THESIS

BID OR NO BID DECISION MAKING TOOL USING ANALYTIC HIERARCHY PROCESS

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ABSTRACT

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In today's competitive business environment, every construction company confronts a decision-making dilemma and must decide whether to bid or not bid on a project(s) or which project(s) to bid on among candidates. Even though the decision-makers come to the conclusion with different judgments, a final evaluation always requires putting different factors into consideration and contemplating the ups and downs of a project. Therefore, bid or no bid decision is complex and crucial for construction companies.

The complexity comes from the consideration of many intangible and tangible factors in the decision-making process (Mohanty 1992). Decision-making is hard because it requires a decision-maker to construct a structured thinking to include many unknown, yet complex variables and compare them simultaneously.

Decision-making is crucial because poorly made bidding decisions could cause severe and irrevocable problems. For example, not bidding a favorable project could result in lost opportunities for companies to make profit, improve contractor's strength in the industry and gain a long-term relationship with a new client. On the other hand, bidding a project that actually does not fit the company's profile requires a lot of time, effort, and commitment without a favorable outcome (Ahmad 1990, Wanous et al. 2003).

Given that "competitive bidding" is the most common bidding method in the construction industry among others (e.g., negotiated contracts, package deals, private finance initiative),

investigating bidding strategies has been a focal point by researchers (Harris et al. 2006). Furthermore, more than 100 key factors that influence bidding decisions have been determined to date since the mid-1950s. Simultaneously, to expedite the process, numerous decision-making models have been proposed.

Despite the excessive availability of the factors and decision-making models, the facilitation rate of the subsidiary tools in the evaluation process in the construction industry is very little. According to a survey by Ahmad & Minkarah (1988), only 11.1 percent of the construction companies use a decision-making tool in order to come to a bid or not bid conclusion in the United States.

The ultimate purpose of this study is to develop a practical decision-making tool to assist decision-makers in the construction industry to select the most appropriate projects to bid on using Analytic Hierarchy Process (AHP). Based on the collected demographic information (e.g., sector, size, type), the combined importance weights of the construction professionals are also presented in the study. Finally, the statistically significant differences between different groups of construction companies in how much weight they assign to a given bid/no bid decision factor is investigated.

In reaching the abovementioned purpose, the following questions are addressed:

- What are the most common key factors that influence bid/no bid decisions?
- How can different judgments from different decision-makers be combined into one final decision?
- How differently the construction companies in the United States (US) value the key factors that are commonly utilized to make bid/no bid decisions?

The validation of the bid/no bid decision-making tool was performed based on two participants' responses; and the tool provided accurate results for one of the evaluations. Because of insufficient response rate to the validation process, it cannot be concluded that the bid/no bid decision-making tool is validated; however, the results of the participants point out the need for further research.

The results showed that the compliance with the business plan and location of the project factors were found statistically significantly different for the "Contractor Type" classification. On the contrary, none of the key factors was found statistically significantly different for the "Contractor Sector" groups. For the "Contractor Size" classification, the compliance with the business plan factor was found statistically significantly different.

The Group AHP approach allows construction companies to come with a combined bidding judgment instead of using the tool individually. As a major finding of this study is that, the contractors grouped under each construction classifications (i.e., Contractor Type, Contractor Sector and Contractor Size) put more value on the overall firm related-internal factors than the overall project related-external factors based on the Group AHP results. It is also found that the project duration and project size key factors have the lowest weights for all contractor classification groups.

This study contributes to the construction engineering and management body of knowledge by providing an user friendly decision-making tool to be used in deciding whether to bid or not bid on a project or which project(s) to bid on and advancing the current state of the knowledge on the different weights/values given to the factors by construction companies with different demographics.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1. Introduction

This chapter provides a brief background discussion on the importance of bid/no bid decisions for construction companies. In addition, this chapter introduces the statement of the problem and the need along with the research purpose, questions, and the contribution to the body of knowledge.

1.1 Background

Getting a new project is the life-blood of project-oriented organizations, which significantly differ from traditional supplier businesses with their highly specialized marketing, human resources and customer involvement operations (Kerzner 2009). As project-oriented businesses, the survival of construction companies also depends on how they make their future investments; therefore selecting the right projects is crucial (Burke 1999). In general, contractors could get bid opportunities from various channels: from a client who had a pleasant business experience in the past, from a referral person who knows the provided services, from clients' website, from a tendering web portal or based on contractors' own attempts (Lewis 2003). Although the following terms are interchangeably used in the industry: "Invitation to Tender", "Request for Proposal", "Request for Quote", "Invitation to Bid" and "Invitation to Quote", they share the same meaning and explain the work requirements to be executed (Cleden 2011).

Contract deals back in the day were based on a chat about project needs, then price negotiation and a handshake on agreement. But, with the advancement of the Antitrust Laws in the public and private sectors in the U.S. and the establishment of European Union, suppliers are required to compete using written proposals to obtain a new job (Jacques 2013). In this regard, a bid secures the job for the contractor after an in-depth client evaluation process. From the client's perspective, a bid could be seen as a quality assurance that warrants the job will be delivered accurately and free of errors (Lewis 2003). Essentially, a bid or a proposal is the supplier's response to the owner's requests for the project, which is also a binding document that specifies the suppliers' and clients' responsibilities (Cleden 2011). Since there is ambiguity between the terms: tender, bid, and proposal, Jacques (2013) clarifies them as follows:

- Tender: The tender refers to a formal document that gives specific instructions on required work, which is issued by a client.
- Bid: The bid is the supplier's response to tender documents.
- Proposal: The proposal stands for a sales document, which is submitted by a supplier to a buyer.

Project selection phase becomes vital for construction companies, given that the construction industry highly differs from other industries in terms of uncertainty and is unique by low profit margins, high rate of asset turnover, high-volume, and low-markup conditions (Park & Chapin 1992). Harris et al. (2006) emphasizes the degree of uncertainty for the construction industry using an analogy with the appearance of roulette: "sometimes they win when they think their price is high; sometimes they lose when their price is dangerously low, and they have a wry smile for the apparent 'winner' ". Bidding on a project is a future-commitment for a company and the selection of a wrong project may limit the internal resources, moreover prevent the company from executing other favorable projects. Therefore, a contractor should consider money and time efforts such as required man-hours to develop an estimate (Halpin & Senior 2011). Considering there are various hurdles in the construction industry, Park & Chapin (1992) suggests 13 principles of successful contracting to help contractors run a profitable business and he claims that the number one principle is to "be selective in choosing jobs to bid".

In today's competitive business environment, every construction company confronts a decision-making dilemma and must decide whether to bid or not bid on a project(s) or which project(s) to bid on among candidates. Although, the decision-makers come to the conclusion with different judgments, a final evaluation always requires putting different factors into consideration and contemplating the ups and downs of a project. Burke (1999) implies that companies have infinite project opportunities in the construction industry, therefore the selection of projects should be focused on the one that provides the most beneficial changes to the company. Specifically, he states that the contract price is one of the main focuses in the project selection criteria, which can create a pricing dilemma caused by a trade-off between the profit and the chance of winning the project. In the same sense, Park & Chapin (1992) support Burke's (1999) opinion and express that to be successful in a bidding situation, contractors should bid low enough to get the job and bid high enough to profit from the project. From a different perspective, Lewis (2003) declares that, the decision to bid on a project should be grounded on realistic and carefully weighted assessments of the opportunity along with the potential benefits and costs. For this purpose, he advises to raise questions and provides a checklist of issues to be considered in the project selection stage. Those issues are (Lewis 2003):

- The competitive situation
- Bid preparation costs
- The relation of the contract to business strategy
- Project costs and revenues
- The characteristics of the client
- The professional value of the contract

- The implication of the workload and personnel
- The skills and experience that can be offered

With the increasing competitive environment of the construction industry, investigating the bidding strategies and the influential factors on biddings decisions have become a topical research area since the mid-1950s (Harris et al. 2006). Based on the previous research, more than 100 factors have been identified for this purpose. However, comparing numerous variables and understanding which factors are the most important can be difficult to determine due to the nature of human reasoning (Deng 1994). Therefore, to expedite the decision-making process, numerous decision-making tools with different underlying methodologies have been offered in time.

1.2 Decision-Making Process

Decision-making is a part of everyday human life, such as deciding on daily activities, a family issue or business operations. Roy (1981) describes the "decision activity" as choices to do or not to do things or when to do them in particular ways. He also revealed that a person faces four types of decision problems on a daily basis. Those are (Ishizaka & Nemery 2013, Roy 1981):

1. The choice problem, which aims to identify the best option or selecting the top options through a given set.
2. The sorting problem, which categorizes the options based on their similar features.
3. The ranking problem, which ranks the options in order from best to the worst.
4. The description problem, which describes the options and their effects.

The construction industry has an unstable business nature that includes many tangible and intangible factors; and comparing them simultaneously makes the decision-making process very complex (Mohanty 1992). Therefore, in order to solve the decision-making problems and save time by accelerating this process, many decision-making tools have been created. Park & Chapin (1992) categorize the most powerful decision-making tools for construction management as the following:

1. Statistics, which aims to forecast the future business status of a company through the collection, tabulation, analysis, presentation and interpretation of the data processes.
2. Probability theory is explained as a sub-branch of statistics and is used by decision-makers to determine the odds of the occurrence of an event by considering both the probability theory and the experience of an organization.
3. Operations Research models' goal is to determine inventory, allocation, waiting-time, repair-replacement, competitive problems and develop methods in order to describe the events, forecast future, and provide alternative solutions.
4. Game theory is a methodology that considers not only the participants' optimum gains but also the interactions between the opponents. In a nutshell, a participant's gain or loss depends on the decisions/strategies of others.

Oo et al. (2007) classifies the Bid/No Bid Models into three categories and for the remainder of this write-up, those three categories will be used. Those are:

1. Multi-attribute decision-making models
2. Artificial intelligence-based models
3. Statistical models

Although, the ultimate purpose of all the decision-making models is to identify the most beneficial projects for the organizations in short and long-term, the taken approaches vary greatly from each other with their structures and underlying methodologies.

1.2.1 Multi-Attribute Decision-Making Models

Multi-attribute decision-making (MADM) is a subset of Multi-criteria decision-making (MCDM) that is also a branch of the Operation Research (Triantaphyllou 2000). In Multi-criteria decision-making (MCDM) analysis, the aim is to find a solution by centering the decision-maker into the decision-making process. The results of the method varies from one decision-maker to another and in that context, the method uses the subjective selections of a decision-maker as a basis (Ishizaka & Nemery 2013). While many of the MCDM methods vary from each other; some of them have common characteristics. Those are (Hwang et al. 1992, Triantaphyllou 2000):

1. Alternatives: The alternatives stand for different options, which interchangeably can be named as “cause of action” or “candidates”. The number of the alternatives may range from several to thousands, however alternatives should always be screened, prioritized, selected, and ranked in the order given.
2. Multiple Attributes: The attributes can be referred to as the “goals” or “decision criteria” and each MCDM problem has multiple attributes. When the attribute numbers are large, the structure of the attributes could be organized as hierarchies. In that sense, there may be several major attributes, which may have sub-attributes, and moreover each sub-attribute may have sub-sub-attributes.
3. Conflict among Criteria: In general, multiple attributes conflict with each other. For example, the efficiency of equipment might affect the size or comfort.
4. Incommensurable Units: Analyzing different criteria in one process bring unit problems and could make the problems difficult to solve.
5. Decision Weights: In general, the MCDM methods works based on the assigning importance weights of the criteria.

6. Decision Matrix: A decision matrix is the mathematical expression of a MCDM problem. In that regard, a (m x n) matrix is the combination of finite sets of decision alternatives (A={Ai for i=1, 2, 3, ..., n}) and finite set of criteria/goals (C=Cj for j=1, 2, 3,..., m}), which is constructed according to decision-makers' judgments (denoted as wj for j = 1, 2, 3,..., n) (See Table 1.1).

Table 1.1 Simple Decision-Making Matrix Form (Triantaphyllou 2000)

Alternatives	**Criteria**		
	C. 1	**C. 2**	**C. 3**
	w_1	w_2	w_n
Alt. 1	a_{11}	a_{12}	a_{1n}
Alt. 2	a_{21}	a_{22}	a_{2n}
…	…	…	…
Alt. m	a_{m1}	a_{m2}	a_{mn}

Jato-Espino et al. (2014) investigated the multi-criteria decision-making models that have been used in the construction industry for different decision-making purposes and identified 22 different methods based on the 88 research papers. In Table 1.2, the multi-criteria decision-making models are given in accordance with their number of occurrences as used as single or hybrid methods in the research papers.

Table 1.2 The Number of Occurrences of the Multi Criteria Decision-Making Models in the Construction Industry (Jato-Espino et al. 2014)

Approach	Method	Number of occurrences
Single	AHP (Analytic hierarchy process)	20
	DEA (Data envelopment analysis)/ ELECTRE (Elimination et choix traduisant la realite)	6
	TOPSIS (Technique for order of preference by similarity to ideal solution)	3
	ANP (Analytic Network process)/ Delphi/ GST (Grey system theory)	2
	Other	1
Hybrid	AHP (Analytic hierarchy process)	26
	FSs (Fuzzy sets)	24
	TOPSIS (Technique for order of preference by similarity to ideal solution)	11
	ANP (Analytic Network process)/ MCS (Monte Carlo simulations/ MIVES (Modelo integrado da valor para evaluaciones sostenibles)/ VIKOR (Visekriterijumska optimizacija I kompromisno resenje)	4
	COPRAS (Complex proportional assessment)/ GST (Grey system theory)/ PROMETHEE (Preference ranking organization method for enrichment of evaluations)/ SAW (Simple additive weighting)	2
	Other	1

1.2.2 Artificial Intelligence-Based Models

Although Artificial Intelligence (AI) is one of the newest disciplines that have been investigated since 1956, the roots of the discipline could be traced to around 450 B.C. Approximately 2000 years of research in philosophy and 400 years in mathematics have promoted the development of the field and brought the theory to reality. Specifically, with the improvement of computer technology in the early 1950s, interest has been drawn to the field, leading it to be a convenient approach for a variety of different disciplines such as playing chess, writing poetry or diagnosing diseases. Despite this cumulative interest, there is not a common definition of the Artificial Intelligence in the literature. Russell et al (1995) reviewed eight different text books and revealed that the definition of the Artificial Intelligence can be grouped under four categories, which are mostly focused on the thought process, reasoning, behavior and rationality performance of human beings (Russell & Norvig 1995 p. 5):

1. Systems that think like humans.
2. Systems that act like humans.
3. Systems that think rationally.
4. Systems that act rationally.

