

The final questionnaire was handed out to professionals experienced in the field of FIDIC contracts and who took part in international projects governed by FIDIC contracts. First, the contract managers involved in construction projects in Turkey financed by European Union funds were reached and a questionnaire was sent to the recipients through e-mail. In addition, the questionnaire was sent via e-mail to the members of Turkish Association of Consulting Engineers and Architects (TMMOB) which is a FIDIC accredited institution in Turkey. In this way, it was possible to get information connected not only the FIDIC contracts applied in the projects in

Turkey, but also the FIDIC contracts applied in other countries by the Turkish contractors/engineers.

Part I of the questionnaire consists of 23 questions that cover the general information related to the subject contract and project are asked to the participants. In addition, for the correlation that will be tried to be established in the later parts of the analysis, dispute and/or litigation history of the project is asked whether the project subjected to dispute/litigation processes or not.

In Part II, 37 questions are asked to get respondents perception concerning the specified factors that may affect the contract completeness and ambiguity. The likert scale (0-5) is used to define the level of agreements of the respondents for the factors listed in Part II.

- 0 = N/A (Not Applicable)
- 1 = Strongly Disagree
- 2 = Disagree
- 3 = Neither Agree Nor Disagree
- 4 = Agree
- 5= Strongly Agree

Eventually, it is aimed to determine the level of effect of the factors that may create ambiguity in the international FIDIC construction contracts by means of the questions asked in the questionnaire and to reveal the correlation between these factors taking the project to the litigation process. In addition to this, it is also aimed to develop a model evaluating the potential of litigation due to ambiguity with the aid of Logistic Regression. Also, the accuracy of the model is tried to assess through Neural Network and Support Vector Machine analysis techniques.

CHAPTER 4

RESEARCH FINDINGS AND ANALYSIS

The questionnaire study was conducted with the individuals who have experience in international FIDIC contracts applied either in Turkey or applied by Turkish contractors/engineers in other countries. The desired participant group to be reached was the professionals who worked in the construction projects governed by FIDIC contracts and were familiar with the dispute/litigation processes. A total of 38 questionnaire forms belonging to the respective contracts were returned by the individuals and an overall data set was formed by the data obtained from 38 real projects. In this thesis, the scope of the construction contracts is FIDIC contracts applied in the projects in Turkey, or the projects in other countries with Turkish contractors/engineers or consultants.

4.1 General Informatıon of the Data

The total of 38 questionnaire forms data set comprises "13" contracts of projects subjected to the litigation and "25" contracts of projects completed without getting to the litigation process. In Part I of the questionnaire, general characteristics related to the subject contract and project were asked and the first information about the project/contract filled by the participants was the project type. The types of the projects are listed in Table 3 with the percentages. In the data set, building construction projects come to the fore quantitively in total, as there are various building types for different needs. However, industrial plant projects are in the lead in litigated projects. Accordingly, due to the complexity of the projects and the need for expertise in different disciplines, the incidence of disputes leading to litigation processes in industrial plant projects seems to be high considering the overall data set.

Table 3 - Types of the Project

Status	Project Type	# of Contracts	Percentage
LITIGATED	Infrastructure	2	15%
	Transportation	2	15%
	Industrial Plants	4	31%
	Pipeline	0	0%
	Building	3	23%
	Dam	0	0%
	Residential	0	0%
	Power Plant	2	15%
	Coastal Structure	0	0%
	Total	13	100%
NON-LITIGATED	Infrastructure	3	12%
	Transportation	0	0%
	Industrial Plants	3	12%
	Pipeline	3	12%
	Building	14	56%
	Dam	0	0%
	Residential	0	0%
	Power Plant	0	0%
	Coastal Structure	0	0%
	Restoration	2	8%
	Total	25	100%

In Figure 17, the distribution of the contract type in overall data set is demonstrated. *Lump Sum*, *Unit Price* and *Cost Plus Fee* types of construction contracts are the main 3 types. The basic rationale behind the formation of distinctive types of contracts is the regulation of risk allocation between the parties. According to the characteristics of the project, it is determined which type of contract would be adopted at the stage of contract preparation. In FIDIC contracts, while the Yellow Book (Conditions of Contract for Plant and Design-Build) is mostly used for lump sum contracts, the Red Book (Conditions of Contract for Construction) is mostly used for unit price contracts. Such a generalization cannot be made for cost plus fee contracts specific to FIDIC. As can be noticed in the graphics in Figure 17, the majority of the contracts in the overall data set are unit price contracts. This case also reflects the general condition of the construction sector. In addition, the fact that the lump sum contract proportion in the litigated contracts is higher than in the non-litigated contracts indicates that the risk allocation or basic characteristics in the lump sum contracts may contributes to the expectation of litigation.

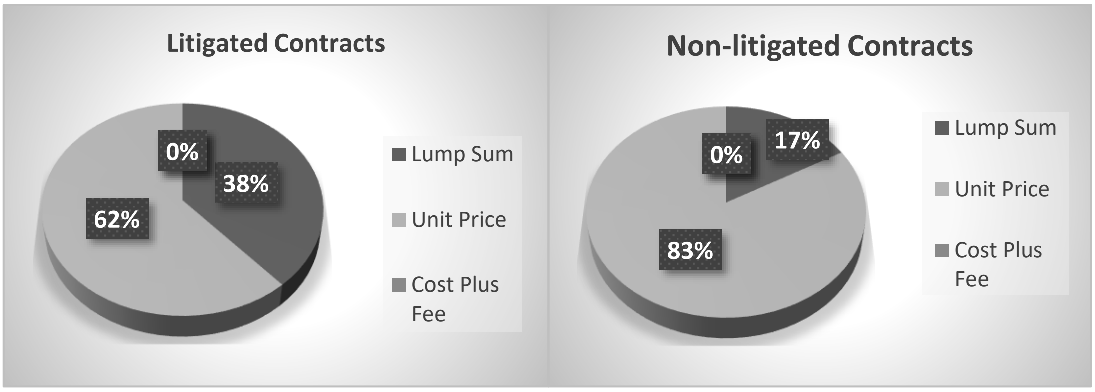

Figure 17 – Contract Type

Another factor that is considered to influence the relationship between contract ambiguity and litigation among the data received through questionnaires is the project delivery method. Various delivery methods are employed in international construction projects, yet 3 primary methods stands out in the overall data set. *Design Build* is the method where design and construction is carried out with a single contractor and is represented by the FIDIC Yellow book. *Design Bid Build* is the method where design and construction are undertaken by a separate contractor and is represented by the FIDIC Red book. *EPC Turnkey* is the method in which the contractor takes care of every stage of the project and delivers the work ready-made and is represented by the FIDIC Silver Book. Apart from these, different delivery methods are gathered in the category of others. In Figure 18, the distribution of project delivery methods in litigated and non-litigated contracts is given.

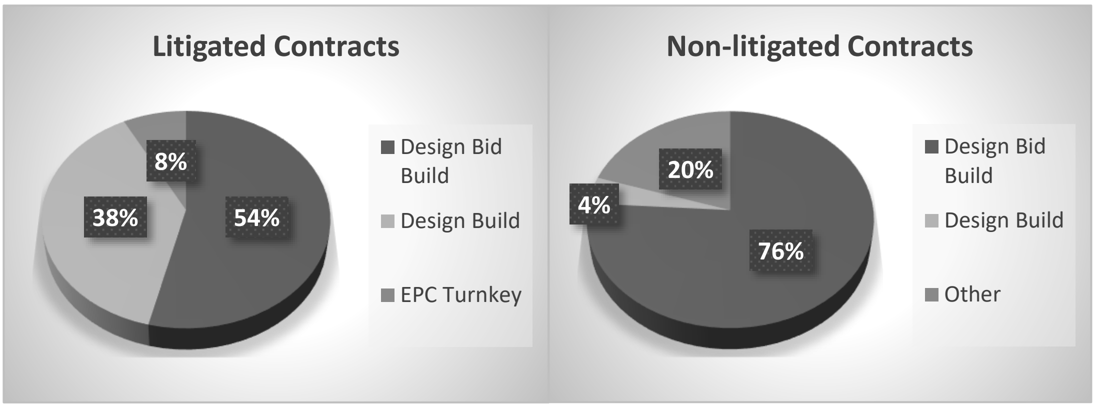

Figure 18 – Project Delivery Method

In construction tenders, the tendering institution/company establishes the form of bidding and the procedure of participation in the tender is realized according to the established form. There are essentially 3 different methods: *Open Bid with Prequalification, Open Bid without Prequalification* and *Invitational Bid*. Since the tender procedure may also affect the ambiguity of the contract, this information was also requested in the questionnaire forms and the data obtained are shown in Figure 19.

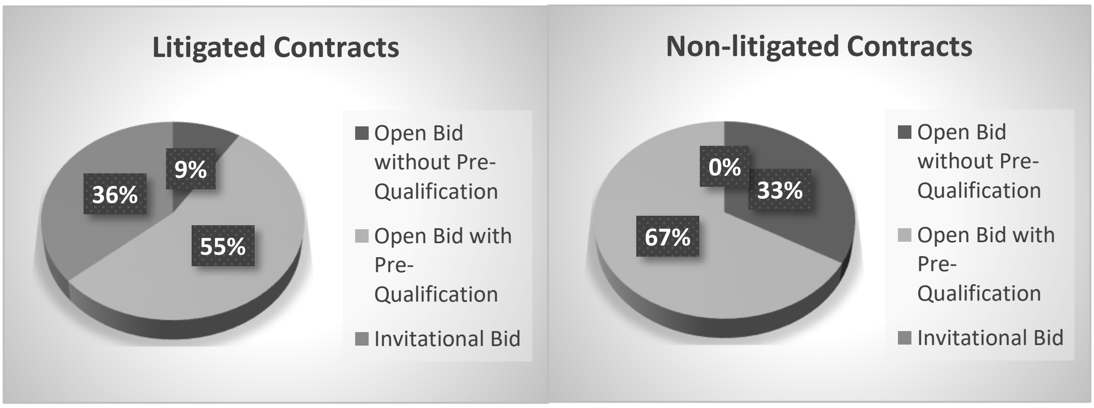

Figure 19 – Type of Bidding

Along with the type of bidding, the participants of the questionnaire were further asked about the Tender Evaluation Criteria. There are two basic approaches for tender evaluation principles. In the *Lowest Bid Amount* method, the company that offers the lowest quantitively among the bidders is awarded the tender. The *Best Value method*, on the other hand, is based on the combination of the technical evaluation of the proposals in compliance with the standards set by the owner and the numerical value of the proposal to determine an overall evaluation score. Although there are different adopted methods besides these 2 basic procedures, there are merely 2 contracts of these different procedures in the contracts examined within the scope of this thesis, and these are specified as others. Separate distribution of Bid evaluation criteria for litigated and non-litigated contracts is shown in Figure 20.