From this standpoint, Artificial intelligence discipline has also created implementations for the construction management industry. Elbeltagi (2007) aggregated some of the implication examples of AI in the industry and listed the following with their usage purposes:

- Artificial Neural Network Approach for Bid/No Bid Model
- Analogy-Based Solution to Markup Estimation Problem
- Neuro-modex -Neural Network System for Modular Construction Decision Making
- Neuroform - Neural Network System for Vertical Formwork Selection
- Building KBES for Diagnosing PC Pile with Artificial Neural Network
- Modeling Initial Design Process using Artificial Neural Networks
- Intelligent Planning of Construction Projects
- Construction Robot Fleet Management System Prototype
- Bridge Planning Using GIS and Expert System Approach
- Comparison of Case-Based Reasoning and Artificial Neural Networks
- Site-Level Facilities Layout Using Genetic Algorithms
- HPC Strength Prediction Using Artificial Neural Network

- Estimating Resource Requirements at Conceptual Design Stage Using Neural Networks
- DAPS: Expert System for Structural Damage Assessment
- Artificial Neural Network Approach for Pavement Maintenance

1.2.3 Statistical Models

Given that statistical models have been frequently used in all areas of the construction management industry, varying from hoisting time models, to project performance assessments, the statistical bidding strategy models also have a solid background in the industry. In regards to the three decision-making problems (“Decision-making under certainty”, “Decision-making under risk”, “Decision-making under uncertainty”), most of the research has been focused on the “decision-making under risk” issues in the industry (Jha 2011). On the other side, statistical models have been categorized into two groups based on the implication purposes as Expected Monetary Value Models and Expected Utility Value-Based Models, which the former aims to maximizing the profit of a contractor while the latter focuses on the management of a contractor’s wealth and possessions (Jha 2011) .

1.3 Statement of the Problem and the Need

Despite the excessive availability of the factors and decision-making models, the facilitation rate of the subsidiary tools in the evaluation process in the construction industry is very little. According to a survey by Ahmad & Minkarah (1988), only the 11.1 percent of the construction companies use a decision-making tool in order to come to a bid or not bid conclusion in the United States. In addition, the United Kingdom also shows the similar interest percentage (17.6%) on using the decision-making tools.

In fact, there is an evident relationship between the lack of interest and difficulty of use for the bid/no bid decision-making models. Some of the models have been criticized due to their complexity and cumbersome requirements (Gates 1983). Depending on the bid/no bid decision-making model, the problems that have been discussed in the literature can be listed as following:

1. Providing excessive numbers of key factors, which makes it harder for contractors to compare.
2. Failure to provide simple solutions without requiring extensive user effort.
3. Requiring a comprehensive project history database.
4. Lacking of validation process.
5. Not able to combine different decisions from various decision-makers.

From this standpoint, a decision-making tool for the bid/no bid decisions is needed in the construction industry, which can attract decision-makers' attention by providing practical, user centered and accurate solutions.

1.4 Purpose of Research

To address the abovementioned need, the ultimate purpose of this study is to develop a decision-making tool to assist decision-makers in the construction industry to select the most appropriate projects to bid on via using Analytic Hierarchy Process (AHP). In this method, the main problem is divided into hierarchies as sub-problems, which are then addressed individually. AHP is a multi-criteria decision-making method that utilizes pairwise comparison technique by providing a preference scale. By constructing pairwise comparisons within each sub-problem, the weights of importance of the factors will be determined and furthermore the weights will be used to form a basis for the decision-making tool. This method determines the relative importance of the factors based on the subjective preferences of the respondents (Saaty & Vargas 1991). In this context, every decision-making tool pertains to a company and works in the direction of the decision-maker's own preferences.

Based on the collected demographic information (e.g., sector, size, type), the combined importance weights of the construction professionals will also be presented in the study. This information is valuable because it enables construction companies to see how much weight/value is put on the key factors by other construction companies who have different demographics.

Finally, the statistically significant differences between different groups of construction companies in how much weight they assign to a given bid/no bid decision factor will be investigated.

1.5 Research Questions and Contribution to the Body of Knowledge

In reaching the abovementioned purpose, the following questions are addressed:

- What are the most common key factors that influence bid/no bid decisions?
- How can different judgments from different decision-makers be combined into one final decision?
- How differently the construction companies in the United States (US) value the key factors that are commonly utilized to make bid/no bid decisions?

This study contributes to the construction engineering and management body of knowledge by providing a user friendly decision-making tool to be used in deciding whether to bid or not bid on a project or which project(s) to bid on and advancing the current state of the knowledge on the different weights/values given to the factors by construction companies with different demographics.

1.6 Scope and Limitations

The decision-making tool will be developed based on the factors which are commonly identified and utilized in the literature. Therefore, an investigation that aims to reveal the validity of the existing factors or new additions is not in the scope of this study. The sample size will be limited to the construction professionals who have a relationship with the Department of Construction Management at Colorado State University.

Chapter 2. Literature Review

This chapter presents a comprehensive literature review on bid/no bid decision-making models. For this purpose, various bidding decision-making models were categorized in accordance with the implemented approaches and explained under i) Multi-attribute decision-making, ii) Artificial intelligence-based model categories and iii) Statistical decision-making models.

2.1 Background

In today's competitive business environment, bid or no bid decision is complex and crucial for construction companies. The complexity comes from the consideration of many intangible and tangible factors in the decision-making process (Mohanty 1992). The decision-making is hard because it requires from a decision-maker to construct a structured thinking in accordance to include many unknown, yet complex variables and compare them simultaneously. Considering the nature of human thinking, Deng (1994) comments on the efficiency of decision-makers stating the following:

"Due to human's bounded rationality and limited capacity of information processing, a decision-maker can seldom consider all of the relevant variables and understand the complex relationships among decision variables." (Deng 1994 p. 552)

Decision-making is crucial because poorly made bidding decisions could cause severe and irrevocable problems. For example, not bidding a favorable project could result in lost opportunities for companies to make profit, improve contractor's strength in the industry and gain a long-term relationship with a new client. On the other hand, bidding a project that actually does not fit the company's profile requires a lot of time, effort, and commitment without a favorable outcome (Ahmad 1990, Wanous et al. 2003). Moreover, the reputation of a company can be damaged by submitting many non-winning proposals; and thus sometimes giving a “no bid” decision could be the right thing to do for companies (Gido & Clements 2009).

According to Ansoff (1965) a decision to a bid opportunity could result in three outcomes, namely: i) rejection to bid, ii) provisionally acceptance (includes adding the project to a reserve list or replacing it with the current project), and iii) unconditionally acceptance of the tender (Lowe & Parvar 2004).

Shash (1993) separates the bidding process into two different decision phases. The first decision includes whether or not to bid a project and the second decision is the preparation of the mark-up price. In the literature, the factors that influence bid/no bid and mark-up price decisions have been examined together and investigated consecutively; however, for the purpose of this study, only the factors that affect bid/no bid decisions and the models that serve to provide bidding decision support will be investigated.

To draw attention to the importance of a new project, Lin & Chen (2004) depicts it as the “lifeblood“ of a company and suggests that preparing a proposal for a large project should be considered as a new project by itself for companies. Moreover, the survival of a companies is dependent on how they tackle with different bidding situations (Wanous et al. 2003). In the selection of a project, many multidimensional reasons should be taken into the consideration such as financial, technological and availability of human resources. According to Mohanty (1992), while making a decision for a project, profitability, feasibility, optimal-resources and desirability of the project should be investigated. He also defines an attractive project with the following characteristics:

1. Viability of the project
2. Availability of a competent team

3. Availability of financial and other resources
4. High return on investment ratio

In some situations, the selection of a project may pertain to a geographical location. For example, in India, bidding decision may be given based on family pressure or political angle (Mohanty 1992), however this may not be the case for other countries.

Friedman (1956) also emphasizes the uniqueness of project situations stating the following:

" *The important thing to remember is that each bidding situation has unique properties and must be treated individually*" (Friedman 1956 p. 104).

Given that "competitive bidding" is the most common bidding method in the construction industry among others (e.g., negotiated contracts, package deals, private finance initiative), investigating bidding strategies has been a focal point by researchers since mid-1950s (Harris et al. 2006). The first known model was proposed by Friedman (1956), which concerned the issues related to the probability of winning and estimating the optimum bid amount by using probabilistic approaches. According to the study, by gathering previous bidding information, bidding patterns of the potential competitors could be estimated. Moreover, this method could be implemented for a single contract or multiple contracts simultaneously.

Up to date many bid/no bid decision support models have been introduced in the literature based on Friedman (1956)'s point of view to guide contractors in their bidding decisions; while others have criticized Friedman (1956)'s solution. For example, Whittaker (1981) advanced Friedman (1956)'s model by including decision-maker's perspective into his model. King & Mercer (1987) fitted the quotes by lognormal distributions and implemented his model for different sectors in the construction industry, namely a kitchen equipment manufacturer and a civil engineering contractor. On the contrary, Gates (1983) debated over the

Friedman (1956)'s study and introduced the concept of his expectation value (EV) model, which is used for determining the optimum profit and optimum risk for various bidding situations (e.g., lone-bidder strategy, two-bidder strategy, many bidder strategy).

Indeed, even though the strategic bidding models differed from each other with their theoretical grounds (i.e., game theory, decision theoretic approach (King & Mercer 1987)) they shared a common goal of "maximizing the profit "and they mostly focused on the estimation of mark-up price (Bageis & Fortune 2009).

Considering the historical development of the probabilistic models, Harris et al. (2006) summarized the steps for investigating a competitor's performance against an organization based on the competitor's historical data. The steps are:

1. Collect the historical contract data of the potential competitors
2. Divide the competitors bid by company's estimated bid and calculate the ratio
3. Create a frequency distribution

He also suggests that by converting the frequency distribution to a cumulative frequency curve, the relationship between probability of winning and mark-up bid amount could also be plotted.

The mathematical models have been discussed as not being suitable for real-world situations despite their excessive availability. In his "A Bidding Strategy Based on ESPE (The Expert Subjective Pragmatic Estimate)" study, Gates (1983) commented on contractors' unawareness of the applied mathematics vocabulary and stated that the mathematical models are only related to bidding values disregarding other factors in the perspective of a contractor. In this study Gates (1983) used Delphi method to estimate the optimum bid amount based on the numerous evaluations of a group of experts.

Wanous, Boussabaine, & Lewis (2000) summarized inapplicability of the probabilistic models due to the following:

- Failure to capture the real-world situations because of the over simplicity of the proposed models
- They are based on mathematical models which makes harder for contractors to use
- They are only focused on monetary values (i.e., maximizing the profit) and disregard contractors' other objectives

Gates's (1983) statement was also supported with the survey findings of various researchers. Ahmad & Minkarah (1988) found that only 11.1% of the contractors are using mathematical/statistical bidding models in the USA, while Shash (1993) reported 17.6% of the contractors are giving their decisions based on the mathematical/statistical models in UK. Therefore, this need has triggered researchers to provide practical solutions to the questions of i) whether to bid on a project or not and ii) which project(s) to bid on given a few candidate projects.

Based on the implemented approaches, Bid/No Bid Models can be classified in three categories (Oo et al. 2007):

1. Multi-attribute decision-making models
2. Artificial intelligence-based models
3. Statistical models

In the rest of this chapter, bid/no bid decision-making models will be categorized and explained under each category.

2.1.1 Multi-Attribute Decision-Making Models

Ahmad & Minkarah (1988) discussed inapplicability of the probability models by asserting the heuristic nature of the bidding environment. To answer the question of “How are bid decisions made?” and to investigate the factors that influence bidding decisions in depth, the authors conducted a survey among 400 general contractors in the USA and determined 31 factors that affect decision-making process. The factors were ranked by the companies using a relative importance scale (1-6) and the reported top three factors were listed as “Type of job”, “Need for work” and “Owner”. The study also revealed that approximately 90 % of the respondents do not use any mathematical or statistical approaches to make their bidding decision. The results showed that most of the contractors are relying on their” Experience”, “Judgment” and “Subjective assessment” tools for decision-making. Most importantly, it was found that sometimes the decisions are given based on any reasonable basis.

Since then, most of the research has been based on the factors determined in Ahmad & Minkarah (1988)’s study. Even though follow-up studies mostly referred to the questionnaire method from Ahmad & Minkarah (1988), they used different approaches to identify the importance of weights of the determined factors. In those studies, the importance of weights of the factors are based on the characteristics of the decision-makers; moreover the accuracy of the multi-attribute decision-making models are found to be vulnerable due to the decision-makers’ characteristics (Bageis & Fortune 2009).

To combine rational bidding decision methods and bidders’ subjective preferences into one decision-making model, Ahmad (1990) presented a two-stage decision-making process. In the first stage of the model, a deterministic attention focus method was used, while in the second stage a probabilistic decision method was implemented. In this model, the major objectives of a construction company were constructed into four hierarchical categories and sub criteria were assigned to each category. The categories were determined as job related, market related, firm related and resource related.

Shash (1993) modified the same questionnaire by Ahmad & Minkarah (1988) and identified 55 factors affecting decision-making process. The questionnaire was conducted to include 300 UK construction companies and gathered responses from 85 contractors. The measurement of the factors was made by using "Importance index" and the highest ranked factors that influence contractors bidding decisions were reported as "Need for work", "Number of competitors tendering" and "Experience in such projects".

Bageis & Fortune (2009) criticized Ahmad & Minkarah (1988) and Shash (1993)'s studies due to the lack of testing in the models based on the various weights of the respondents. In Bageis & Fortune's (2009) study, 87 factors were determined based on the literature and supported by the pilot interviews. The factors were identified by modifying the questionnaire format by Ahmad & Minkarah (1988). A total of 91 responses were gathered out of 240 Saudi Arabian contractors and the responses were categorized under four groups, namely the size of contractor, the type of main client, the type of work and the classification status of the contractors. The factors were ranked by decision-makers using 0-6 rating scale and the weights were calculated by "Importance Index" formulation. For the purpose of determining the most important factors, Principal Component Analysis (PCA) was conducted and the analysis resulted in retaining 39 factors. To determine the interrelations between contractor characteristics and the bidding decisions, various statistical approaches (i.e., ANOVA, Chi-Square) were used. The findings of the study showed that the weights of importance given to the factors are highly influenced by the contractor characteristics. In that case, the weights of importance of the respondents were mostly influenced by the contractor size, the classification status of the contractors and the client type. In the study, it was suggested that, to provide most accurate decisions to decision-makers, the collected data should be categorized by considering contractor characteristics.

Chua & Li (2000) criticized the reasoning methods of the Ahmad & Minkarah (1988) and Shash (1993)' s studies and identified four sub goals that relate to the bid/no bid decision-making process. Those sub goals are: competition, risk, need for work and company's position in bidding. Analytic Hierarchy Process (AHP) was implemented to determine key factors; therefore, four hierarchies were constructed in order to investigate the relationship between different contract types (e.g., unit rate, lump sum, design build). Only one sub goal was not included for different contract types, "Need for work", which is assumed to be independent from the considered contract types. The survey gathered responses from 25 companies out of 153, which were initially contacted; and the results showed that most of the factors are found to be independent from the different contract types. For example, the type of contract showed the most significant impact on risk sub goal while it indicated the least impact on company's position in bidding.

Mohanty (1992) also used AHP and determined 15 key factors. An Indian construction company was included in the study. According to the results, the benefits of the model are reported as i) providing a structured method to capture decision-makers' subjective goals, ii) organizing essential information systematically, iii) minimizing biased selections of decision-makers and most importantly iv) helping organizations to select most profitable and feasible projects.

Jarkas, Mubarak, & Kadri (2014) identified 43 factors based on the literature review and conducted a survey within the contractors in the State of Qatar. Relative Importance Index (RII) technique was implemented to analyze the data. The findings of the study showed that "employer" related factors have the most influential effects on the bidding decisions, while the other main groups were ordered by their importance as the following "contractor", "bidding situation", "contract" and "project".

Han, Diekmann, & Ock (2005) conducted an experimental design including the students from the University of Colorado, Yonsei University in Korea, and the professionals from both USA and Korea construction industry. A total of 91 participants were included in the study. To shed light into the process of bidding strategies in international projects and risk attitudes of the contractors, a formal decision support method was constructed. For the purpose of the study, three case studies (i.e., good project, bad project, moderate project) were randomly provided to each participant and the participants were expected to evaluate the risk conditions based on the provided project characteristics. The unforeseen conditions of the projects were also included and assessed in the study by using cross impact analysis method (CIA). Findings of the study revealed that the participants were more likely to distinguish bad projects from others. However, when it comes to the distinction of good and moderate projects, it became troublesome for the participants, therefore eventually those decisions caused losing good opportunity to make more profit. The authors also found that the individual risk attitudes of the participants and their bidding decisions on behalf of their companies were inconsistent.

Shash (1998) conducted a survey among 320 subcontractors in the State of Colorado and received 30 responses. The study differed from his "Factors considered in tendering decisions by top UK contractors (Shash 1993)" study due to the target population (general contractors vs.

subcontractors). Even though, the study approach was slightly different; this study can be assumed to be a subset of the former study. Four different factors were determined that influence subcontractors' bidding decisions and the results showed that "Past experience with general contractors" was highly influential on subcontractors' decisions.

El-mashaleh (2010) proposed the Data Envelopment Analysis (DEA) approach to guide decision-makers in their bidding decisions. In DEA, an "efficient frontier" is created based on organizations' historical data and used to identify favorable projects to bid. To create historical data, every project in contractors' database needs to be scaled with negative (i.e., inputs) and positive (i.e., outputs) factors that affect bid/no bid decisions. Furthermore, these factors need to be weighed by managers by using a subjective scale (i.e., 1-10). DEA approach was proposed with its wide applicability disregarding any project size, project location, number/types of factors considered in bidding situations. A limitation of this approach is that the necessity of a maintained and scaled historical database by contractors.

Lin & Chen (2004) used a fuzzy linguistic approach to determine bidding decisions. In this approach, the managers assigned the project criteria by using linguistic terms; then the terms were converted to the fuzzy numbers; and finally fuzzy attractiveness rating was estimated. Consequently, estimated fuzzy attractiveness rating was matched with linguistic levels. In the study, it was estimated that using this framework caused 15-25% reduction in man-hours for the proposal preparation. Even though the project was validated comparing the results with Analytic Hierarchy Process approach, validating the study with only one project could be seen as a limitation of the study.

2.1.2 Artificial Intelligence-Based Models

Wanous, Boussabaine, & Lewis (2003) implemented a model by using artificial neural network (ANN) based on 157 real-life projects from Syrian construction companies.18 key factors were determined through a survey and supported by interviews. 20 projects were randomly selected out of 182 projects and used to test the model. The accuracy of the model was found to be 90% for the selected Syrian construction projects.

Chua, Li, & Chan (2001), used Case-based Reasoning (CBR) approach by focusing on two reasoning factors namely, Risk and Competition. The framework, CASEBID was proposed to tackle with complex decision-making problems by gathering information from the case library. Moreover, the approach was used to obtain markup values for new projects relying on similar cases. For this purpose, a case library should be created and the project attributes should be labeled. Similarly, to the Data Envelopment Approach, maintaining a database could be mentioned as a limitation of the proposed approach. To retrieve the similar cases, the projects should be labeled correctly, if not this could cause inaccuracy and efficiency problems.

Egemen & Mohamed (2007) investigated the factors that affect bidding and mark-up decisions of the 80 Northern Cyprus and Turkish construction firms. For the final model, 50 and 44 factors were included in the framework, respectively. The results showed that bidding and mark-up decisions of the small and medium sized companies were significantly different. According to the study, “need for work”, “project profitability”, “strength of firm” and “client’s financial situation” factors were reported as the most important factors that affect bid/no bid decisions.

“Strategically Correct Bid/No Bid and Mark-up Decision” (SCBMD) decision-making tool was also created by Egemen & Mohamed (2008) to contribute to the field of study. 79

questions were nested into the system under eight subgroups to provide bid or no bid advices and markup percentages to contractors. 100 real bidding cases were gathered from Northern Cyprus and Turkish construction companies to validate the study and the accuracy of the system was noted as 86%.

2.1.3 Statistical Models

A parametric solution was offered by Wanous, Boussabaine, & Lewis (2000) by determining 18 factors. For this purpose, the data was gathered from 182 Syrian companies and the final model was tested with 20 real bidding cases. The accuracy of the model was found to be 85%.

Lowe & Parvar (2004) determined 21 factors based on the literature review and conducted correlation analysis between the factors and decision to bid. Functional decomposition model was used to organize the factors, which provides more understanding of the relationships between the factors and the decision-makers. Based on the results, a significant positive linear correlation was found for eight key factors and the contractors' decisions to bid a project. Those factors are namely, strategic and marketing contribution of the project, competitive analysis of the tender environment, competency-project size, competitive advantage-lowest cost, resources to tender for the project, feasibility of alternative design to reduce cost, external resources, and tendering procedures. Additionally, a predictive model was created by using logistic regression approach and the accuracy of this model was reported as 98.4%.

Oo et al., (2007) investigated unobserved heterogeneity across 18 contractors by implementing random coefficients logistic model. In the study, it was found that there is a significant difference between the contractors' bidding preferences and responses to the factors that affect their bidding decisions even though they were provided with the same bidding conditions. The study was not constructed on the experimental data, however it provided another approach for contractors to strategize bidding decisions by considering the unobserved heterogeneities of their competitors.

Type of client, type of construction work, and size of construction work factors were selected as target key factors; and their impact on the competitiveness of a Hong Kong construction company were investigated by Drew, Skitmore, & Po (2001). Quadratic regression models were created for this purpose and the models were fitted based on 100 bidding proposals from the same company. The models didn't provide enough evidence to prove that the competitiveness strategy of the Hong Kong company significantly impacted by work size, work sector or client size/type. On the other hand, the results revealed a pattern that shows contractor's strength point relative to project size ranges on various client sectors.

Oo, Drew, & Lo (2008) conducted the bidding experiment methodology and compared Singapore and Hong Kong construction contractors' decisions based on different market conditions. For this purpose, 20 hypothetical cases were created based on two extreme market conditions (i.e., booming conditions, recession conditions) and were provided to the 49 construction professionals. Additionally, to see the impact of number of bidders on decisions, eight different number of bidder scenarios for each hypothetical case were also included. To estimate the probability of bidding on a project, a logit model, which is a function of market conditions, was used. The results showed that, even though there are remarkable similarities between Singapore and Hong Kong bidding conditions, the decision of the contractors in those cities were significantly different in response to the booming and recession conditions. Particularly, the probability of bidding on a project in recession times was found to be four times more than booming times in Hong Kong while this value was reported two for Singapore contractors. This finding is also compatible with the finding of Drew, Skitmore, & Po (2001)'s results considering the unclear bidding strategy of Hong Kong contractors.

The relationships between risk assessment and risk perception and bid/no bid decisions of 134 Chinese contractors were experimentally investigated by Chen, Zhang, Liu, & Hu (2015). The analyses concluded that there is a significant relationship between the outcome history of professionals and their risk propensity. On the other hand, the probability of potential gain or loss has found to be more influential on risk perception than the magnitude of potential gain or loss. Additionally, bid/no bid decision-making was found significantly dependent on risk perception and risk propensity of contractors while a down slope correlation was observed between risk propensity and risk perception. Even though the study emphasized the importance of risk perception and risk propensity of decision-makers, the study may be found insubstantial for only including the professionals who have working experiences ranging from only two to five years.

Chapter 3. Methodology

The purpose of this chapter is to discuss the methodology that is used in this research. As mentioned in Chapter 1, the main methodology used in this study is Analytic Hierarchy Process (AHP). In order to conduct an AHP study, several steps need to be undertaken. In this chapter, the steps of the methodology are discussed and a numerical example is provided to explain the AHP methodology in depth. Additionally, One-Way Anova Test, Kruskal Wallis (Non-parametric alternative of One-Way Anova), Two-Sample t-test, and Wilcoxon Rank Sum (Non-parametric alternative of Two-Sample t-test) tests are introduced in this chapter, which are utilized to analyze the results of the AHP evaluations.

3.1 Overview of the Research Method

Quantitative research methods provide opportunities to better understand the tendency of respondents and help explain their attitudes towards an issue. Explaining a research problem through data trends, providing a baseline for literature review, enabling investigators to collect numeric data, and allowing unbiased analyses could be given as some of the major characteristics of the quantitative research methods. In quantitative research methods, the researchers can provide survey instruments to collect variables and moreover, those variables could be analyzed by using mathematical procedures, e.g., statistics. For instance, by comparing different groups' demographic information; the investigators could observe trends and describe the interrelations between variables (Creswell 2002).

In this study, quantitative research methods are employed to identify the weights of importance of the key factors collected from the construction companies with a survey instrument: the pairwise comparison tool. The further explanation of the pairwise comparison tool is given in section 3.3. As was mentioned before, Analytic Hierarchy Process (AHP) is used as the research methodology in this study and the determination of importance weights of the key factors by using AHP is explained in section 3.4. Furthermore, the One-Way Anova Test, Kruskal Wallis (Non-parametric alternative of One-Way Anova), Two-Sample t-test, and Wilcoxon Rank Sum (Non-parametric alternative of Two-Sample t-test) tests are used to evaluate the differences of contractors' valuation based on the demographic classification (i.e., Contractor Type, Contractor Sector and Contractor Size) as explained in section 3.5.2. Figure 3.1 shows the steps that are taken in this research and provides an overview of the research method.