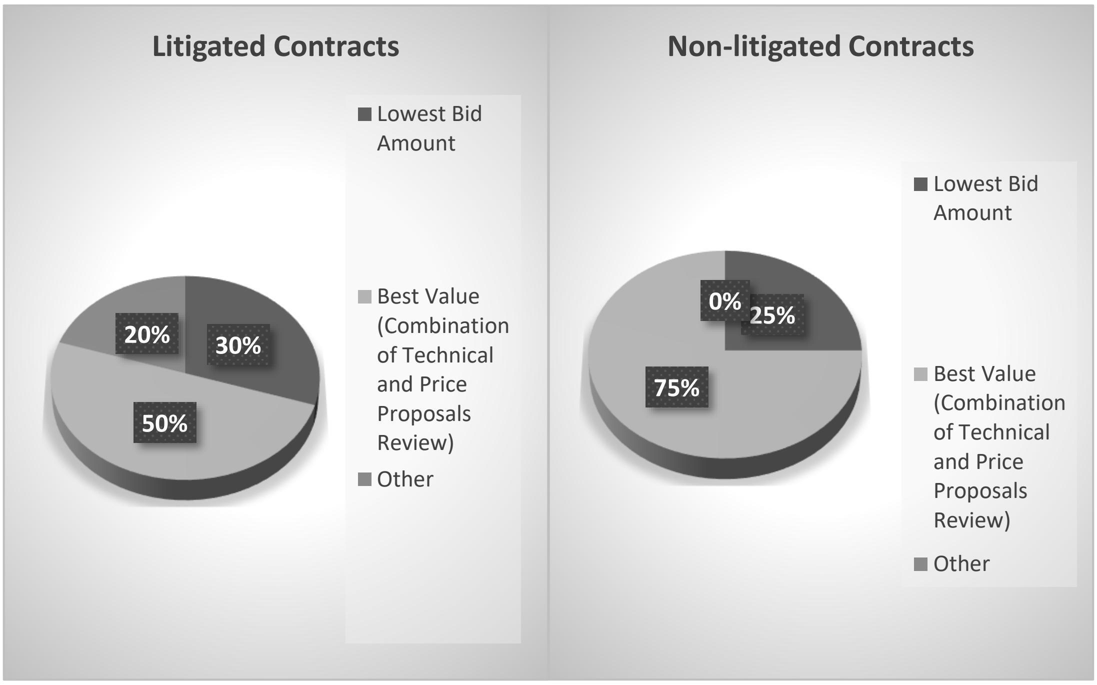

Figure 20 – Bid Evaluation Criteria

Since the other questions asked in the Part I of the questionnaire, where general information about the contract/project is requested, are not associated with the statistical model that is tried to be established in the thesis, information and statistics related to those questions and the answers received are not given in this section.

4.2 Factors Affecting Ambiguity in Construction Contracts

4.2.1 Application of t-test

The most commonly used hypothesis test among the statistical tests in which the means of two samples are compared is the *t-test* and it is also referred as *Student's t-test* (Kim 2005). Besides, for a particular datasets that are not useful for analysis using the normal distribution, t-test provides us to perform statistical analysis for the datasets. It is presumed in t-test that the sample population is normal and observations are independent (Gerald 2018). In this thesis, the *t-test* is used to determine whether the mean values of litigated and non-litigated contracts are significantly different from each other.

Student's t distribution properties are as below listed:

- The Student t distribution is different for different sample sizes.
- The Student t distribution is generally bell-shaped, but with smaller sample sizes shows increased variability (flatter). In other words, the distribution is less peaked than a normal distribution and with thicker tails. As the sample size increases, the distribution approaches a normal distribution. For $n > 30$, the differences are negligible.
- The mean is zero (much like the standard normal distribution).
- The distribution is symmetrical about the mean.
- The variance is greater than one, but approaches one from above as the sample size increases ($\sigma=1$ for the standard normal distribution).
- The population standard deviation is unknown.
- The population is essentially normal (unimodal and basically symmetric)

If we consider that a simple random sample (from Normal population) of size n with a mean "μ" and standard deviation "σ". Let "$\bar{x}$" symbolize the sample mean and “s”, the sample standard deviation. The formula of “t” with n-1 degree of freedom is:

$$t = \frac{\bar{x} - \mu}{s/\sqrt{n}} \tag{4.1}$$

There are 3 main type of t-test as below listed with its purposes (Gerald 2018):

1. *One sample t-test* is used for comparing the mean of a single variable with a known constant
2. *Two sample t-test is* used for comparing the means of two independent population
3. *Paired t-test* is used for comparing the means of two paired (or closely matched) samples

In this thesis, two sample t-test assuming unequal variances is used with an aim of testing the significance of the factors affecting the contract ambiguity and analyzing the critical “t” value. For this purpose MS Excel 2016 software is used. This analysis tool, which is performed by selecting the relevant section from the Excel Data Analysis menu, assumes that the subject is from the distribution of two independent data sets with unequal variances, and the purpose of the test is to determine whether two samples have an equal mean. Its equation is as follows:

$$t' = \frac{\bar{x} - \bar{y} - \Delta_0}{\sqrt{\frac{S_1^2}{m} + \frac{S_2^2}{n}}} \tag{4.2}$$

The degrees of freedom (*df*) is calculated with below equation;

$$df = \frac{\left(\frac{S_1^2}{m} + \frac{S_2^2}{n}\right)^2}{\frac{\left(S_1^2/m\right)^2}{m-1} + \frac{\left(S_2^2/n\right)^2}{n-1}} \tag{4.3}$$

In the initial part of the *t-test*, the mean values of two groups are compared to identify whether they are equal or not. One-tailed (one-sided) *t-test* is performed for this purpose. First, the null hypothesis and the alternative hypothesis are described. The null hypothesis is symbolized H_0 and this is a statement of population parameter. The alternative hypothesis is the reverse hypothesis of null and symbolized H_1 (Gerald 2018).

$H_0 = \mu_1 = \mu_2$ (there is no statistically significant difference between two samples means)

$H_1 = \mu_1 \neq \mu_2$ (there is a statistically difference between the two samples)

As stated above, *t-test* is implemented assuming unequal variances between two groups. This assumption is called conservative approach (Moore and McCabe 2002).The maximum tolerable likelihood for rejecting null hypothesis is represented by the significance level (alpha level) (Gerald 2018). The alpha level is determined as 95% (0.05) that means 95 time out of 100 there would be statistically significant difference between the two mean values of the groups. The next step of *t-test* is to compute the statistics. The degrees of freedom (df), and P value (T≤t (one-tail)) are computed by the MS Excel software with defined alpha value. According to the P value results of each factor, it is decided that the difference between the two groups are large enough to be statistically significant. By this means, the significant factors are specified.

4.2.2 *t-test* Findings

50 of the questions (13 contract/project information and 37 ambiguity factors) asked in 38 questionnaires obtained in total were subjected to t-test. Some questions in the questionnaire were not considered as a factor and were not included in the t-test analysis, as they were thought to have no substantial effect on contract ambiguity. The categorical answers to the questions asked in the Part I were noted as 1 and 0 for statistical analysis. For instance, contract type *(Unit Price, Lump Sum, Cost Plus Fee)* were noted “1” if the first category is valid and noted “0” if the other categories are valid. Same procedure were applied for each categorical answers. In addition, contracts were categorized as “1” and “0” respectively according to whether they are subject to litigation or not. In the Part II of the questionnaire, it is aimed to get the level of agreements of the respondents for the specified ambiguity factors using likert scale (1 to 5). Part I factors were stated by initial “C” from 1 to 13 (C01, C02, …, C13) and Part II factors were stated by initial “AF” from 1 to 37 (AF01, AF02, …, AFG37).

According to the results, factors with a P-value less than 0.05 were determined by considering the set 95% alpha level and are shown in the Table 4.

Table 4 – Significant Factors

Notation	Description	P(T<=t)one tail (p-value)
C03	Project Delivery Method (Design Bid Build or Design Build)	0.0500
C10	Type of Bidding (Open without pre-qualification or not)	0.0401
C12	Type of Financing (Owner financed or not)	0.0166
AF01	Owner's (Director/Client) responsibility structure was defined	6.82395E-05
AF02	Engineer/Consultant's authority, responsibilities and power to instruct were described.	2.58326E-06
AF03	Contractor's duties/obligations structure were defined.	0.0012
AF05	Sub-contracting conditions were set.	0.0004
AF06	Risks were defined and the allocation of its responsibilities were made	0.0017
AF07	Liability details for Contractor's organization (joint venture, consortium etc.) were set	0.0037
AF12	The terms regarding termination and suspension were explicit	0.0004
AF17	Environmental management requirements were included in the contract	0.0019
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.0387
AF21	Law of the contract and its details was specified	0.0086
AF22	Communication processes were defined	0.0001
AF23	Bonds/deductions and its sub-conditions were defined	0.0003
AF25	Superintendance and reporting procedures/necessities were determined	0.0325
AF31	Conditions of extension of time for completion and defect notification period were specified	0.0276
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	2.49245E-07
AF34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim	9.68024E-08
AF35	Interpretation rules and definitions were specified	0.0001
AF37	Conditions for administrative and financial penalties were determined	0.0006

Eventually, 21 significant factors were determined as listed in Table 4. According to the t-test results for these factors, there is sufficient evidence to reject the null hypothesis since the P-values are less than or equal to the determined alpha level and to say that there is a significant difference between the means of the 2 groups for these factors.