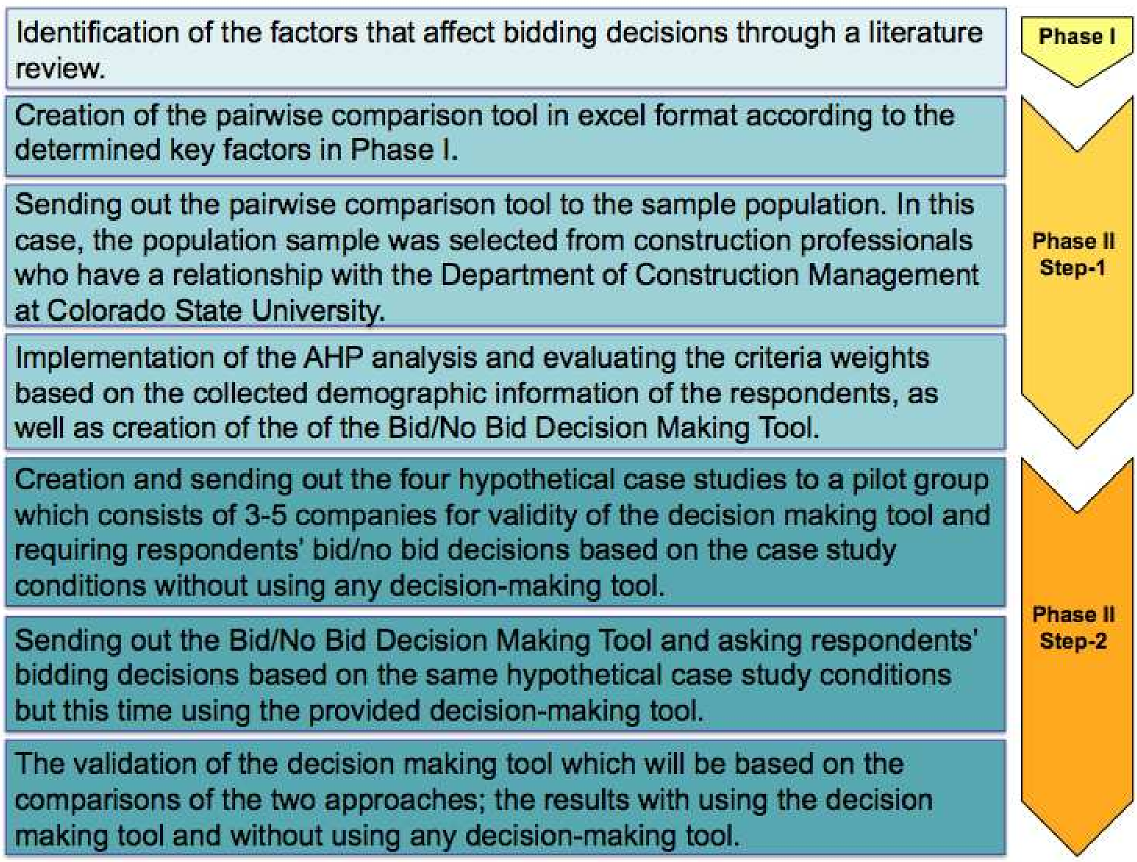


Figure 3.1 The Overview of the Research Method

3.2 Phase I: Determination of the Bid/No Bid Decision Factors

To date, more than 100 factors that affect bidding decisions have been identified in the literature. Considering that most of the existing research has already focused on the determination of the factors that influence bidding decisions, to expedite the research process, the key factors were selected through a literature review in this study.

To organize the factors in the literature, the factor comparison table, from Bageis & Fortune's study (2009 p. 55) was used as a guideline and the identified factors from various researchers (Bageis & Fortune (2009), Wanous et al.(2003), Ahmad & Minkarah (1988), Shash (1993), Chua & Li (2000), Mohanty (1992), Oo et al. (2007)) in the literature are presented side by side in Table 3.1. The rationale for the key factor determination process is explained for each study below:

- Based on the literature review and pilot interviews conducted with the industry experts, Bageis & Fortune (2009) determined 87 potential factors that affect bid/no bid decisions. In order to identify the most influential factors on bidding decisions, the authors conducted the principal component analysis (PCA) and as a result, 39 key factors were identified. For this study, 39 key factors were included as being more influential on bidding decisions and highlighted in green color in Table 3.1, while the remaining key factors were highlighted in purple.
- To determine the key factors that affect bid/no bid decisions, Wanous et al. (2000, 2003) conducted a formal survey among Syrian contractors. Based on the survey results, a total of 35 key influential key factors were determined. In order to rank the importance of the key factors, "Importance Index" method was utilized. In the study, the authors set a limit of 50 percent of importance index and omitted the remaining key factors less than 50

percent. Therefore, out of 35 factors, 18 key factors were identified as being more important than the others. In this study, 18 key factors were highlighted in green color while the remaining key factors were marked in purple in Table 3.1.

- Ahmad & Minkarah (1988) conducted a survey among 400 contractors in U.S. and determined 31 factors. Additionally, extra 17 key factors were presented based on the comments of the contractors. To determine the most influential key factors, the first ten key factors were identified as being more important than the others and highlighted in green color. Additional 17 key factors were not included in the most important key factors' determination process and were highlighted in purple along with the remaining 21 key factors in Table 3.1.
- Shash (1993) conducted a survey instrument among 300 top UK contractors and identified 55 factors that potentially affect bid/no bid decisions. In this study, to determine the most influential/important key factors, 14 factors, which were the 25 percent of the whole factor list, were identified as the most influential factors on bidding decisions. A total of 55 factors are given in Table 3.1, while 14 factors were highlighted in green color as being more important than the others.
- Chua & Li (2000) determined 51 factors based on the literature review. Using Analytic Hierarchy Process method, 28 key factors were determined as being more influential on bidding decisions. In this study, 51 factors are given in Table 3.1 and the 28 top key factors are highlighted in green color.
- Mohanty (1992) and Oo et al. (2007) conducted literature reviews and identified 15 and 6 key factors, respectively. Considering the number of the key factors, all of the key factors

are color coded in Table 3.1 in green as being influential key factors on bidding decisions.

To minimize the numbers of the key factors; the factors were grouped according to their similarities. For instance, the reputation of the client and the client honesty factors were grouped under "owner identity" factor. As a result of the grouping analysis, 14 most-commonly identified and utilized factors were determined and grouped under two main headings as firm-related and project-related factors as shown in Table 3.2.

3.2.1 Grouping the Key Factors

To reduce the number of the factors available in the literature, 46 consolidation groups were created by taking the factor similarities into consideration. The repetitive or similar factors, which are identified by various researchers in the literature, were included in the same consolidation groups. In order to determine whether to include a factor in the final key factor list or not, green and purple highlights were used.

For example, in consolidation group 3 (See Table 3.1), the "Location of the project" factor has been pointed out as being potentially influential on bidding decisions in five studies out of seven. In the consolidation group, three of them were marked in green color to show that the factor was identified as one of the most influential factors on bidding decisions by the authors in those studies. On the other hand, two of them were highlighted in purple color to show that the factors were found unimportant by the authors. Therefore, considering the number of the green and purple highlights (green no:3 > purple no:2), the "Location of the project" factor was included in the final key factor list.

However, for some of the consolidation groups, even though the number of green highlights is less than the number of purple highlights, the factor is still included in the final key factor list. For example, in consolidation group 13 (see Table 3.1), the green color number (n=3) is less than the number of purple colors (n=5); considering that the required resources can play an important role on bidding decisions, the “Availability of equipment, materials and human resources” factor was included in the final key factor list.

Further explanation of the key factor inclusion criteria for each consolidation group is provided in section 3.2.2. The comparison list of the factors originating from different studies is provided in Table 3.1 below.

Table 3.1 The Comparison of the Factors Identified from the Literature Review

Group Number	Bageis & Fortune (2009)	Wanous et al. (2000, 2003)	Ahmad & Minkarah (1988)	Shash (1993)	Chua & Li (2000)	Mohanty (1992)	Oo et al. (2007)	Key Factor	Key Factor Description
1	Size of contract in SR (size of the project)	Project size	Size of job	Project size	Size of project		Project size	Project size	This item explains the scope of the project without considering any potential project or work extensions.
	The receipt of the work and work measurement								
	The possibility of work extension								
	The possibility of project extension								
	The possibility of additional work								
					Degree of subcontracting				
2	Duration of the project	Original project duration	Duration	Project duration	Project timescale	Project duration		Project duration	This item explains the project's timescale.
			Job schedule						
3	Location of the project	Project Location	Location	Project location		Location		Location of the project	This item explains the location of the project.
4	Project cash flow	Expected project cash flow	Project cash flow	Project cash flow	Cash flow requirement			Not included in the final key factors list.	
5	Current work load	Current work load	Current work load	Current work load	Current work load in bid preparation / Current workload of projects			Current work load	This item explains the current workload in bid preparation or the current workload of projects that prevent the decision-maker to give a bid decision.

6	Past experience with similar project	Experience in similar projects		Experience in such projects	Similar experience	Past experience	Years of experience (of decision maker)	Experience in similar projects	This item explains the company's past experience with similar projects including historic profit, familiarity with site conditions, managing similar projects etc.
	Past experience with the management consultant								
	The project management system				Expertise in management and coordinator	Past experience			
			Historic profit						
	Familiarity with site condition				Familiarity with site condition				
	Past profit in similar project	Past profit in similar project		Past profit in similar project					
7		Risk expected	Risk of investment	Risk involved in the investment/ Risk involved owing to the nature of the project				Considering that the risk factor is intrinsically included in all other factors, the risk factor is not included as a separate factor.	
	Will be there many unknown factors such as labor rates, material prices or other prevailing economic conditions, which may upset the project?	Fluctuation in labor/material price	Economic condition	Risk in fluctuation labor price/Risk in fluctuation material prices	Resource price fluctuation				
				Anticipated value of liquidated damage					

8	Confidence in workforce		Confidence in workforce	Confidence in company workforce				Availability of equipment, materials and human resources	This item explains the company's internal resources to implement the project such as type of qualified staff, supervisory, labor, equipment and materials etc.
	Type of equipment required	Availability of equipment owned by the contractor		Availability of equipment	Type and number of equipment required				
	Availability of qualified human resources			Availability of qualified staff	Availability of qualified staff	Managerial capabilities			
	Type of labor required	Availability of skilled labor	Labor requirement		Type and number of Labor required	Personnel			
	Quality of available labor			Quality of available labor	Availability of qualified labor				
					Possession of qualified staff				
					Possession of qualified labor				
	Availability of labor			Availability of labor	Availability of qualified labor				
	Type and number of supervisory and labor required		Supervisory persons	Type and number of supervisory persons available/Type and number of supervisory persons required	Type and number of supervisory required				
9			Type of job	Project type	Type of project		Project type	Project type	This item explains the type of the job to be executed such as Residential, Commercial, Industrial or Heavy Construction projects etc.
10	Job start time		Job start time	Project start time				Not included in the final key factors list.	
		Expecting date of commencing							

11	The client honesty/Clients reputation with contractors they had previously worked with/Seriousness of the client/The size of client/The client's experience of the construction industry		Owner	Owner/ promoter client identity	Identity of owner/ consultant			Owner/ promoter/ Client identity	This item explains the owner/promoter/client identity including reputation, honesty, seriousness, size, experience, requirements, prompt payment habit and relations with the client etc.
	Prompt payment habit of the client/ The project payment system				Delay or shortage on payment				
	Past experience with the client	Relation and reputation of the client			Relationship with the owner				
	The client financial capacity	Financial capability of the client							
	The client requirements			Owner's special requirements					
	Establishing long relationship to the client								
12	Availability of required cash			Availability of required cash	Financial ability			Financial ability	This item explains the financial ability of the company to bid a project such as cash requirement, work capital, required bond capacity etc.
	Work capital required to start the project	Availability of capital required	Capital requirement						
	Required bond capacity		Bonding requirement	Bond requirement	Required bond capacity				
	Degree of difficulties in obtaining bank loan				Degree of difficulties in obtaining bank loan				
				Insurance premium					
13	Availability of equipment and materials	Availability of equipment/ materials required			Availability of equipment	Raw materials		Availability of equipment, materials and human resources	This item explains the company's internal resources to implement the project such as type of qualified staff, supervisory, labor, equipment and materials etc.
	Availability of required equipment		Equipment requirement			Equipment			
					Possession of qualified equipment				

14					Availability of qualified subcontractors			Not included in the final key factors list.	
					Possession of qualified subcontractor				
15	Uncertainty in cost estimate	Confidence in cost estimate	Uncertainty in estimate	Reliability of company cost estimate				Not included in the final key factors list.	
16	General (office) overheads		General overhead	General (office) overheads	General office's overhead recovery			Not included in the final key factors list.	
17			Strength of the firm	Company strength in the industry	Strength of business partner/subsidiaries			Not included in the final key factors list.	
18	How many bidders will be there?	Expected numbers of competitors (degree of competition)	Competition	Number of competitors tendering		Competitive conditions	Number of bidders	Competition	This item explains the competitiveness of the competitors (or the tender environment) including expected number of bidders, identity of competitors and similarity between the contractors etc.
	Are the bidders equal, or are they similar contractors with similar overheads?	Competence of the expected competitors		Competitiveness of competitors	Competence of estimators				
	Who else is likely to bid this job			Identity of competitors					
19	The ability of portion subcontracted to others	Proportions to be subcontracted	Subcontracted amount	Portion subcontracted to nominated subcontractors/Portion subcontracted to domestic subcontractors				Not included in the final key factors list.	
	Use of nominated subcontractor								
	Reliability level of subcontractors		Reliability of subcontractors		Reliability of subcontractors				
20	Safety hazards		Degree of hazard	Degree of hazard (safety)	Safety hazards			Not included in the final key factors list.	

21	Contract Conditions/The contract special requirements/The ability of modifying the contract	Rigidity of specifications	Contract terms and type of contract	Contract conditions		Terms of contract/ Stringency of quality specifications		Contract conditions and type of contract	This item explains the contract conditions including special requirements, the ability of modifying contract, stringency of specifications and prequalification requirements etc.
	Prequalification requirements	Fulfilling the to-tender conditions imposed by the client		Qualification requirements	Prequalification requirements				
			Change order potential						
	The procedure of dispute resolution								
	The classification class required								
	Bidding methods		Type of bidding (open, close)/Invitation or public	Tendering method (selective, open)	Bidding method (open/close)				
	Type of contract			Type of contract					
	Completeness of drawings and specification/Clarity of work and specifications/Sufficiency of project's information			Completeness of the documents	Completeness of drawings and specification	Stringency of quality specifications			
	Sufficiency of project's information								
					Consultants' interpretation of the specification				
22	Design quality		Design quality	Design quality				Not included in the final key factors list.	
23	Public exposure		Public exposure of the project/Prestige of the project	Public exposure	Project public exposure and prestige	Social environment		Not included in the final key factors list.	
		Public objection							

24			Need for work	Need for work				Need for work	This item explains the company's keenness in getting the job for continuity of employment and workforce.
					Need for continuity in employment of key personnel and work force				
			Prevailing wage requirements						
25	Time allowed for submitting bids		Time given to bid		Time allowed for bid preparation			Not included in the final key factors list.	
		Availability of time for tendering		Tendering duration					
26	Governmental division requirements		Government requirements	Government regulations	Government regulation	Government rules and regulations		Not included in the final key factors list.	
	The responsibility of issuing the work permits								
			Tax liability	Tax liability					
		Local customs				Legal implications			
27		Local climate						Not included in the final key factors list.	
28	Overall economy (availability of work)	Availability of other projects		Availability of other projects	Availability of other projects			Not included in the final key factors list.	
29			Contingency	Job related contingency				Not included in the final key factors list.	
30			Labor environment	Labor environment (union/non-union)				Not included in the final key factors list.	
31	Time of bidding (season)		Season					Not included in the final key factors list.	
32	Bidding document price							Not included in the final key factors list.	
	The cost of preparing the bid								

33					Adequacy of resource market price information			Not included in the final key factors list.
	Degree of possible alternative design to reduce cost							
		Specific feature that provide competitive advantage						
34				Policy in prediction cost saving				Not included in the final key factors list.
35			Emerging marketplace		Share of market		Market conditions	Not included in the final key factors list.
36		Relations with other contractors and suppliers						Not included in the final key factors list.
37	Original price estimated by the client	Original price estimated by the client						Not included in the final key factors list.
	The project mark-up size							
38		Site accessibility	Logistics		Site accessibility			Not included in the final key factors list.
		Site clearance of obstructions			Site space constraints			

39			Degree of difficulty	Degree of difficulty	Degree of technological difficulty			Technical knowhow	This item explains the company's ability of the project execution or required construction technique.
						Managerial capabilities	Firm size		
		Proportions that can be constructed mechanically							
	Ability of project execution				Contractor's ability in required construction technique	Technical knowhow			
		Degree of build ability							
40	Company ability with respect to design involvement and innovation				Company ability in design involvement and execution			Not included in the final key factors list.	
	Design team			Designer/ Architect/ Engineer					
				Contractor involvement in the design phase					
	Past experience with the design team								
41	Fines for delay				Project timescale and penalty for non-completion			Not included in the final key factors list.	

42	The benefits expected in terms of the company reputation/ The benefits expected in terms of the project management experience/ The benefits expected in terms of the project general relationship/ The benefits expected in terms of the equipment assets of the company		Possibility of future work/Growth potential for company		Promotion of company reputation			Not included in the final key factors list.	
	The benefits expected in terms of the labor experience								
			Rate of return	Rate of return	Required rate of return investment				
43	The project matches the company's strategy and future vision		Compliance with business plan			Company objective and policy		Compliance with business plan	This item explains the company's strategy and future vision considering monetary and non- monetary contributions of the project.
44	The project supervision procedure							Not included in the final key factors list.	
45	The projects stakeholders							Not included in the final key factors list.	
46				Policy in economic use of building resources				Not included in the final key factors list.	
			Mediation clause						

3.2.2 The Key Factor Consolidation Groups

3.2.2.1 Group Number 1

The “Size of contract in SR (size of the project)” and “Degree of subcontracting” factors were grouped under Group Number 1 based on the factor similarities. Considering that the majority of the research has found that the size of the project factor is influential on bidding decisions, the factors listed in Table 3.1 under Group Number 1 were consolidated as “Project size”. The key factor is described as “This item explains the scope of the project without considering any potential project or work extensions.”

3.2.2.2 Group Number 2

Considering the number of green highlights in the research, in which the “Duration of the project” factor has been found influential on bidding decisions, the factors listed in Table 3.1 under Group Number 2 were consolidated as “Project duration”. The key factor is described as “This item explains the project's timescale”.

3.2.2.3 Group Number 3

Considering the majority of the research shows that the “Location of the project” factor is influential on bidding decisions, the factors listed in Table 3.1 under Group Number 3 were consolidated as “Location of the project”. The key factor is described as “This item explains the location of the project”.

3.2.2.4 Group Number 4

Considering that the “Project cash flow” factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.5 Group Number 5

Considering that the majority of the research has concluded that the "Current work load" factor is influential on bidding decisions, the factors listed in Table 3.1 under Group Number 5 were consolidated as "Current work load". The key factor is described as "This item explains the current workload in bid preparation or the current workload of projects that prevent the decision-maker to give a bid decision".

3.2.2.6 Group Number 6

The "Past experience with similar project", "Past experience in managing similar project", "Historic profile", "Familiarity with site condition", and "Past profit in similar project" factors were grouped under Group Number 6 based on their similarities. Considering that the majority of the research has found the given factors influential on bidding decisions, the factors listed in Table 3.1 under Group Number 6 were consolidated as "Experience in similar projects". The key factor is also described as "This item explains the company's past experience with similar projects including historic profit, familiarity with site conditions, managing similar projects etc.".

3.2.2.7 Group Number 7

The "Risk involved in investment", "Risks expected fluctuation in labor material …etc.", and "Anticipated value of liquidated damage" factors were grouped under Group Number 7 based on their similarities. Even though the expected risk has been commonly identified as highly influential on bidding decisions, because of the uncertain nature of risk in construction, this factor was not included in the final key factors list.

3.2.2.8 Group Number 8

The “Confidence in workforce”, “Type of equipment required”, “Availability of qualified human resources”, “Type of labor required”, “Quality of available labor”, “Possession of qualified staff”, Possession of qualified labor, “Availability of labor”, and “Supervisory persons” factors were grouped under Group Number 8 based on their similarities. Even though the majority of the research has not found the given factors to be influential on bidding decisions, considering the required resources for projects can play an important role to decide whether to bid on a project or not, the factors listed in Table 3.1 under Group Number 8 were consolidated as “Availability of equipment, materials and human resources”. The key factor is also described as “This item explains the company's internal resources to implement the project such as type of qualified staff, supervisory, labor, equipment and materials etc.”.

3.2.2.9 Group Number 9

Considering the majority of the research has found the “Type of project” factor influential on bidding decisions, the factors listed in Table 3.1 under Group Number 9 were consolidated as “Project type”. The key factor is also described as “This item explains the type of the job to be executed such as Residential, Commercial, Industrial or Heavy Construction projects etc.”.

3.2.2.10 Group Number 10

The “Project start time” and “Expecting date of commencing” were grouped under Group Number 10 based on their similarities. Considering that the given factors have not been identified as highly influential on bidding decisions by various researchers in the literature, these factors were not consolidated and included in the final key factors list.

3.2.2.11 Group Number 11

The "Owner (private, public)", "Prompt payment habit of the client", "Relationship with the owner", "The client financial capacity", "The client requirements" and "Establishing long relationship to the client" factors were grouped under Group Number 11 based on their similarities. Considering that the majority of the research has found the given factors to be influential on bidding decisions, the factors listed in Table 3.1 under Group Number 11 were consolidated as "Owner/ promoter/client identity". The key factor is also described as "This item explains the owner/promoter/client identity including reputation, honesty, seriousness, size, experience, requirements, prompt payment habit and relations with the client etc.".

3.2.2.12 Group Number 12

The "Availability of required cash", "Work capital required to start the project", "Required bond capacity", "Degree of difficulties in obtaining bank loan", "Percentage of insurance premium" and "Recourses to tender for the project" factors were grouped under Group Number 12 based on their similarities. Even though the majority of the research has not found the given factors influential on bidding decisions, considering that finance can play an important role for contractors to decide whether to bid on a project or not, the factors listed in Table 3.1 under Group Number 12 were consolidated as "Financial ability". The key factor is also described as "This item explains the financial ability of the company's to bid a project such as cash requirement, work capital, required bond capacity etc.".

3.2.2.13 Group Number 13

The "Type of equipment required", "Availability of equipment and materials", "Availability of required equipment" and "Possession of qualified equipment" factors were grouped under Group Number 13 based on their similarities. Even though the majority of the research has not found the given factors to be influential on bidding decisions, considering the required resources can play an important role for contractors to decide whether to bid on a project or not, the factors listed in Table 3.1 under Group Number 14 were consolidated as "Availability of equipment, materials and human resources". The key factor is also described as "This item explains the company's internal resources to implement the project such as type of qualified staff, supervisory, labor, equipment and materials etc.".

3.2.2.14 Group Number 14

The "Availability of qualified subcontractors" and "Possession of qualified subcontractor" factors were grouped under Group Number 14 based on their similarities. Considering that the factors have not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.15 Group Number 15

Considering that the "Uncertainty in cost estimate" factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.16 Group Number 16

Considering that the "General (office) overheads" factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor was not included in the final key factors list.

3.2.2.17 Group Number 17

Considering that the "Strength in industry" factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.18 Group Number 18

The "How many bidders will be there?" "Are the bidders equal, or are they similar contractors with similar overheads?" and "Who else is likely to bid this job" factors were grouped under Group Number 18 based on their similarities. Even though the majority of the research has not found the given factors influential on bidding decisions, considering that competition can play an important role for contractors to decide whether to bid on a project or not, the factors listed in Table 3.1 under Group Number 18 were consolidated as "Competition". The key factor is also described as "This item explains the competitiveness of the competitors (or the tender environment) including expected number of bidders, identity of competitors and similarity between the contractors etc.".

3.2.2.19 Group Number 19

The factors "The ability of portion subcontracted to others" and "Reliability level of subcontractors" were grouped under Group Number 19 based on their similarities. Considering that the factors have not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.20 Group Number 20

Considering that the "Safety hazards "key factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.21 Group Number 21

The "Contract conditions", "Prequalification requirements", "Availability of required equipment", "Bidding methods", "Type of contract" factors were grouped under Group Number 21 based on their similarities. Considering that the given factors under this group have been found equally influential on bidding decisions, the factors listed in Table 3.1 under Group Number 21 were consolidated as "Contract conditions and type of contract". The key factor is also described as "This item explains the contract conditions including special requirements, the ability of modifying the contract, stringency of specifications and prequalification requirements etc.".

3.2.2.22 Group Number 22

Considering that the "Design quality" factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.23 Group Number 23

The "Public exposure" and "Public objection" factors were grouped under Group Number 23 based on their similarities. Considering that the factors have not been identified as highly influential on bidding decisions by various researchers in the literature, these factors are not included in the final key factors list.

3.2.2.24 Group Number 24

The "Need for work" and "Need for continuity in employment of key personnel and workforce" factors were grouped under Group Number 24 based on their similarities. Considering that the majority of the research has found the given factors influential on bidding decisions, the factors listed in Table 3.1 under Group Number 24 were consolidated as "Need for work". The key factor is also described as "This item explains the company's keenness in getting the job for continuity of employment and workforce".

3.2.2.25 Group Number 25

The “Time allowed for submitting bids” and “Tendering duration” factors were grouped under Group Number 25 based on their similarities. Considering that the factors have not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.26 Group Number 26

The “Governmental division requirements”, “Tax liability” and “Local custom” factors were grouped under Group Number 26 based on their similarities. Considering that the factors have not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.27 Group Number 27

Considering that the “Local climate” factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.28 Group Number 28

Considering that the “Availability of other projects” factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.29 Group Number 29

Considering that the “Contingency” factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.30 Group Number 30

Considering that the “Labor environment “factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.31 Group Number 31

Considering that the “Time of bidding (season)” factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.32 Group Number 32

Considering that the “Bidding document price” factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.33 Group Number 33

The “Lowest cost”, “Adequacy of resource market price information”, “Degree of possible alternative design to reduce cost” and “Specific feature that provide competitive advantage” factors were grouped under Group Number 33 based on their similarities. Considering that the factors have not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.34 Group Number 34

Considering that the “Policy in prediction cost saving” factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.35 Group Number 35

Considering that the "Market share" factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.36 Group Number 36

Considering the "Relation to other contractors and supplier" factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.37 Group Number 37

Considering that the "Original price estimated by the client" factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.38 Group Number 38

The "Site accessibility" and "Site clearance of obstruction" factors were grouped under Group Number 38 based on their similarities. Considering that the factors have not been identified as highly influential on bidding decisions by various researchers in the literature, these factors are not included in the final key factors list.

3.2.2.39 Group Number 39

The "Degree of technological difficulties", "Degree of difficulties", "Ability of executing the project", "Method of construction", "Company's ability in required construction technique", "Degree of build ability" factors were grouped under Group Number 39 based on their similarities. Considering that the majority of the research has found the given factors are influential on bidding decisions, the factors listed in Table 3.1 under Group Number 39 were consolidated as “Technical knowhow”. The key factor is also described as “This item explains the company's ability of the project execution or required construction technique”.

3.2.2.40 Group Number 40

The “Company ability with respect to design involvement and innovation”, “Design team” and “Contractor involvement in the design phase” factors were grouped under Group Number 40 based on their similarities. Considering that the factors have not been identified as highly influential on bidding decisions by various researchers in the literature, these factors are not included in the final key factors list.