According to these results, for the factors of project delivery method (C03), bidding type (C10), financing type (C12), owner(employer), engineer and contractors responsibilities/obligations definitions (AF01, AF02, AF03), sub-contracting conditions (AF05), risk allocation (AF06), the liability of contractors organization (AF07), termination and suspension conditions (AF12), environmental management (AF17), progress payment procedures (AF18), the law of the contract (AF21), communication processes (AF22), the terms bonds/deductions (AF23), superintendence and reporting procedures (AF25), extension of time for completion terms (AF31), definitions of dispute resolution processes and alternative dispute resolution (ADR) (AF33), claims procedure (AF34), interpretation rules and conditions (AF35) conditions of the penalties (AF37), a significant difference was determined between litigated and non-litigated contracts.

For instance, for the factor C10 - Type of Bidding (Open without pre-qualification or not), t-test result are presented in Table 5.

Table 5 - t-test Results for C10 – ***Type of Bidding (Open without pre-qualification or not)***

	Litigated	*Non-litigated*
Mean	0.090909	0.333333333
Variance	0.090909	0.231884058
Observations	11	24
df	30	
t Stat	-1.81063	
P(T<=t) one-tail	0.040112	
t Critical one-tail	1.697261	

The p-value of C10 were calculated 0,040112 and this value is less than 0.05 which means that the null hypothesis is rejected. The results of t-test for the factors asked in Part I of the questionnaire are presented in the following Table 6 and Table 7.

Table 6 - t-test Results for C03 - *Project Delivery Method (Design Bid Build or Design Build)*

	Litigated	*Non-litigated*
Mean	0.538462	0.76
Variance	0.269231	0.19
Observations	13	25
df	21	
t Stat	-1.31668	
P(T<=t) one-tail	0.050068401	
t Critical one-tail	1.720743	

Table 7 - t-test Results for C12 - *Type of Financing (Owner financed or not)*

	Litigated	*Non-litigated*
Mean	0.384615	0.04
Variance	0.25641	0.04
Observations	13	25
df	14	
t Stat	2.359944	
P(T<=t) one-tail	0.016663	
t Critical one-tail	1.76131	

As explained above, the answers of 3 significant factors from the Part I of the questionnaire of which the t-test results are presented is categorical and the data were processed as "1" and "0". If *C10 – Bidding Type* is *Open without pre-qualification,* the answer is noted "1", otherwise the answer is noted "0". If *C03 - Project Delivery Method* is *Design Bid Build* the answer is noted "1", otherwise (*Design Build*) the answer is noted "0". Same procedure is applied to *C12 - Type of Financing*. If the answer is *Owner Financed*, it is noted "1", otherwise it is noted

“0”. The P(T<=t) one-tail (p-value) values obtained through *t-test* of the significant factors addressed in Part II of the questionnaire in which the participants ranked the factors between 1 and 5 are presented in the Table 4. Since the factors specified in Part II are directly linked to the content of the contract and determined as a result of the literature review and interviews carried out with the experts, it is considered that each of them has a significant interaction with the contract ambiguity and they were subjected to *t-test*. However, for the subsequent part of the analysis, it was checked whether there was a difference statistically large enough between the means of litigated and non-litigated contracts according to the *t-test* results of these determined factors, and those with a P-value less than 0.05 considering 95% alpha level were determined to be statistically significant.

In an overall evaluation/interpretation of t-test results of the ambiguity factors, it was revealed some factors e.g. *C09-Tender preparation days* and *AF13-Scope definitions in terms of both technical (specification, design, price schedule) and administrative (conditions of contract)* that initially presumed they may be statistically significant are not statistically significant. In other words, the weights of effect of these factors on contract ambiguity are statistically low when comparing litigated and non-litigated contracts. From another point of view, some factors that were not considered to be significant, for example *C10-Type of Bidding (Open without pre-qualification or not)* were resulted to be statistically significant according to the *t-test* outcomes. The limited data used in the analysis and/or the fact that the scope of the questionnaire study is limited by the FIDIC contracts may have caused such cases.

4.3 Model Development

In this section regression analysis, neural networks, and support vector machine methods for used to develop a model for evaluating the potential of litigation due to contract ambiguity in international construction projects. These techniques are commonly used in construction management for modeling purposes.

4.3.1 Logistic Regression

Regression analysis is an analysis technique employed to measure the relationship between two or more quantitative variables. In regression, *y* stands for dependent variable and other variables $(x_1, x_2, x_3, \ldots, x_n)$ are independent variables. Depends on the type of the distribution of *y*, regression model type is determined; it is linear regression model for continuous and approximately normal distribution of *y*, it is logistic regression for dichotomous distribution of *y* (Alexopoulos 2010). Logistic regression, a technique used for model developing in statistics, is applied to establish a model for the dependent variable (*y*) in data that can be expressed in two or more classes. In logistic regression, dependent variable can be expressed categorically such as yes-no, dead-alive, female-male (Tunç 2020). To determine the cause and effect relationship between the dependent variable and the independent variables, logistic regression is used if the dependent variable is binary or ordinal (Kaya and Yeşilova 2011). Dichotomous (two categories), unordered polytomous or polytomous nominal (three or more categories) are the types of dependent variables in logistics regression (Menard 2010). In linear regression, on the other hand, the independent variable is not typically in a certain range (such as 0-1). The aim in the linear regression equation is the estimation of the value of the dependent variable. In logistic regression, on the other side, the aim is in general to determine the probability of the dependent variable.

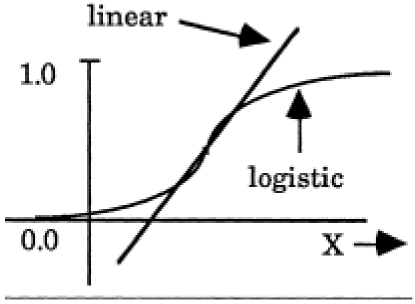

Figure 21 - Linear and Logistic Function of (4.4)

The equation of linear (4.4) regression is;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n + e \qquad (4.4)$$

Logistic regression measures the probability of an event occurring. The odds ordinarily describes the independent variables effect on the probability of an event not occurring (Park 2013). The mean of the response variable y(x) in terms of an explanatory variable x is designed with regard to y(x) and x via the equation $y(x)=\alpha+\beta x$ in logistic regression.

However, according to the Park (2013), this is not a good model, as some outliers will cause the value of y(x) not to fall between 1 and 0. In logistic regression, this problem is solved by transforming the ratios using natural logarithm and the equation (4.5) is as follows;

$$\text{logit}\,(Y) = \ln(\text{odds}) = \alpha + \beta 1\ X1 + \beta 2\ X2 + \ldots + \beta n\ Xn = \log\left(\frac{Y(x)}{1-Y(x)}\right) \qquad (4.5)$$

Y(x) is the probability of interested outcome and x is the explanatory variable. Also, having the equation 4.5, below equation (4.6) can be derived for the prediction of the probability of the occurrence of interested event;

$$Y = \frac{e^{(\alpha+\beta 1\ X1 + \beta 2\ X2 + \ldots + \beta n\ Xn)}}{(1 + e^{(\alpha+\beta 1\ X1 + \beta 2\ X2 + \ldots + \beta n\ Xn)})} \qquad (4.6)$$

Y stands for dependent variable and *x* is independent variable in the equations. The dependent variables (*x*) can be continuous, binary, ordinal. Each independent variable (x_1, x_2,…,x_n) has a coefficient (β_1, β_2,…, β_n). These coefficients are computed according to the logistic regression results. The dependent variable value is received by adding interception to the sum of the products of each independent variable and its coefficient.

Logistic regression allows the usage of continuous or categorical estimators and maintains the capability to adjust for multiple estimators. For analysis of experimental data when adjustment is required to reduce potential bias from differences in groups compared; logistic regression becomes useful by this (LaValley 2008). The assumptions of linear regression models derived from ordinary least squares (OLS) method are not required in logistic regression (Park 2013).

The assumptions of logistic regression made by Park (2013) listed;

- Logistic regression can deal with non-linear relationships between the dependent and independent variables, since it gives a non-linear log transformation of the linear regression
- Error terms (residuals) require not have a multivariate normal distribution, but multivariate normality maintains a more balanced solution
- The variance of the errors may vary for each level of the independent variables
- Both continuous data and discrete data as independent variables can be handled in logistic regression
- Dependent variable requires to be discrete dichotomous
- Dependent variable should be coded as logistic regression predicts the probability of the event occurring
- Insignificant variables should not be included to avoid over fitting and the model should be fitted accurately
- Each observation is expected to be independent and multicollinearity is undesirable
- Due to the non linear relationship, the independent variables are needed to be linearly related to the log odds of an event
- Maximum likelihood measures are less powerful than ordinary least squares (OLS) employed to predict unknown parameters in a linear regression model, so the sample size needs to be wide

In this thesis study, since the value of the independent variable (y) is categorical and it is aimed to identify where the relevant contract stands based on the ambiguity factors between litigated contracts (1) and non-litigated contracts (0), a logistic regression model has been established. A statistical model based on the correlation between the ambiguity factors as the independent variables *(x)* and the litigation status of the contracts as the dependent variable *(y)* is tried to be established by means of logistic regression.