3.2.2.41 Group Number 41

Considering that the “Fines for delay” factor has not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

3.2.2.42 Group Number 42

The “The benefits expected in terms of the company reputation” and “Rate of return” factors were grouped under Group Number 42 based on their similarities. Considering that the factors have not been identified as highly influential on bidding decisions by various researchers in the literature, these factors are not included in the final key factors list.

3.2.2.43 Group Number 43

The “The project is matching the company strategy and future vision”, “Financial goals of the company” and “Economic contribution of the project” factors were grouped under Group Number 43 based on their similarities. Considering that the majority of the research has found the given factors influential on bidding decisions, the factors listed in Table 3.1 under Group Number 43 were consolidated as “Compliance with business plan”. The key factor is also described as “This item explains the company's strategy and future vision considering monetary and non- monetary contributions of the project”.

3.2.2.44 Group Number 44-45

The “The project supervision procedure” and “The projects stakeholders” factors were identified by Bageis & Fortune (2009). Considering that the factors have not been identified as highly influential on bidding decisions by various researchers in the literature, these factors are not included in the final key factors list.

3.2.2.45 Group Number 46

Considering that the “Policy in economic use of building resources” and “Mediation clause” key factor have not been identified as highly influential on bidding decisions by various researchers in the literature, this factor is not included in the final key factors list.

The final list of the key factors, which are identified based on the selection criteria, is given in Table 3.2. The key factors are grouped under two different hierarchies as firm related/internal key factors and project related/external key factors. The Firm Related-Internal Factors reflect the company's ability and current status. Those factors are inherently related to the company's experience, financial ability, and resource possession. The Project Related-External Factors are the project related and uncontrollable factors by the companies. Those factors are related to the nature of the work, social, and economic environment.

Table 3.2 The Key Factors that Affect Bid/No Bid Decision as Determined from the Literature Review

Firm Related (Internal) Factors	Project Related (External) Factors
1) Current workload	8) Project size
2) Experience in similar projects	9) Project duration
3) Availability of equipment, materials and human resources	10) Location of the project
4) Financial ability	11) Project type
5) Need for work	12) Contract conditions and type of contract
6) Technical knowhow	13) Owner identity
7) Compliance with the business plan	14) Competition

3.3 Phase II, Step-1: Data Collection Using the Pairwise Comparison Tool

In order to identify the weight of importance given to the key factors identified in Phase I, the pairwise comparison tool, which depends on the AHP methodology as described in detail in section 3.4, was developed (see Appendix A). Under two main hierarchy levels, the pairwise comparison list, which includes 43 pairwise comparisons were provided in the excel format. The pairwise comparisons were constructed by using the columns, named A and B and the respondents were asked to identify which factor is more important to consider using those columns. The pairwise comparison scale options were also provided as a dropdown menu list and the respondents were asked to indicate their scale selections in the "More Important Factor" column. In Level 1, the respondents were asked to compare Firm Related-Internal and Project Related-External Factors in general. In Level 2-A, the pairwise comparisons of the firm related internal factors were provided, while the comparison of the project related external factors were asked in Level 2-B.

At the beginning of the pairwise comparison tool, a brief explanation was provided which includes the aim of the pairwise comparison tool, the duration and the instructions to complete the tool. The pairwise comparison scale (see Table 3.5) is also added to the file. To prevent missing information in the pairwise comparison columns; Excel's "Conditional Formatting" option was employed in the tool cells. The developed survey tool also included the components discussed in the following two sub-sections.

3.3.1 Company Profile Questionnaire

In order to collect the demographic information of the participants, the Company Profile Questionnaire (see Appendix B) was provided to the respondents along with the pairwise comparison tool. The following questions were asked in the questionnaire:

1. Title or position of the respondent
2. Years of experience of the respondent
3. In what year was your company founded
4. Type of Contractor (primarily). *Please select from the drop-down menu. (The dropdown menu options are General Contractor and Sub Contractor)*
5. Number of employees
6. What was your firm's gross revenue in 2014? Please specify the amounts according to the market categories below.

    6.1 Residential Construction (Homes and apartments)

    6.2 Industrial Construction (Manufacturing plants, refineries, high-tech facilities like laboratories and hospitals, etc.)

    6.3 Commercial Construction (Office buildings, stores, schools, libraries, etc.)

    6.4 Heavy/Highway Construction (Highways, dams, water/wastewater treatment plants, railroads, bridges, tunnels, etc.)

The collected data is used for the contractor classification and analysis purposes. The demographic data was sorted based on contractor type (general contractor vs. subcontractor),

contractor sector (e.g., Residential, Commercial, Industrial, and Heavy/Highway), and contractor size, which was determined based on the quartiles of revenue. The individual judgments of the participants are combined using the Group AHP (see section 3.4.2) approach based on contractor classification groups. Furthermore, One-Way Anova Test, Kruskal Wallis (Non-parametric alternative of -Way Anova), Two-Sample t-test, and Wilcoxon Rank Sum (Non-parametric alternative of Two-Sample t-test) tests were conducted to test whether the given importance to the key factors by different contractor classification groups are significantly different or not. For example, it is investigated if there are differences between general contractor and subcontractor' valuation of the key factors.

The types of the contractors are determined based on the Question #4 results: The contractor type groups are:

- General contractor
- Subcontractor

Results of Question #6 are used to determine the contractor sectors. For instance, when a contractor gives their revenue information for the Residential Construction (Homes and apartments) and Industrial Construction groups, this group is named as Residential- Industrial Revenue. The contractor sector groups are:

- Residential Construction
- Commercial Construction
- Industrial Construction
- Heavy/Highway Construction
- Residential-Commercial Construction
- Residential-Commercial-Heavy Construction

- Residential-Commercial-Industrial Construction
- Commercial-Industrial Construction
- Commercial-Industrial-Heavy Construction
- Residential-Commercial-Industrial-Heavy Construction

Question results are also used to identify the contractor size categories. The data is analyzed based on the quartiles of total revenue and four groups are created (See Table 3.3).

Table 3.3 The Revenue Range and the Corresponding Company Size Based on the Responses Received

Revenue	**Size**
<=$39,500,000	Small Size Construction Company
$39,500,000< <=$125,500,000	Small-Medium Size Construction Company
$125,500,000< <=487,500,000	Medium-Large Size Construction Company
>487,500,000	Large Size Construction Company

For the purpose of preventing missing information in the Company Profile Questionnaire, Excel's "Conditional Formatting" option was utilized in the response cells. When the participants fill a cell, the cell color is changed from red color to green.

3.3.2 Definitions of Factors

Definitions of the key factors were also provided as a part of the pairwise comparison tool document. The key factors were separated for each hierarchy and each key factor was explained in the list. The definitions of factors list are given in Table 3.4.

Table 3.4 Definitions of the Bid/No Bid Decision Key Factors

1	**Firm Related-Internal Factors: The internal factors reflect the company's ability and current status. Those factors are inherently related to the company's experience, financial ability, resource possession etc.**	
1.1	**Current workload**	This item explains whether there is capacity to bid on the project given the current workload of projects being built or current workload of the preconstruction/estimating department in proposal development.
1.2	**Experience in similar projects**	This item explains the company's past experience with similar projects (to the one being considered) including historic profit in similar projects, familiarity with site conditions, managing similar projects, etc.
1.3	**Availability of equipment, materials and human resources**	This item explains the company's internal resources to implement the project such as type of qualified staff, supervisors, labor, equipment and materials, etc.
1.4	**Financial ability**	This item explains the company's financial ability to bid on the project such as cash reserves, working capital, required bonding capacity etc.
1.5	**Need for work**	This item explains the company's keenness in getting the project for continuity of employment and workforce.
1.6	**Technical knowhow**	This item explains the company's technical ability of executing the project.
1.7	**Compliance with the business plan**	This item explains how well the project fits with the company's future vision and strategic goals.
2	**Project Related-External Factors: The external factors are the project related and uncontrollable factors by the companies. Those factors are related to the nature of the work, social, and economic environment.**	
2.1	**Project size**	This item explains the scope of the project.
2.2	**Project duration**	This item explains the project's duration.
2.3	**Location of the project**	This item explains the physical location of the project.
2.4	**Project type**	This item explains the type of the project to be executed such as residential, commercial, industrial, or heavy construction projects.
2.5	**Contract conditions and type of contract**	This item explains the project's contract type, contract conditions including special requirements, the ability of modifying the contract, stringency of specifications, prequalification requirements, etc.
2.6	**Owner identity**	This item explains the project owner's identity including reputation, honesty, seriousness, size, experience, requirements, prompt payment habit, etc.
2.7	**Competition**	This item explains the strength of the potential competitors (or the bid environment) in the project including expected number of bidders, identity of competitors, similarity between the contractors, etc.

3.4 Analytic Hierarchy Process

As was mentioned at the beginning of this chapter, Analytic Hierarchy Process (AHP) is used as the main research methodology in this study. The data, which was collected with the pairwise comparison tool, is evaluated by using Analytic Hierarchy Process (AHP). Therefore, the weights of importance given to the key factors are estimated. The Analytic Hierarchy Process

(AHP) is a multi-criteria decision-making method, which was developed by Thomas L. Saaty in the mid-1970s. It is a subsidiary decision-making tool to solve complex decision-making problems. To date, it has been used in various industries for different purposes. The use area of AHP is given by following (Saaty & Vargas 1991 p. 13):

1. Setting priorities
2. Generating a set of alternatives
3. Choosing best policy alternative
4. Determining requirements
5. Making decision using benefits and costs
6. Allocating resources
7. Predicting outcomes-Risk assessment
8. Measuring performance
9. Designing a system
10. Ensuring system stability
11. Optimizing
12. Planning
13. Conflict resolution

The AHP methodology is also a very commonly used methodology in the construction industry. Jato-Espino (2014) revealed that AHP is the most common decision-making tool for both single and hybrid approaches.

In AHP methodology, instead of providing numeric values to the respondents, to familiarize the decision-making problems into daily life decisions, a relative verbal appreciation method is used (Ishizaka & Nemery 2013). The method also provides a baseline for absolute and relative comparisons. In the absolute comparison, an alternative decision is compared to the standard decision, which is obtained through self-experiences, while in the relative comparisons; the alternatives are compared in pairs towards an attribute (Saaty 1986).

As was identified by Ishizaka & Nemery (2013), the motto of the Analytic Hierarchy Process (AHP) is to "divide and conquer". In that sense, in the AHP method, instead of dealing with complicated problems, the researcher can divide the problem into several small problems and solve them individually. The methodology uses the multi-level hierarchical structure of goals, criteria, sub criteria and alternatives (Triantaphyllou & Mann 1995). In AHP method, the problem is divided into hierarchies; the elements under each hierarchy can be named as level, cluster or stratum. The top element is the goal of the decision. A simple, three level hierarchy could be seen in Figure 3.2 below.

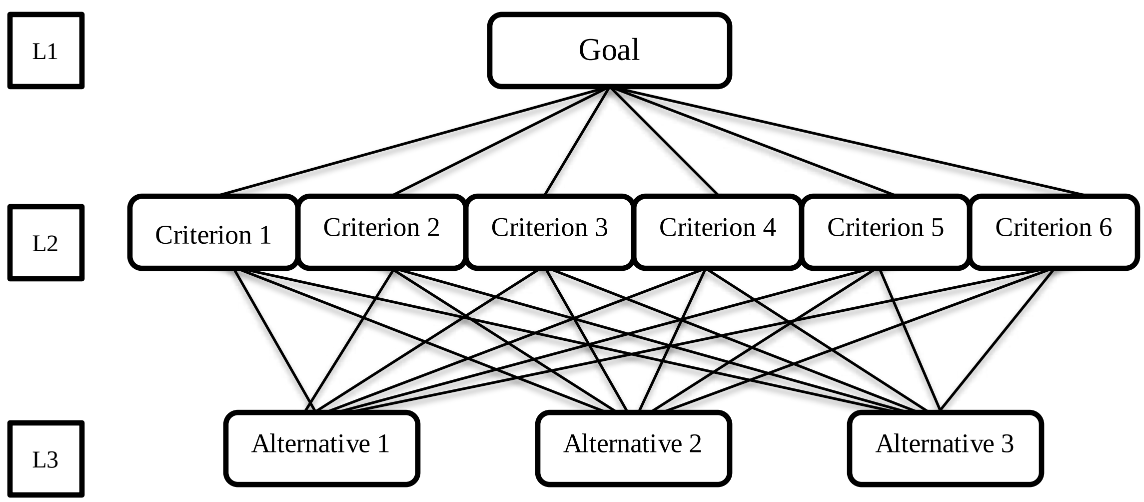


Figure 3.2 Three Level AHP Hierarchy Structure

** The "L" letter denotes the level of hierarchy. L1 shows the highest level of the hierarchy, while L3 stands for the alternatives that need to be compared. In each level, the elements are compared to each other.*

As was mentioned earlier, the multi-level hierarchical structure is used in AHP methodology. In Figure 3.2, the goal of the decision-making is identified in Level 1 (L1) and it is the ultimate objective to be achieved at the end of the AHP process. At this point, it is important to note that the goal of the decision-making should always be represented at the top of the hierarchy. The criteria are represented in Level 2 (L2), which are used to evaluate the best alternative. In this level, all criteria are compared to each other to contribute to the problem stated in L1. Finally, the alternatives that are considered for the decision-making problem are given in Level 3 (L3). In general, there is not a procedure on how to construct a hierarchical system and it depends on the decision-maker in how she/he is attempting to solve the question. The hierarchical model could be structured from very simplistic models to very tedious forms. The hierarchical structures give ability to see the problems in upper and lower levels.

To give a decision by using AHP method the following steps should be taken in the given order (Saaty 2008) :

1. Definition of the problem and determination of the knowledge to proceed.
2. Structuring the hierarchy from the highest level, this is the goal of the decision, following by criteria to the lowest level.
3. Conducting pairwise comparisons between criteria.
4. Using the priorities evaluated from the pairwise comparisons to calculate the weights of the priorities in the below level.

3.4.1 A Numerical AHP Example

To explain the steps of forming a decision in the AHP method, the following example will be illustrated. The example was modified from the “Relative measurement: Choosing the best house” example from Saaty & Vargas (1991 p. 13).

3.4.1.1 Definition of the Problem and the Structure of the Hierarchy

A committee wants to select the most appropriate student for the graduate school. There are three candidates; the committee must choose the best student from the three alternatives. To proceed, the committee should build hierarchies and identify the factors that affect the student selection process. According to Saaty & Vargas (2012 p. 12), to create a hierarchical structure, the question of “Can I compare the elements on a lower level in terms of some or all of the elements on the higher level?” should be asked by the decision-makers. Based on the explanation given above, the committee identifies six factors to select the best student for the university and prefers to compare elements on the higher level. The factors are:

- Statement of Purpose
- Letter of Recommendation
- Construction Industry Experience
- Personal Interview
- GPA Scores
- GRE Scores

The hierarchical structure of the problem is given in Figure 3.3. For this example, the goal of the decision-making is to select the best student who meets the selection criteria of the committee, which is structured in Level 1 (L1) in Figure 3.3. The committee determines six criteria for this selection and they should give their final decision based on the final evaluations of the AHP process. The selection criteria are given in Level 2 (L2). There are three candidates in the selection, which can be stated that there are three alternatives and given in Level 3 (L3).

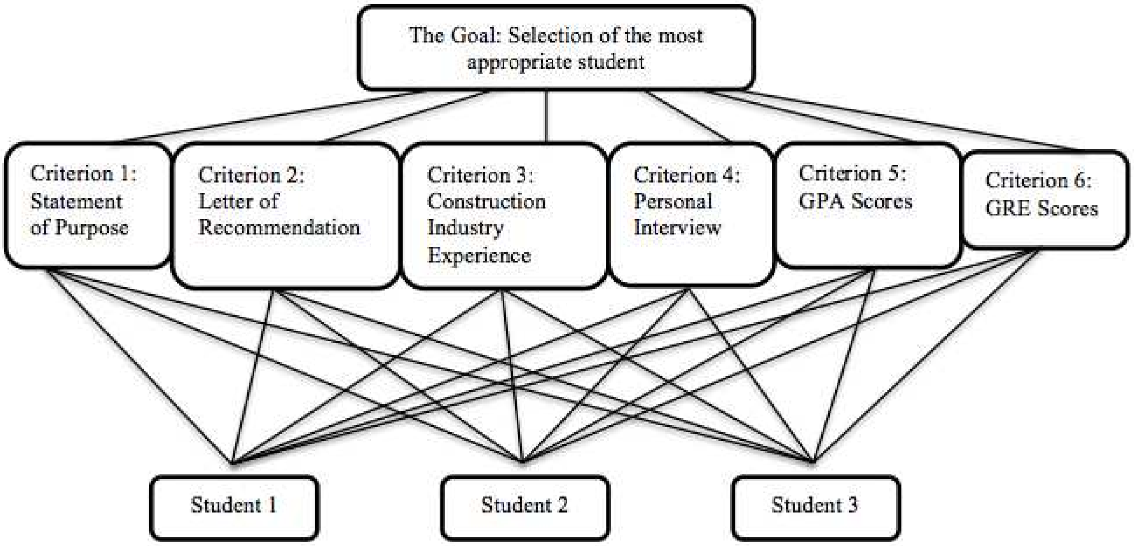


Figure 3.3 The Hierarchical Structure of the Problem

3.4.1.2 Comparative Judgment

AHP determines the relative importance of the factors based on the subjective preferences of the respondents and it provides the scale of absolute magnitudes to determine the relative judgmental preferences of one element over another. In sum, the scale is used to quantify pairwise comparisons. The pairwise comparison scale is given in Table 3.5.

Table 3.5 The Pairwise Comparison Scale of AHP

Intensity of importance	Definition	Explanation
1	Equal Importance	Two criteria contribute equally to the objective
2	Slightly More Important	
3	Moderate Importance	Experience and judgment slightly favor one criteria over another
4	Moderate to Strong Importance	
5	Strong Importance	Experience and judgment strongly favor one criteria over another
6	Strong to Very Strong Importance	
7	Very Strong Importance	A criteria is strongly favored and its dominance is demonstrated in practice
8	Very, Very Strong Importance	
9	Extreme Importance	The evidence favoring one criteria over another is of the highest possible order

To determine the vector of priorities, the formulation could be derived from a matrix (a_{ij}) (Saaty & Vargas 1991). A matrix is an array of numbers and can be represented as a rectangle. In a matrix, the horizontally sequenced numbers are named as rows, while the vertically placed numbers are called column. A matrix, which has only one row and one column, is named a vector. The matrix of ratio comparisons (the matrix is named as Student for this example, see Table 3.6) gives the pairwise ratios, which its' rows give the ratios of the weights of each student in relation to all other student weights.

In order to estimate which student is most suitable, the eigenvector needs to be estimated (Triantaphyllou & Mann 1995). The eigenvector provides the priority ordering, while the eigenvalue can be defined as the measure of the consistency of the judgment (Saaty 1980). Therefore, the eigenvalue formulation is given with Equation 3.1 (Saaty & Vargas 2012):

Student*w=n*w Equation 3.1

Where;

n is the number of the student, Student 1,…, Student n

w is the weights of the candidates, $w_1,\dots,w_n$

Table 3.6 Matrix of Ratio Comparisons

	Student 1	**Student 2**	**Student n**			
Student 1	w_1/w_1	w_1/w_2	w_1/w_n	w_1		w_1
Student 2	w_2/w_1	w_2/w_2	w_2/w_n	w_2	= n	w_2
…	…	…	…	…		…
Student n	w_n/w_1	w_n/w_2	w_n/w_n	w_n		w_n

In practice, the precise values of w_i/w_j cannot be provided, but only an estimate can be made.

Then, the problem becomes (see Equation 3.2):

$\text{Student}'*w'=\lambda\max'*w'$ Equation 3.2

Where;

$Student'$ is the perturbed value of Student

λmax is the largest or principal eigenvalue of the $Student'$.

To simplify the notation, the formulation becomes (see Equation 3.3):

Student*w= λmax *w Equation 3.3

In order to estimate an approximation of the priorities, the corresponding maximum left eigenvector can be approximated by using the geometric mean approach. The geometric mean can be defined as multiplying n elements in each row and taking the n^{th} root. Then, the numbers should be normalized by dividing them to their sum. On the other hand, λmax can be estimated by multiplying resulting vector by the priority vector.

In practice, an accurate consistency rarely exists. As a rule of thumb, for Student matrix to be consistent, λmax should be equal to n, especially λmax ≥n always holds. Therefore, to estimate the Consistency Ratio (C.R.), Consistency Index (C.I.) needs to be calculated by the following:

C.I.=(λmax-n)/(n-1) Equation 3.4

Consistency Ratio is estimated by taking the ratio of estimated consistency index (C.I.) to the Random Consistency index (R.I.), which is already determined by averaging the randomly generated reciprocal matrices based on the scale 1/9, 1/8,…,1,…,8, 9 (Saaty & Vargas 1991). The average Random Consistency Index (R.I.) is given in Table 3.7.

Table 3.7 Random Consistency Index (R.I.) Scale

N	1	2	3	4	5	6	7	8	9	10
Random Consistency Index (R.I.)	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

In AHP method, to evaluate the most accurate consistency, it is advised that the corresponding consistency ratio (CR) of 0.10 or less is acceptable, otherwise, the selections need to be revised (Saaty 1980).

Back to the numerical AHP example, the pairwise comparisons for the selection criteria (L2) are given in Table 3.8. Therefore, the six selection criteria are compared by using the pairwise comparison scale given in Table 3.5. It is important to note that, this example represents one committee member's judgmental preferences, and the Group AHP approach will be explained in section 3.4.2.

Table 3.8 The Pairwise Comparisons of Six Criteria Based on Subjective Selections of the Committee Member

	Statement of Purpose	Letter of Recommendation	Construction Industry Experience	Personal Interview	GPA Scores	GRE Scores
Statement of Purpose	1	4	3	1	3	4
Letter of Recommendation	1/4	1	7	3	1/5	1
Construction Industry Experience	1/3	1/7	1	1/5	1/5	1/6
Personal Interview	1	1/3	5	1	1	1/3
GPA Scores	1/3	5	5	1	1	3
GRE Scores	1/4	1	6	3	1/3	1

λmax=7.49, C.I.=0.30, C.R.=0.24

λmax, C.I., and C.R. values are estimated by using the above-mentioned approaches. The priority vector of the matrix is found by normalizing the eigenvectors of each row. Those values are:

0.32 (S-Statement of Purpose)

0.14 (L-Letter of Recommendation)

0.03 (C-Construction Industry Experience)

0.13 (P-Personal Interview)

0.24 (GP-GPA Scores)

0.14 (GR-GRE Scores)

In the level 3 of the hierarchy, the same structure must be constructed for the comparisons of the alternatives. The comparisons of the students are given in Table 3.9 with respect to the six selection criteria. In that case, the student qualifications are compared with each other.

Table 3.9 The Pairwise Comparisons of the Students under Each Criterion Based on the Subjective Selections of the Committee Member

	Statement of Purpose		
	Student 1	**Student 2**	**Student 3**
Student 1	1	1/3	1/2
Student 2	3	1	3
Student 3	2	1/3	1
	λmax=3.05		
	C.I.=0.025		
	C.R.=0.04		
	Letter of Recommendation		
	Student 1	**Student 2**	**Student 3**
Student 1	1	5	1
Student 2	1/5	1	1/5
Student 3	1	5	1
	λmax=3.00		
	C.I.=0		
	C.R.=0		
	Construction Industry Experience		
	Student 1	**Student 2**	**Student 3**
Student 1	1	1/2	1
Student 2	2	1	2
Student 3	1	1/2	1
	λmax=3.00		
	C.I.=0		
	C.R.=0		
	Personal Interview		
	Student 1	**Student 2**	**Student 3**
Student 1	1	1	1
Student 2	1	1	1
Student 3	1	1	1
	λmax=3.00		
	C.I.=0		
	C.R.=0		

	GPA Scores		
	Student 1	**Student 2**	**Student 3**
Student 1	1	9	7
Student 2	1/9	1	1/5
Student 3	1/7	5	1
	$\lambda max=3.21$		
	C.I.=0.105		
	C.R.=0.18		
	GRE Scores		
	Student 1	**Student 2**	**Student 3**
Student 1	1	6	4
Student 2	1/6	1	1/3
Student 3	1/4	3	1
	$\lambda max=3.05$		
	C.I.=0.025		
	C.R.=0.04		

The final weight of priorities are given in Table 3.10:

Table 3.10 Estimated Weight of Priorities Given to the Criteria and Alternatives

	Statement of Purpose	Personal Interview	Letter of Recommendation	GPA Scores	Construction Industry Experience	GRE Scores	The results from the Level 2 pairwise comparisons
Student 1	0.16	0.33	0.45	0.77	0.25	0.69	0.32 (S)
Student 2	0.59	0.33	0.09	0.05	0.50	0.09	0.14 (L)
Student 3	0.25	0.33	0.46	0.17	0.25	0.22	0.03 (C)
							0.13 (P)
							0.24 (GP)
							0.14 (GR)

The results from the Level 3 pairwise comparisons

According to the values given in Table 3.10, the following equations are constructed:

Student 1: 0.16*0.32+0.33*0.14+0.45*0.03+0.77*0.13+0.25*0.24+0.69*0.14=0.37

Student 2: 0.59*0.32+0.33*0.14+0.09*0.03+0.05*0.13+0.50*0.24+0.09*0.14=**0.38**

Student 3: 0.25*0.32+0.33*0.14+0.09*0.03+0.05*0.13+0.50*0.24+0.09*0.14=0.25

The results yield that; the student 2 is the best alternative considering the committee member’s selection criteria.

3.4.2 The Group AHP

In general, giving a decision is not the responsibility of a single individual, but requires the judgments from a group or a committee. In order to come up with a decision to a decision-making problem, there are two alternative ways that can be used. In the first approach, the decision-makers in the committee can meet and debate the ins and outs of the decision-making problem and complete the steps of the AHP methodology based on their consensus. In the other case, if the decision-makers do not have the opportunity to meet and debate the problem, each individual can complete the prioritization of the alternatives and the final decision can be constructed by geometrically averaging the individual findings. In this study, the second alternative is followed and the following equation are employed for the analysis (Saaty 1989):

	Decision Maker			**Combined Judgments**	
Judgments	**1**	**2**	**n**		Equation 3.5
	a_{12}^{1}	a_{12}^{2}	a_{12}^{n}	$a_{12} = [a_{12}^{1}\, x\, a_{12}^{2}\, x\, a_{12}^{n}]^{1/n}$	

As seen from Equation 3.5 the above, the individual judgments of decision-makers are combined by multiplying each other and taking the $1/n^{th}$ root. Consistency Ratio (C.R.) is also estimated for Group AHP results. Different from individual AHP calculations (see section 3.4.1), to estimate the Consistency Ratio (C.R.), Consistency Index (C.I.) is estimated by the following equation:

C.I.=(λmax-n)/(n) Equation 3.6

3.4.3 The Sample Population

The sample population was selected from construction companies who have a relationship with the Department of Construction Management at Colorado State University. The pairwise comparison tool was sent to 903 individuals (481 construction related companies).