4.3.2 Variable Elimination Process and Logistic Regression Model

The more variables that enter in a regression equation, the less error the equation possesses. However, owing to the struggle of having observations and data for each of the independent variables, time constraints and potential errors, it may become unavoidable to reduce the number of independent variables. In addition to this, excluding some irrelevant independent variables that cannot explain the correlation between dependent variable and independent variables from the equation would further increase the performance of the model. Variable selection improves predictions and reduces model complexity by removing noisy, unreliable variables (Andersen and Bro 2010).

It is not regularly possible for all of the independent variables in the logistic regression equations to be effective in explaining the dependent variable. Keeping the variables that cannot explain the error in the equation reduces the efficiency and predictive capability of the logistic regression equation. Statistical processes known as variable elimination methods are used in order to eliminate the allocation of useless resources and time to measure variables and collect data. Backward elimination, forward selection, and stepwise regression are traditional variable elimination methods, in which variables are added or deducted sequentially through mean squared error or modified mean squared error criteria (Kuo and Mallick 1960). The desired features of the statistical model tried to be established within the scope of this thesis study are simplicity, practicality, and efficient estimation performance. Therefore, the variable selection is deemed appropriate and the method of backward elimination from traditional methods is adopted. The basic stages of backward elimination were defined by Fırat (1996) and as follows:

1. Regression equation containing all variables is established
2. F partial test (or t-test) values are calculated for the variables in the regression equation.
3. The minimum value among the calculated partial F values is compared with the critical value F_k at the predetermined significance level. If $F<F_k$, the variable to which F belongs is eliminated from the regression equation.
4. The model is established for the remaining variables and the candidate variable to be eliminated is redefined by the path in step 2. The process is reiterated.
5. The process continues until there are no more independent variables to be eliminated.

In the elimination process, independent variables of which the p-values are less than predetermined 95% (0.05) significance level are eliminated one by one as above defined. Initially, the logistic regression model is developed with 21 significant independent variables belong to the ambiguity factors identified according to the *t-test* results. MS Excel 2016 software is used to develop the logistic regression models and to calculate the p-values of independent variables.

The first variable dropped from the logistic regression model is *AF02 - Engineer/Consultant's authority, responsibilities and power to instruct were described* with a p-value of 0.996. The results of first model are presented in Table 8. Also, R^2 value of Model 1 was computed 0.9208 which is a goodness of fit measure for the regression model indicating the percentage of the variance in dependent variable that the independent variables explain collectively.

Table 8- Logistic Regression Model 1

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.1381258
C10	Type Of Bidding (Open without pre-qualification or not)	0.8728053
C12	Type of Financing (Owner financed or not)	0.039953
AF01	Owner's (Director/Client) responsibility structure was defined	0.6546237
AF02	**Engineer/Consultant's authority, responsibilities and power to instruct were described**	**0.9961592**
AF03	Contractor's duties/obligations structure were defined	0.4720839
AF05	Sub-contracting conditions were set.	0.8891508
AF06	Risks were defined and the allocation of its responsibilities were made	0.2202294
AF07	Liability details for Contractor's organization (joint venture, consortium etc.) were set	0.47466
AF12	The terms regarding termination and suspension were explicit.	0.9503312
AF17	Environmental management requirements were included in the contract.	0.0392852
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.495744
AF21	Law of the contract and its details was specified	0.2136304
AF22	Communication processes were defined	0.2241703
AF23	Bonds/deductions and its sub-conditions were defined	0.4578277
AF25	Superintendence and reporting procedures/necessities were determined	0.1609204
AF31	Conditions of extension of time for completion and defect notification period were specified.	0.0064349
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.5449938
AF34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined	0.2534453
AF35	Interpretation rules and definitions were specified	0.3527745
AF37	Conditions for administrative and financial penalties were determined	0.868197

The second model set with 20 variables as shown in Table 9 and the variable belongs to the factor *AF12 - The terms regarding termination and suspension were explicit* which has the highest p-value was dropped. R^2 value of Model 2 was computed 0.9208.

Table 9 - Logistic Regression Model 2

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.12257407
C10	Type Of Bidding (Open without pre-qualification or not)	0.86715553
C12	Type of Financing (Owner financed or not)	0.03404523
AF01	Owner's (Director/Client) responsibility structure was defined	0.6439704
AF03	Contractor's duties/obligations structure were defined	0.44822398
AF05	Sub-contracting conditions were set	0.88557531
AF06	Risks were defined and the allocation of its responsibilities were made	0.19482271
AF07	Liability details for Contractor's organization (joint venture, consortium etc.) were set	0.43298164
AF12	**The terms regarding termination and suspension were explicit**	**0.9488882**
AF17	Environmental management requirements were included in the contract	0.02858723
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.47009555
AF21	Law of the contract and its details was specified	0.18968807
AF22	Communication processes were defined	0.2060107
AF23	Bonds/deductions and its sub-conditions were defined.	0.4401583
AF25	Superintendence and reporting procedures/necessities were determined.	0.14390227
AF31	Conditions of extension of time for completion and defect notification period were specified	0.00255746
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.52988217
AF34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined.	0.23182073
AF35	Interpretation rules and definitions were specified	0.33730624
AF37	Conditions for administrative and financial penalties were determined.	0.86259279

The next variable eliminated was *AF05 - Sub-contracting conditions were set* in the third model developed with 19 independent variables. The results of 3rd model are demonstrated in Table 10. R^2 value of Model 3 was computed 0.9208.

Table 10 – Logistic Regression Model 3

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.10450557
C10	Type Of Bidding (Open without pre-qualification or not)	0.8481816
C12	Type of Financing (Owner financed or not)	0.02211513
AF01	Owner's (Director/Client) responsibility structure was defined	0.61804339
AF03	Contractor's duties/obligations structure were defined	0.42877285
AF05	**Sub-contracting conditions were set**	**0.89410955**
AF06	Risks were defined and the allocation of its responsibilities were made	0.18200462
AF07	Liability details for Contractor's organization (joint venture, consortium etc.) were set	0.40633862
AF17	Environmental management requirements were included in the contract.	0.02422355
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.4509376
AF21	Law of the contract and its details was specified	0.17644154
AF22	Communication processes were defined	0.19327593
AF23	Bonds/deductions and its sub-conditions were defined	0.42334334
AF25	Superintendence and reporting procedures/necessities were determined.	0.12959739
AF31	Conditions of extension of time for completion and defect notification period were specified	0.0008624
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.50509779
AF34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined	0.21616083
AF35	Interpretation rules and definitions were specified	0.32354092
AF37	Conditions for administrative and financial penalties were determined	0.84516984

In the 4^{th} trial, the variable *C10* having a p-value 0.8716 was dropped from the logistic regression analysis conducted with 18 independent variables. R^2 value of Model 4 was computed 0.9207.

Table 11 – Logistic Regression Model 4

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.08757762
C10	**Type Of Bidding (Open without pre-qualification or not)**	**0.87161852**
C12	Type of Financing (Owner financed or not)	0.01623343
AF01	Owner's (Director/Client) responsibility structure was defined	0.61446745
AF03	Contractor's duties/obligations structure were defined	0.41457166
AF06	Risks were defined and the allocation of its responsibilities were made	0.16029731
AF07	Liability details for Contractor's organization (joint venture, consortium etc.) were set	0.38474022
AF17	Environmental management requirements were included in the contract.	0.01499238
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.44480617
AF21	Law of the contract and its details was specified	0.11473046
AF22	Communication processes were defined	0.16562065
AF23	Bonds/deductions and its sub-conditions were defined	0.39982356
AF25	Superintendence and reporting procedures/necessities were determined	0.10082429
AF31	Conditions of extension of time for completion and defect notification period were specified	0.00048314
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.35471111
AF34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined	0.19897049
AF35	Interpretation rules and definitions were specified	0.26671732
AF37	Conditions for administrative and financial penalties were determined	0.79522641

The following variable to be dropped in model 5 which the p-values of the independent variable is demonstrated in Table 12 is *AF37 - Conditions for administrative and financial penalties were determined.* R^2 value of Model 5 was computed 0.9206.

Table 12 – Logistic Regression Model 5

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.06161809
C12	Type of Financing (Owner financed or not)	0.00895809
AF01	Owner's (Director/Client) responsibility structure was defined	0.59147112
AF03	Contractor's duties/obligations structure were defined.	0.40560129
AF06	Risks were defined and the allocation of its responsibilities were made	0.14844898
AF07	Liability details for Contractor's organization (joint venture, consortium etc.) were set.	0.35801736
AF17	Environmental management requirements were included in the contract.	0.00882144
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified.	0.43096979
AF21	Law of the contract and its details was specified.	0.10621837
AF22	Communication processes were defined.	0.15024328
AF23	Bonds/deductions and its sub-conditions were defined.	0.36157122
AF25	Superintendence and reporting procedures/necessities were determined.	0.07923573
AF31	Conditions of extension of time for completion and defect notification period were specified.	0.00026827
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.27649057
AF34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined.	0.16322679
AF35	Interpretation rules and definitions were specified.	0.19338784
AF37	**Conditions for administrative and financial penalties were determined.**	**0.80451572**

The sixth regression model (Table 13) consists of 16 variables and following highest p-value 0.6080 shows the insignificance of *AF01* to the model. R^2 value of Model 6 was computed 0.9203.

Table 13 – Logistic Regression Model 6

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.056515
C12	Type of Financing (Owner financed or not)	0.007601
AF01	**Owner's (Director/Client) responsibility structure was defined**	**0.608046**
AF03	Contractor's duties/obligations structure were defined	0.346476
AF06	Risks were defined and the allocation of its responsibilities were made	0.127788
AF07	Liability details for Contractor's organization (joint venture, consortium etc.) were set	0.362871
AF17	Environmental management requirements were included in the contract.	0.006819
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.331636
AF21	Law of the contract and its details was specified	0.101588
AF22	Communication processes were defined	0.125959
AF23	Bonds/deductions and its sub-conditions were defined	0.315722
AF25	Superintendence and reporting procedures/necessities were determined	0.068145
AF31	Conditions of extension of time for completion and defect notification period were specified	7.63E-05
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.273183
AF34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined	0.15946
AF35	Interpretation rules and definitions were specified	0.165714

The results of Model 7 of logistic regression is presented in Table 14. The variable dropped in this model is *AF03 - Contractor's duties/obligations structure were defined*. With seventh model, the p-value of the independent variables appeared to fall below 0.5. R^2 value of Model 7 was computed 0.9193.

Table 14 – Logistic Regression Model 7

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.05212
C12	Type of Financing (Owner financed or not)	0.007053
AF03	**Contractor's duties/obligations structure were defined**	**0.403899**
AF06	Risks were defined and the allocation of its responsibilities were made	0.14057
AF07	Liability details for Contractor's organization (joint venture, consortium etc.) were set	0.382004
AF17	Environmental management requirements were included in the contract	0.00223
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.254912
AF21	Law of the contract and its details was specified	0.099215
AF22	Communication processes were defined	0.127544
AF23	Bonds/deductions and its sub-conditions were defined	0.2797
AF25	Superintendence and reporting procedures/necessities were determined	0.067528
AF31	Conditions of extension of time for completion and defect notification period were specified	1.78E-05
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.15609
AF34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined	0.173981

The eighth regression model results consists of 14 independent variable are given in Table 15. The next variable found insignificant "was bonds/deductions and its sub-conditions were defined" having a p-value of 0.3489. R^2 value of Model 8 was computed 0.9167.

Table 15 – Logistic Regression Model 8

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.053409
C12	Type of Financing (Owner financed or not)	0.008701
AF06	Risks were defined and the allocation of its responsibilities were made	0.212167
AF07	Liability details for Contractor's organization (joint venture, consortium etc.) were set	0.306714
AF17	Environmental management requirements were included in the contract	0.001581
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.318464
AF21	Law of the contract and its details was specified	0.113537
AF22	Communication processes were defined	0.125022
AF23	**Bonds/deductions and its sub-conditions were defined**	0.348953
AF25	Superintendence and reporting procedures/necessities were determined	0.096163
AF31	Conditions of extension of time for completion and defect notification period were specified	8.37E-06
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.116781
AF34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined	0.139924
AF35	Interpretation rules and definitions were specified	0.156915

Liability details of Contractor's factor is the following variable (AF07) in the Model 9 of logistic regression and the results are presented in Table 16. The goodness of fit value (R^2) value of Model 9 was computed 0.9134.

Table 16 – Logistic Regression Model 9

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.084154
C12	Type of Financing (Owner financed or not)	0.004837
AF06	Risks were defined and the allocation of its responsibilities were made	0.334391
AF07	**Liability details for Contractor's organization (joint venture, consortium etc.) were set**	**0.555612**
AF17	Environmental management requirements were included in the contract.	0.001823
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.137032
AF21	Law of the contract and its details was specified	0.131555
AF22	Communication processes were defined	0.125937
AF25	Superintendence and reporting procedures/necessities were determined	0.052438
AF31	Conditions of extension of time for completion and defect notification period were specified	8.53E-06
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.134027
AF34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined	0.094182
AF35	Interpretation rules and definitions were specified	0.153826

The tenth trial (Table 17) is conducted with remaining 12 variables and *AF06 - Risks were defined and the allocation of its responsibilities were made* with a p-value of 0.3951 was dropped. The goodness of fit value (R^2) value of Model 10 was calculated 0.9121.

Table 17 – Logistic Regression Model 10

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.074317
C12	Type of Financing (Owner financed or not)	0.004614
AF06	**Risks were defined and the allocation of its responsibilities were made**	**0.395185**
AF17	Environmental management requirements were included in the contract	0.001256
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.009282
AF21	Law of the contract and its details was specified	0.153085
AF22	Communication processes were defined	0.078657
AF25	Superintendence and reporting procedures/necessities were determined	0.05651
AF31	Conditions of extension of time for completion and defect notification period were specified	5.65E-06
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.090124
AF34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined	0.080039
AF35	Interpretation rules and definitions were specified	0.02486

While relatively small p-values have now appeared to be achieved, the AF34 variable was removed from the model (Table18) with a p-value of 0.1164 corresponding to the 11^{th} model results. R^2 value of Model 11 was computed 0.9094.

Table 18 – Logistic Regression Model 11

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.076181
C12	Type of Financing (Owner financed or not)	0.004654
AF17	Environmental management requirements were included in the contract	0.001413
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.010562
AF21	Law of the contract and its details was specified	0.08194
AF22	Communication processes were defined	0.063944
AF25	Superintendence and reporting procedures/necessities were determined	0.029863
AF31	Conditions of extension of time for completion and defect notification period were specified	5.28E-06
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.06133
AF34	**Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined**	**0.116428**
AF35	Interpretation rules and definitions were specified	0.032058

Twelfth step of the analysis proceeded with 10 factors and the p-values are displayed in Table 19. In this trial law of the contract factor (AF21) was dropped. R^2 value of Model 12 was computed 0.9003.

Table 19 – Logistic Regression Model 12

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.125743
C12	Type of Financing (Owner financed or not)	0.003303
AF17	Environmental management requirements were included in the contract	0.002079
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.011648
AF21	**Law of the contract and its details was specified**	**0.134403**
AF22	Communication processes were defined	0.096583
AF25	Superintendence and reporting procedures/necessities were determined	0.066898
AF31	Conditions of extension of time for completion and defect notification period were specified	5.01E-06
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.000463
AF35	Interpretation rules and definitions were specified	0.011885

Together with Model 13 and Model 14, the variables AF22 and AF25, which have the smallest p-values at each step, were excluded from the model, respectively. The results of these trials are demonstrated in Table 20 and Table 21. R^2 values of Model 13 and 14 were computed 0.8915 and 0.8828 respectively.

Table 20 – Logistic Regression Model 13

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.15299
C12	Type of Financing (Owner financed or not)	0.00497
AF17	Environmental management requirements were included in the contract	0.002162
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.004382
AF22	**Communication processes were defined**	**0.145475**
AF25	Superintendence and reporting procedures/necessities were determined	0.108426
AF31	Conditions of extension of time for completion and defect notification period were specified	1.82E-06
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.000183
AF35	Interpretation rules and definitions were specified	0.00369

Table 21 – Logistic Regression Model 14

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.05585
C12	Type of Financing (Owner financed or not)	0.004982
AF17	Environmental management requirements were included in the contract	5.1E-05
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.01082
AF25	**Superintendence and reporting procedures/necessities were determined**	**0.183883**
AF31	Conditions of extension of time for completion and defect notification period were specified	8.97E-07
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	0.000172
AF35	Interpretation rules and definitions were specified	0.007346

In the Model 15, the significance level of 0.05 is satisfied except *C03 – Project Delivery Method* variable. The backward elimination process is stopped at this stage since it was considered that C03 should be included in the model even if the p-value of the variable was not below the predetermined significance level but close to the significance level. The logic behind the determination to include C03 in the model is that it is perceived as a result of literature review and preliminary study that the project delivery method would contribute to the ambiguity of the contract and the probability that this ambiguity would take the contract to litigation process. The results of final model of logistic regression are shown in Table 22. R^2 value of final model was computed 0.8753.

Table 22 – Logistic Regression Model 15

Notation	Description	*P-value*
C03	Project Delivery Method (Design Bid Build or not)	0.087619
C12	Type of Financing (Owner financed or not)	0.010655
AF17	Environmental management requirements were included in the contract.	7.41E-05
AF18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified	0.013008
AF31	Conditions of extension of time for completion and defect notification period were specified	1.49E-06
AF33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	9.54E-05
AF35	Interpretation rules and definitions were specified	0.010097

As the completion of the backward elimination process with the 15^{th} model, the coefficients of the equation are presented in Table 23 and logistic regression equation is formed as follows;

$$Y = \frac{e^{(18.4318+0.3922*C03-0.0948*C12-2.3564*AF17+2.4637*AF18-1.2199*AF31-0.3957*AF33-5.1052*AF35)}}{(1 + e^{(18.4318+0.3922*C03-0.0948*C12-2.3564*AF17+2.4637*AF18-1.2199*AF31-0.3957*AF33-5.1052*AF35)})} \qquad (7)$$

Table 23 – Logistic Regression Coefficients of Model 15

Notation	Coefficients
Intercept	18.4318
C03	0.3922
C12	-0.0948
AF17	-2.3564
AF18	2.4637
AF31	-1.2199
AF33	-0.3957
AF35	-5.1052

In Table 24, the results of Logistic Regression Model are presented.

Table 24 - Logistic Regression Model Results

	coeff	***s.e.***	***Wald***	***p-value***	***exp(b)***
intercept	18.4318	10.71828	2.957238	0.085494	9.89E-09
C03	0.3922	0.850738	0.212514	0.087619	0.67558
C12	-0.0948	0.751637	0.015924	0.010655	1.099492
AF17	-2.3564	1.541229	2.337493	7.41E-05	10.5525
AF18	2.4637	1.705221	2.087484	0.013008	0.085117
AF31	-1.2199	0.748842	2.654019	1.49E-06	3.387023
AF33	-0.3957	0.42448	0.868925	9.54E-05	1.485399
AF35	-5.1052	3.482927	2.148481	0.010097	164.8721

s.e stands for standart error, *Wald* value is used to interpret if the variable is significant or not, *p-value* help determine if the relationship observed in the sample also exist in the larger population and *exp(b)* or the *odds ratio* is the predicted chance in odds for a unit increase.

Logistic regression assumes that the dependent variable is a stochastic event and considers the probability of the event being or not. If the probability of occurrence is > 0.5, it is considered the event is happened, if it is <0.5, it is considered the event is not happened.

In our study;

Y = 1 is accepted in case of presence of litigation

Y = 0 is accepted in case of litigation is not presence

According to the logistic regression model, Y is the probability of litigation based on the ambiguity factors. It is presumed that if Y>0.5 litigation is expected and if Y<0.5 litigation is not expected.

As a result of the analyzes carried out up to this stage, the logistic regression model is established with statistically significant factors, but it is also necessary to review whether the model provides logical results. For this purpose, the relationships suggested by the model were tested by giving a score between 1 and 5 for each independent variable and keeping the remaining independent variables at the average value of 3. This procedure was applied for each independent variable one by one. No situation contrary to the general contract logic has been identified.

In order to demonstrate the application of the model, the properties of an imaginary contract are accepted and the model is looked at with the following values;

Suppose; *C03*=1, *C12*=1, *AF17*=2, *AF18*=3, *AF31*=5, *AF33*=4 and *AF35*=3

It is a design-bid-build and owner financed project, the requirements of environmental management is not defined sufficiently in the contract, the procedures of progress payments are specified in sufficient level, time extension and defects notification conditions are comprehensively set, dispute resolution processes are specified sufficiently and interpretation rules are satisfactory in the contract.

The logistic regression model gives the result Y= 0.1693 < 0.5 meaning that litigation possibility is less and it is not expected depending the ambiguity factors.

4.3.3 Model Validation

In this section, the performance of the logistic regression model is examined. The accuracy (% correct classification) of the model is measured with the K-fold cross validation method. The data set is randomly divided into 5 separate folds and 20% of the data is selected as the validation set and the remaining 80% as the training set. Cross Validation would allow us to understand if the high performance of the model is random. In this way, the prediction performance of the logistic regression model is evaluated.

The software embedded in MS Excel 2016, which is employed for logistic regression analysis, also presents confusion matrixes (classification matrixes) to illustrate the accuracy of the model.

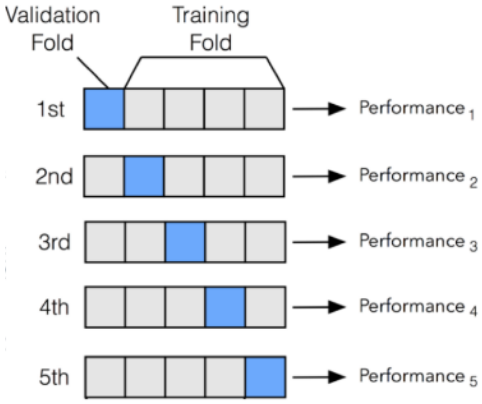

Figure 22 - K-fold Cross Validation

After creating confusion matrices for each fold, the performances of the models are calculated by Percent Correct Classification (PCC).

$$\text{PCC} = \frac{\text{Percent of Correct Classifications}}{\text{Total Number of Classifications}} \quad (4.8)$$

		Observed Classes (Reference)	
		Negative	Positive
Predicted Classes	Negative	a	b
	Positive	c	d

Figure 23 – Confusion Matrix

According to the letters represented in Figure 23, model accuracy is calculated as follows;

$$PCC = \frac{a+d}{a+b+c+d} \tag{4.9}$$

The results of the 5 fold cross validation using confusion matrixes and Formula (4.8) is summarized in Table 25.

Table 25 - Prediction Performance of Logistic Regression Models

	Accuracy(%Correct Classification)
Test Model 1	85.71%
Test Model 2	62.50%
Test Model 3	75.00%
Test Model 4	75.00%
Test Model 5	71.42%
Average Prediction Performance	**73.92%**

As can be observed from the results presented in Table 25 and Table 26, the prediction performance of the model varies between 71% and 85%, and the average prediction performance of the logistic regression model appears to be 73.92% that means approximately 74 times out of 100, the model predicts the correct classification.

In Table 26, the classification values of the model's total successful and failed predictions are shown. According to the PCC method, the ratio of correct classifications to total classification was calculated as 0.74 (74 %).

Table 26 – Confusion Matrix of Cross Validation of Logistic Regression Model

		Observed Classes		
		Succesful	Failed	
Predicted Classes	Succesful	18	6	24
	Failed	4	10	14
		22	16	38
				0.74

In order to assess the performance of the logistic regression model, it is tried to establish a neural network model and a support vector machine model with the significant variables specified as a result of backward elimination process. Thus, through comparing the prediction performances of these models with the performance of the logistic regression model, the model that reveals the relation between contract ambiguity and litigation with the most accurate identification would be decided.

4.3.4 Neural Network and Support Vector Machine Models

4.3.4.1 Neural Network Model

Artificial *neural networks* emerged by virtue of mathematical modeling of the learning process by taking the human brain as an example. Investigators tested successfully establishing certain levels of intelligence on silicon influencing the sophisticated functionality of human brains where hundreds of billions of interconnected neurons process information in parallel (Wang 2003). Artificial *neural networks* are a subdivision of machine learning and are in central to deep learning algorithms. In *neural networks*, inspired by the human brain, names and structures mimic the action biological neurons deliver signals to each other ("What Are Neural Networks?" 2020). According to Tolon and Tosunoğlu (2008) the advantages and disadvantages of artificial neural networks are listed as;

Advantages:

- Neural networks can learn from preceding experience, once trained they can immediately respond to a new dataset. It can explain other cases starting from one case.

- Artificial neural networks do not need a mathematical model. In the artificial neural network literature, no certain assumption has been identified for the use of data in the training of the artificial neural network.

- Artificial neural networks can intelligently reveal unknown relationships based on data immediately. This feature of networks is important from an application point of view.

Disadvantages:

- Structure content can not be recognized. Therefore, in some cases it can be challenging to evaluate the results of networks.

- They may not turn up a particularly suitable solution in dealing with a problem or they may make mistakes. This is because there is no function to train the network. In some cases, even if the function is found, not enough data can be found.

- They require a long time to be trained and therefore cost time and money.

- It can be troublesome to adapt to different systems.

- The quality and capacity of the network is proportional to its speed in implementation. So much so that even an increase in the number of nodes can lead to a much longer time.

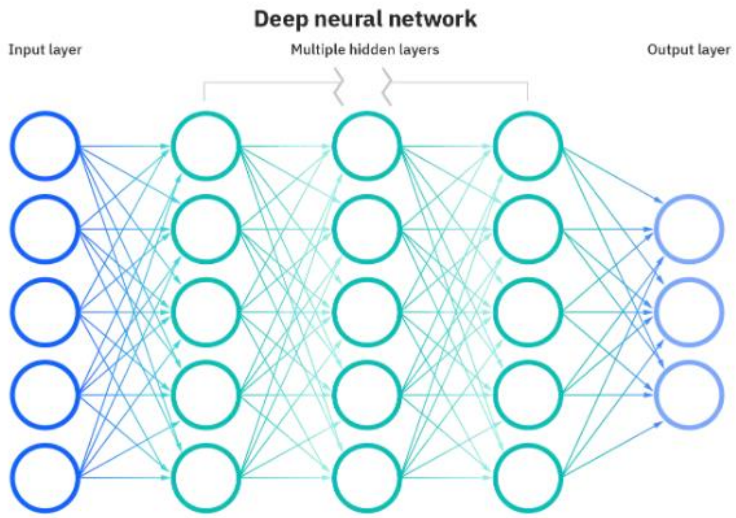

Figure 24 – Neural Network Structure

The structure of *neural networks* are presented in Figure 24. Artificial *neural networks* (ANNs) are formed of an input layer, one or more hidden layers, and an output layer. Each node, or artificial neuron, attaches to another and takes an associated weight and threshold. In our case, the input layer represents independent variables (ambiguity factors) and output layer represents dependent variable (litigation possibility depending ambiguity factors).

In this thesis study, a software called Vaimal embedded to MS Excel 2016 is used to train the data and establish an artificial *neural network* model. The network was formed with 7 independent variables detected as a result of the backward elimination process and it was created with the multilayered perceptron (MLP) as a feedforward type and the hyperbolic tangent function was designated as the activation function. In addition, network consisted of 4 hidden neurons in the hidden layer which is half of the summation of the number of independent variables (number of neurons in the input layer) and the dependent variable (number of neurons in the output layer).

Once the data is trained with backpropagation algorithm, a function called the cost function is adopted to measure the accuracy of the model. This function is also commonly referred as mean square error (MSE) and it is as follows;

$$\text{Cost Function} = \frac{1}{2m} \sum_{i=1}^{m} (\bar{y} - y)^2 \qquad (4.10)$$

i represents the index of the sample,

$\bar{y}$ is the predicted outcome,

y is the actual value, and

m is the number of samples

The prediction performance of the established *neural network* model was investigated by implementing five-fold cross validation technique with the same 5 test subsets (validation and training folds) which were also used to determine the performance of the logistic regression model.

Table 27 - Prediction Performance of Neural Network Models

	Accuracy (%Correct Classification)
Test Model 1	85.71%
Test Model 2	62.50%
Test Model 3	75.00%
Test Model 4	62.50%
Test Model 5	75.00%
Average Prediction Performance	**72.14%**

The results of five fold cross validation performance of *neural network* model can be observed in Table 26, the prediction performance of the model varies between 62% and 85%, and the average prediction performance of the *neural network* model comes out to be 72.14% that means almost 72 times out of 100, the model predicts the correct classification.

4.3.4.2 Support Vector Machine Model

Support vector machine (SVM), one of the managed learning methods, are commonly applied in classification problems and are employed to separate points located on a hyperplane by marking a line. The purpose here is to ensure that this line is at the maximum distance for the points of both classes. It is convenient for complex but small to medium datasets. SVMs performs on the basis of structural minimizing principle from computational learning scheme. Support vector machines incorporate the strengths of traditional statistical methods, which are theoretical and simple to analyze, and machine learning methods that are data-based, distributionfree and robust, and for this reason it has attraction in recent years (Huang et al. 2004). The SVM carries the potential to deal with extremely large feature spaces as the training of the SVM is implemented in such a state that the size of the classified vectors does not have as much of an impact on the performance of the SVM as it does on the performance of the traditional classifier(Widodo and Yang 2007). This is why SVM draws recognition especially in large-volume classification problems.

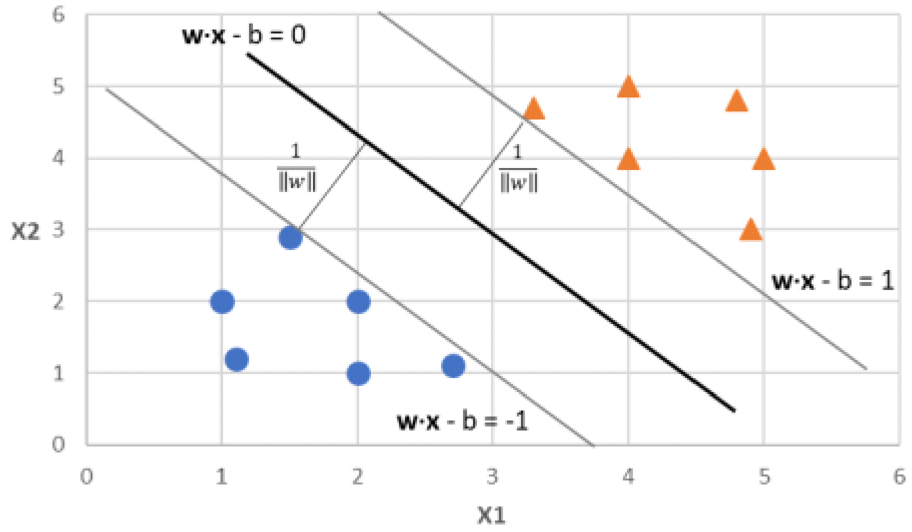

Figure 25 – Linear Support Vector Machine

In linear SVM, The binary classifier is determined by;

$$f(x) = \mathrm{sgn}(w \,.\, x - b) \tag{4.11}$$

As can be observed in Figure 25, the distance between the hyperplanes is $\frac{2}{\|w\|}$ and it is aimed to minimize the magnitude of the *w* vector.

All data are not linearly separable and the dataset we worked in our study is not linearly separable. Therefore, non-linear SVM that maps the feature space to higher dimensions that can allow the data to be seperable was employed. Radial basis function referred as Gaussian was chosen as Kernel function. The default values of Vaimal for penalty parameter *C*, convergence tolerance and gamma were used to construct the litigation/no litigation support vector machine.

After the data is trained, the prediction performance of the constructed *support vector machine* model was examined by implementing five-fold cross validation technique with the same 5 test subsets (validation and training folds) which were also used to determine the performance of the logistic regression model.

Table 28 – Prediction Performance of Support Vector Machine

	Accuracy (%Correct Classification)
Test Model 1	71.42%
Test Model 2	50.00%
Test Model 3	75.00%
Test Model 4	87.50%
Test Model 5	71.42%
Average Prediction Performance	**71.07%**

The results of five fold cross validation performance of *support vector machine* model can be observed in Table 27, the prediction performance of the model varies between 50% and 87%, and the average prediction performance of the *support vector machine* model comes out to be 71.07% that means approximately 71 times out of 100, the model predicts the correct classification.

4.3.5 Comparison of the Prediction Performances of the Models Established

The prediction performances of three different models developed to estimate the potential of of a litigation due to contract ambiguity at the contract preparation stage are shown in Table 28. After the development of the logistic regression model, it was needed to establish a neural network model and a support vector machine model to verify whether the prediction performance would be enhanced or not. Consequently, improvement has not been observed in prediction performance, and logistic regression model offers better prediction performance.

Table 29 - Comparison Table of Established Models Prediction Performances

Average Prediction Performances	**Accuracy (%Correct Classification)**
Logistic Regression Model	73.92%
Neural Network Model	72.14%
Support Vector Machine Model	71.07%

In order to determine whether there is a significant difference between the prediction performances of 3 different models, logistic regression vs. neural network and logistic regression vs. support vector machine comparison was made with the help of *paired t-test*. MS Excel software was employed in this analysis and *paired t-test* results are displayed in Table 29 and Table 30.

Table 30 – Logistic Regression vs. Neural Network

	Logistic Regression	*Neural Network*
Mean	0.73926	0.72142
Variance	0.00695	0.009659
Observations	5	5
Pearson Correlation	0.779919	
Hypothesized Mean	0	
df	4	
t Stat	0.644684	
P(T<=t) one tail	0.277121	
t Critical One Tail	2.131847	

Table 31 – Logistic Regression vs. Support Vector Machine

	Logistic Regression	*Support Vector Machine*
Mean	0.73926	0.71068
Variance	0.00695	0.018239
Observations	5	5
Pearson Correlation	0.590325	
Hypothesized Mean	0	
df	4	
t Stat	0.585917	
P(T<=t) one tail	0.294699	
t Critical One Tail	2.131847	

Eventually, in this thesis research, it was deduced that the logistic regression model to be employed in evaluation of the potential of a litigation due to contract ambiguity in the contract preparation phase of international FIDIC contracts. Correspondingly, equation (4.7) is proposed for evaluation of the potential of a litigation due to contract ambiguity in international FIDIC contracts. Despite the fact that there is a slight difference and correlated results (Table 29 and Table 30) between the performance of the logistic regression model compared to the neural network and support vector machines which are 73.9%, 72.1% and 71.0% respectively as it was also verified through paired t-tests (p-values > 0.05 which means there is not significant difference between the mean values, pearson correlation (r) values are between 0.4 and 0.8 that means the models performances are mid or high level correlated), the logistic regression model was preffered as it provides an easy to develop and easy to use and understand model compared to the neural network and support vector machine models. However, if it was intended, neural network and/or support vector machine could be used to evaluate the potential of litigation due to contract ambiguity since the statistical results are satisfying.

CHAPTER 5

CONCLUSIONS

In the construction projects and the contracts, the targets and purposes for the elements that are directly or indirectly part to this contract may differ from each other and this is considered natural in terms of the contract and the project philosophy. In addition to the varied perspectives of the parties to the projects, such attributes as the dynamics of the construction industry and the sector, its severe and complex structure, the production processes that cannot be repeated precisely in the same way, reveal the importance of the contract for a smooth project management. With reference to the contract's importance briefed above, it is emphasized in this thesis study that the disputes that may arise between the parties during the implementation phase and that may be subject to litigation, could dealt with in the contract preparation phase through the notion of ambiguity in the contract. A statistical model to propose to predict the ambiguity level of the international FIDIC contracts and evaluate the potential of a litigation due to contract ambiguity for this purpose is introduced.

Based on the fact that litigation processes cause considerable losses for disputed parties in construction projects, diversified investigations in literature have been put forward to figure out the root causes of the disputes, to phase out these reasons, to avoid disputes and to constitute alternative dispute resolution processes. In these studies in literature, the causes of disputes were focused on by bringing them to numerous categories and interpretations were conducted on the results stem from these reasons. However, no study that addresses the causes of disputes and its consequences arising from the notion of ambiguity has not been carried before. In this thesis study, the disputes arising in international FIDIC contracts and the projects governed by these contracts and the relation of disputes to litigation are discussed. A model that evaluate the potential of a litigation due to contract ambiguity is developed and the relationship between ambiguity factors and litigation has been introduced. The model developed is an instrument to be used for evaluating the effects of ambiguity to potential of litigation rather than a prediction of litigation.

If the ambiguity factors that may cause litigation are eliminated during the contract preparation stage, it would hinder a considerable loss of time and money for the parties to the contract. At the same time, undesirable positions can be avoided for the parties that are not directly party to the contract but indirectly involved in the project. If any factor of ambiguity that is impossible to eliminate at that stage is identified, alternative dispute resolution processes can be included in the contract and reduction of the losses can be pursued.

Within the context of this thesis, it is reviewed why conflicts arise in construction projects, the reasons for these conflicts, settlement methods and potential consequences. These disputes are approached through the notion of ambiguity and statistical analysis techniques are used to effectively define this concept and to determine contract ambiguity. For this purpose, associated studies in the literature were examined, interviews were held with professionals from the sector and ambiguity factors were determined. A questionnaire form was designed in which the level of agreements of the participants to these factors were asked and general project/contract information was requested, and information on international FIDIC contracts that were implemented or being implemented and that somehow involve a Turkish element were gathered. With the real contract cases received, the overall data set consisted of 13 litigated contracts and 26 non-litigated contracts. 50 questions were asked to the participants through questionnaire and statistical analysis was initiated by subjecting these 50 factors to the t-test, and as a result, 21 significant factors were determined. Subsequently, 21 significant factors were subjected to the backward elimination process so as to specify the independent variables for the model to be formed in the next stage. In order to evaluate the performance of the established logistic regression model, the k-fold cross validation technique was employed. In addition, neural network model and support vector machine model were formed with the significant factors persisting as a result of backward elimination, and the performances of these models were examined through cross validation using the same folds practiced in logistic regression. Eventually, the model with the most successful prediction performance stood out as the logistic regression model.

There are wide variety of factors in contracts, complex or simple, that can constitute ambiguity and lead to specific types of disputes. These ambiguity factors are handled systematically and categorically, and the relationship between disputes and litigation processes provoked by these disputes is revealed in this thesis. Certainly, contract and project management is not a field that suggests definite rules and results in every case, since it involves the human factor. In this sense, the proposition that the established statistical model would present definite results in all cases would not be true. However, it can be claimed that a consistent and successful model is proposed with the real contract data used and the statistical analysis providing satisfactory results. The ultimate model asserts that the project delivery method, funding source, environmental management, progress payment procedure, time extension and defects notification period conditions, dispute resolution methods and alternative procedures and interpretation rules play a key role in the relationship between contract ambiguity and litigation.

The established model will be specifically useful for the professionals in contracting party or for those who require to identify the ambiguities in the contract during the tender phase and create a bid strategy accordingly. In this way, potential losses of time, money and reputation will be prevented or limited. It is also a model that would contribute to essential stages of project and contract management, such as risk identification, distribution, and determination of the amount of contingency. The developed model identifies the effect of ambiguity factors on the litigation potential rather than a litigation prediction, and is an instrument to be used in addition to other project/contract elements while assessing the likelihood of a contract/project get to litigation.

Notwithstanding the statistical outputs received seem healthy, the result of the model is directly dependent to the quality and size of the data. In this sense, this model can be improved in the future studies with larger datasets and varied contract information and therefore more robust models can be proposed on the concept of ambiguity for international construction contracts.

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APPENDIX A

SAMPLE QUESTIONNAIRE FORM

A MODEL FOR EVALUATING THE POTENTIAL OF LITIGATION DUE TO CONTRACT AMBIGUITY IN INTERNATIONAL CONSTRUCTION PROJECTS

The complexity and unclarity of contract documents may lead conflicts and disputes between the parties of contract and litigation, which is challenging process in terms of money and time for either party, may be proceeded. The purpose of this study is to identify the factors that cause **ambiguity** and affect completeness in international construction contracts. By this means, a model that evaluates the potential of a litigation due to contract ambiguity is proposed and correlation of ambiguity with litigation of construction projects will be investigated.

The following questionnaire consists of two main parts and both parts shall be filled for an “international” construction project which has been either completed or about to be 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, international owner or international funding. 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 that resulted with litigation. If you wish to provide information of several projects, for each project please fill a separate questionnaire.

- **PART I** questions that cover the general information related with the subject contract and project.

- **PART II** of the questionnaire is a list of factors that might have an effect on contract ambiguity.

Taking in to account the conditions of the subject international construction contract for each factor please indicate your level of evaluation using a scale of 1-5, by simply marking the related box with an "x". If given situation is not applicable or that term in not included in the subject contract please select *NA-Not Applicable* column. This questionnaire takes about 10-15 minutes to complete. Your questionnaire responses will be strictly confidential and data from this research will only be used for academic purposes.

If you are interested the results of the study will be gladly shared with you. Thank you very much for your time and support.

PART I - GENERAL INFORMATION ABOUT CONTRACTS	
Project Type	☐ Infrastructure ☐ Transportation ☐ Industrial Plants (Refinery, Factory etc.) ☐ Pipeline ☐ Building (Hospital, Hotel etc.) ☐ Dam ☐ Residential ☐ Power Plant ☐ Coastal Structures ☐ Other, please specify
Contract Conditions	☐ FIDIC ☐ Non-FIDIC
Contract Type	☐ Lump Sum ☐ Unit Price ☐ Cost Plus fee ☐ Time and Materials ☐ Other, please specify
Project Delivery Method	☐ Design Bid Build ☐ Design Build ☐ Other, please specify
Project Location (Country)	
Total Project Budget	
Contract Currency	☐ Turkish lira (TRY) US Dollar ($) ☐ Euro (€) ☐ 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	☐ Open Bid without Pre-Qualification ☐ Open with Pre-Qualification ☐ Invitational Bid ☐ Other, please specify
Bid Evaluation Criteria	☐ Lowest Bid Amount ☐ Best value (Combination of Technical and Price Proposal Reviews) ☐ Other, please specify
Type of Financing	☐ Finance Organizations - Banks ☐ Contractor Financed ☐ Owner Financed ☐ Other, please specify
Owner's Origin	
Other Partners' (if any) Origin	1- 2- 3-
Were there any litigation process during the project?	☐ Yes ☐ No
Please state the amount of dispute subject to the litigation (if any)	
Simply describe the cause of litigation	
Were there any dispute process during the project?	☐ Yes ☐ No
Simply describe the cause of dispute	
Which below specified factor was related to the dispute subject to the litigation, if so?	

PART II - FACTORS AFFECTING CONTRACT COMPLETENESS AND AMBIGUITY							
No	Description	(0)	(1)	(2)	(3)	(4)	(5)
		NA – Not Applicable	Strongly Disagree	Disagree	Neither Agree Nor Disagree	Agree	Strongly-Agree
1	Owner's (Director/Client) responsibility structure was defined	☐	☐	☐	☐	☐	☐
2	Engineer/Consultant's authority, responsibilities and power to instruct were described.	☐	☐	☐	☐	☐	☐
3	Contractor's duties/obligations structure were defined.	☐	☐	☐	☐	☐	☐
4	The responsibilities and the process of setting out and site access were defined.	☐	☐	☐	☐	☐	☐
5	Sub-contracting conditions were set.	☐	☐	☐	☐	☐	☐
6	Risks were defined and the allocation of its responsibilities were made	☐	☐	☐	☐	☐	☐
7	Liability details for Contractor's organization (joint venture, consortium etc.) were set.	☐	☐	☐	☐	☐	☐
8	If this is a remeasurement contract, the conditions and the limitations on measurement and evaluation were set.	☐	☐	☐	☐	☐	☐
9	The conditions, limitations, referrals and methods to be used for determining new unit rates were established.	☐	☐	☐	☐	☐	☐
10	Escalation conditions on unit rates were specified.	☐	☐	☐	☐	☐	☐
11	Definition of use extent of provisional sum/contingency was made.	☐	☐	☐	☐	☐	☐
12	The terms regarding termination and suspension were explicit.	☐	☐	☐	☐	☐	☐

PART II - FACTORS AFFECTING CONTRACT COMPLETENESS AND AMBIGUITY							
No	Description	(0) NA – Not Applicable	(1) Strongly Disagree	(2) Disagree	(3) Neither Agree Nor Disagree	(4) Agree	(5) Strongly-Agree
13	Scope definitions in terms of both technical(specification, design, price schedule) and administrative (conditions of contract) were clearly made.	☐	☐	☐	☐	☐	☐
14	Health and safety measures to be taken and its responsibilities were established	☐	☐	☐	☐	☐	☐
15	Expected quality of works and materials were defined in technical contract documents(specification, design, price schedule)	☐	☐	☐	☐	☐	☐
16	Work program requirements and milestones were detailed.	☐	☐	☐	☐	☐	☐
17	Environmental management requirements were included in the contract.	☐	☐	☐	☐	☐	☐
18	Progress payment procedures (thresholds, time limits, deductions, exchange rates etc.) were clearly specified.	☐	☐	☐	☐	☐	☐
19	Defect Notification Period responsibilities, processes and requirements were detailed.	☐	☐	☐	☐	☐	☐
20	The order of precedence (priority of contract documents) was established	☐	☐	☐	☐	☐	☐
21	Law of the contract and its details was specified.	☐	☐	☐	☐	☐	☐
22	Communication processes were defined.	☐	☐	☐	☐	☐	☐

PART II - FACTORS AFFECTING CONTRACT COMPLETENESS AND AMBIGUITY							
No	Description	(0) NA – Not Applicable	(1) Strongly Disagree	(2) Disagree	(3) Neither Agree Nor Disagree	(4) Agree	(5) Strongly-Agree
23	Bonds/deductions and its sub-conditions were defined.	☐	☐	☐	☐	☐	☐
24	Details of insurances and liabilities were elaborated.	☐	☐	☐	☐	☐	☐
25	Superintendence and reporting procedures/necessities were determined.	☐	☐	☐	☐	☐	☐
26	Details regarding specifications and drawings (who will be responsible caring and supplying the documents etc.) were specified.	☐	☐	☐	☐	☐	☐
27	Confidentiality of the documents and information was addressed.	☐	☐	☐	☐	☐	☐
28	The responsibility for obtaining permits, licenses and approvals was determined.	☐	☐	☐	☐	☐	☐
29	Codes of ethics within the contract were specified.	☐	☐	☐	☐	☐	☐
30	The authority and jurisdiction of amendment/variation for the scope, works to be executed, contract clauses and other contract documents (specification, design etc.) were designated.	☐	☐	☐	☐	☐	☐

PART II - FACTORS AFFECTING CONTRACT COMPLETENESS AND AMBIGUITY							
No	Description	(0) NA – Not Applicable	(1) Strongly Disagree	(2) Disagree	(3) Neither Agree Nor Disagree	(4) Agree	(5) Strongly-Agree
31	Conditions of extension of time for completion and defect notification period were specified.	☐	☐	☐	☐	☐	☐
32	Variation/amendment definition, scope and processes were defined.	☐	☐	☐	☐	☐	☐
33	Dispute resolution process was defined and alternative dispute resolution (ADR) techniques were specified	☐	☐	☐	☐	☐	☐
34	Claims procedure and the extent of what kind of claim the Contractor or Owner considers himself to be entitled to claim has been determined.	☐	☐	☐	☐	☐	☐
35	Interpretation rules and definitions were specified.	☐	☐	☐	☐	☐	☐
36	The terms and sentences were sufficiently clear .	☐	☐	☐	☐	☐	☐
37	Conditions for administrative and financial penalties were determined.	☐	☐	☐	☐	☐	☐

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