Additional to the selected sample population, the same recruitment e-mail was sent to approximately 75 members of the Retail Contractors Association by Mrs. Carol Montoya, who is the executive director of Retail Contractors Association.

3.5 Phase II, Step-2: The Validation of the Study

To complete the validation of the study steps, two instruments were developed: The Hypothetical Case studies and the Bid/No Bid Decision-Making Tool. Further explanation of the development of the Hypothetical Case studies and the Bid/No Bid Decision-Making Tool are provided below in section 3.5.1 and in section 3.5.2 respectively.

In the Phase II, Step 2, the validation of the study is completed in two steps. Firstly, a group of people was selected out of the study participants who completed the Phase II, Step 1 instrument; the pairwise comparison tool. In the first step, the pilot group participants were provided with four hypothetical case studies (see section 3.5.1) and asked to make their bidding decisions considering the hypothetical project conditions without using any decision-making tools or statistical approaches.

In the second step, the pilot group participants were provided with the Bid/No Bid Decision-Making Tool along with the hypothetical case study document, through which they can repeat the same decision-making process but this time using the Bid/No Bid Decision-Making tool.

The main purpose of the validation of the study process is to reveal whether the decisions made in two steps are different from each other or not. Therefore, the results of the two approaches (with decision-making tool and without decision-making tool) are compared and the accuracy of the "Bid or No Bid Decision-Making Tool" is tested.

3.5.1 Development of the Hypothetical Case Studies

The hypothetical case studies were developed and used as the main instrument in the validation of the study process and developed based on the demographic information of the pilot group participants. The reason of this approach is to narrow down the hypothetical case possibilities and include participants who have similar tendencies to bid similar projects. For this purpose, the revenue and sector information of the participants were reviewed. Therefore, five companies who have similar revenues ($100,000,000 - $150,000,000) in the commercial industry were selected. The company web-pages were reviewed and similar project types in the companies' past project sections were considered for the case study structures. Additionally, the participants' pairwise comparison tool results were reviewed; and to get more accurate results, the consistencies of their selections were investigated based on the consistency ratios.

14 key factors, which were decided to use for this research and included in the pairwise comparisons, were also used to construct the hypothetical case studies. Each case study is designed with the same 14 key factors provided in the same order, however the magnitude of those factors were made different from each other by assigning the key factors different Likert scale weights (see Table 3.11). In Table 3.12, the key factors in each case study were randomly assigned with different Likert scale weight and the assigned weights were summed for each case study. The total sum of the weights was calculated for each case study, which were 36, 34, 34, 36 and the total sum of weights were used to see if the case studies are homogenously weighed or not. On the other hand, to create more realistic weight dispersion, the preliminary Group AHP results were also used. The preliminary Group AHP results provided the information of how construction companies put value on the key factors. The preliminary Group AHP results and Likert Scale Weights were multiplied and the normalized weights for each key factor under each

case study scenario were estimated. Again, the total sums of the normalized weights were considered if the weights were homogenously dispersed over each case study. As can be seen from Table 3.12, the total sums of the normalized weights are very close to each other and the normalized weights are ranged between 2.916764506 and 3.059970813.

After the researchers completed the hypothetical case studies, a professional help was also received from Mr. William T. Welch to review the case studies, who has been working in the construction industry as a construction manager for over 25 years. Mr. William T. Welch contributed to the development of the case studies by checking the overall logical interrelations between the key factors such as project size vs. project duration.

Table 3.11 Assigned Likert Scale Options to the Key Factors

Key Factors	**Scale**						
Current workload	1-Not convenient	2-Slightly convenient	3-Somewhat convenient	4-Moderately convenient	5-Very convenient	6-Extremly convenient	
Compliance with the business plan	1-Not fits	2-Slightly fits	3-Somewhat fits	4-Moderately fits	5-Highly fits	6-Extremly fits	
Experience in similar projects	1-No experience	2-Low experience	3-Somewhat experience	4-Moderate experience	5-High experience	6-Extreme experience	
Availability of equipment, materials and human resources	1-Not convenient	2-Slightly convenient	3-Somewhat convenient	4-Moderately convenient	5-Very convenient	6-Extremly convenient	
Financial ability	1-Not convenient	2-Slightly convenient	3-Somewhat convenient	4-Moderately convenient	5-Highly convenient	6-Extremly convenient	
Need for work	1-Extremly influential	2-Highly influential	3-Moderately influential	4-Somewhat influential	5 – Slightly influential	6-Not at all influential	
Owner identity	1-Completely dissatisfied	2-Mostly dissatisfied	3-Somewhat dissatisfied	4-Unknown	5-Somewhat satisfied	6-Mostly satisfied	7-Completely satisfied
Technical knowhow	1-Very difficult to execute	2-Difficult to execute	3-Somewhat easy to execute	4-Easy to execute	5-Very easy to execute		
Contract conditions and type of contract	1-Very difficult	2-Difficult	3-Unknown	4 -Easy	5-Very easy		
Competition	1-Very difficult to get	2-Difficult to get	3-Unknown	4-Easy to get	5-Very easy to modify		
Project size	**This part of the hypothetical case studies were created by the help of Mr. William T. Welch**						
Project duration							
Location of the project							
Project type							

Table 3.12 Estimated Weights for the Case Study Development

Preliminary Group AHP Results	Key Factor	Likert Scale Weights for Case Study 1	Likert Scale Weights for Case Study 2	Likert Scale Weights for Case Study 3	Likert Scale Weights for Case Study 4	Normalized Weights for Case Study 1	Normalized Weights for Case Study 2	Normalized Weights for Case Study 3	Normalized Weights for Case Study 4
0.118679199	**Need for work**	2	4	3	5	0.237358399	0.474716797	0.356037598	0.593395996
0.109513282	**Contract conditions and type of contract**	5	4	2	1	0.547566409	0.438053127	0.219026564	0.109513282
0.106639721	**Owner identity**	3	2	5	1	0.319919162	0.213279441	0.533198603	0.106639721
0.088900836	**Compliance with the business plan**	2	4	3	5	0.177801672	0.355603344	0.266702508	0.44450418
0.086812562	**Availability of equipment, materials and human resources**	6	3	5	2	0.520875373	0.260437686	0.434062811	0.173625124
0.078010228	**Experience in similar projects**	4	2	4	6	0.312040911	0.156020455	0.312040911	0.468061366
0.071257741	**Technical knowhow**	3	5	4	2	0.213773223	0.356288706	0.285030964	0.142515482
0.067618596	**Financial ability**	5	4	2	3	0.338092979	0.270474383	0.135237192	0.202855787
0.065532467	**Current workload**	4	2	5	6	0.26212987	0.131064935	0.327662337	0.393194804
0.065206408	**Competition**	2	4	1	5	0.130412816	0.260825631	0.065206408	0.326032039
	Total Sum	**36**	**34**	**34**	**36**	**3.059970813**	**2.916764506**	**2.934205895**	**2.960337782**

3.5.2 Development of the Bid/No Bid Decision-Making Tool

The bid/no bid decision-making tool was developed in excel format similar to the pairwise comparison tool; and Excel's conditional formatting option was employed to minimize the missing information in the tool cells. In contrast to the pairwise comparison tool, the participants were asked to compare case studies under each key factor and identify which project is more attractive than the other by considering the hypothetical case study conditions. First, the participants were asked to consider the key factor, then they were asked to identify which project has more attractive conditions to bid on than the other one based on the key factor. Based on 14 key factors and 4 hypothetical case studies; 84 pairwise comparisons were provided to the pilot group participants. The Bid/No Bid Decision-Making Tool can be seen in Appendix C.

3.6 The Statistical Analysis Method

As was mentioned in Chapter 1, there are three main purposes of this study. First, the ultimate purpose is to develop the decision-making tool. Second, combining Group AHP judgments based on the contractor classification. Third, investigating weights of importance given to the factors by the construction professionals to identify as to whether there are statistically significant differences between different groups of companies' valuation of the key factors or not. In order to assess such differences, One-Way Anova Test, Kruskal Wallis (Non-parametric alternative of One-Way Anova), Two-Sample t-test, and Wilcoxon Rank Sum (Non-parametric alternative of Two-Sample t-test) tests are conducted. The analyses were conducted using the statistical program SAS (2015).

Two-Sample t-test test enables researchers to investigate the data sets by comparing two groups. The only difference between Two-Sample t-test and One-Way Anova tests is more than two groups can be compared in One-Way Anova test. With Two-Sample t-test and One-Way

Anova tests, ordinal, interval or ratio variables can be analyzed. The tests are suitable for unbalanced data sets as well as balanced data, which mean the different sample sizes in the comparison groups do not affect the results of the analysis. The null hypothesis is that the means of the comparison groups are the same.

There are several assumptions to be met in order to conduct the Two-Sample t-test and One-Way Anova tests, those are:

1. The observations should be independent, which is one measurement in the data set should not affect the other measurements.
2. The observations should be sampled from a normal distribution.
3. The observation groups should have equal variances.

The Wilcoxon Rank Sum is the non-parametric alternative to the Two-Sample t-test, while the Kruskal Wallis Test is the non-parametric alternative to the One-Way Anova test. The only assumption of the Wilcoxon Rank Sum and Kruskal Wallis test is the independency of the observations.

If there are differences between the means of the groups (more than two groups), the different groups can be captured by One-Way Anova Test and Kruskal Wallis tests. However, the tests do not provide the information on which of the means differ from one another. Therefore, in order to determine which of the groups in the “Contractor Size” and “Contractor Sector” differ from each other; the Bonferroni correction/adjustment multiple testing procedure was conducted.

Chapter 4. Results

In order to address the purposes and the research questions introduced in Chapter 1, section 1.5, the results of the conducted analyses are presented in the following order:

1. Demographics of the respondents
2. Individual AHP results and the differences of the respondents' valuation of the bid/no bid decision-making key factors
3. Group AHP results
4. The validation of the bid/no bid decision-making tool

4.1 Demographics of the Respondents

4.1.1 Company Profile Questionnaire

To collect demographic information of the participants, Company Profile Questionnaire (see Chapter 3, Section 3.3.1) was provided to the respondents along with the pairwise comparison tool. The pairwise comparison tool was sent to 903 construction professionals (481 construction related companies) who have a relationship with the Department of Construction Management at Colorado State University. The recruitment e-mail was provided to the participants on July 15, 2015 and the reminder e-mail was sent on August 12, 2015. As a result, a total of 49 responses were collected. The collected information in each question in "Company Profile Questionnaire" is presented below:

4.1.1.1 Title or Position of the Respondent

The job titles or positions of the respondents with their frequencies are given in Table 4.1. According to the findings of the survey, 47 percent of the respondents acknowledged themselves as the president, vice president or founder of their companies.

Table 4.1 Title or Position of the Respondents

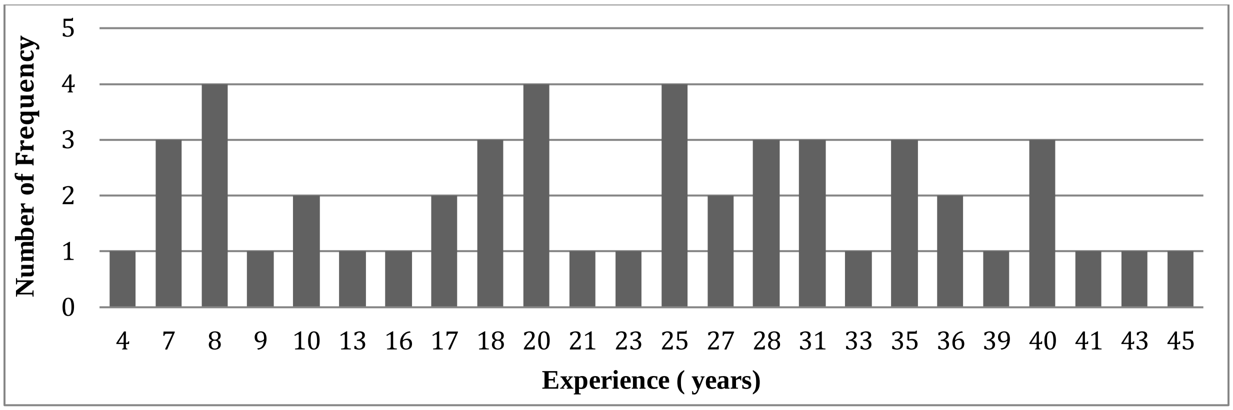
Job Title of the Respondents	Total Number
Branch Manager	2
Chief Estimator	2
Chief Estimator/Preconstruction Manager	1
Contracting Manager	1
Director of Business Development	1
Director of Industrial Sales & Estimating	1
Director/Preconstruction Services	1
Estimating Executive	1
Estimating Manager	1
Estimator/Preconstruction Manager	1
Manager of Sales	1
Marketing Manager	1
Operations Manager	1
Partner/Director of BD	1
Project Manager	2
Purchasing Agent	1
Senior Estimating Manager	1
Senior Estimator	2
Senior Manager	2
Senior Project Manager	1
Sponsor/Area Manager	1
Associate Vice President/Business Development	**1**
Executive Vice President	**1**
President	**6**
President/Founder	**4**
Senior Vice President	**1**
Vice President	**4**
Vice President of Business Development	**1**
Vice President/Chief Estimator	**1**
Vice President/COO	**1**
Vice President/Preconstruction	**1**
Vice President/Preconstruction Services Director	**1**
Vice President/Senior Preconstruction Manager	**1**
Grand Total	**49**

**The bold cells show the respondents who acknowledge themselves as the president, vice president or founder of the construction companies.*

4.1.1.2 Years of Experience of the Respondent

The years of experience of the respondents are given in Table 4.2. According to the results, the highest frequencies belong to 8, 20 and 25 years of experiences in the data set.

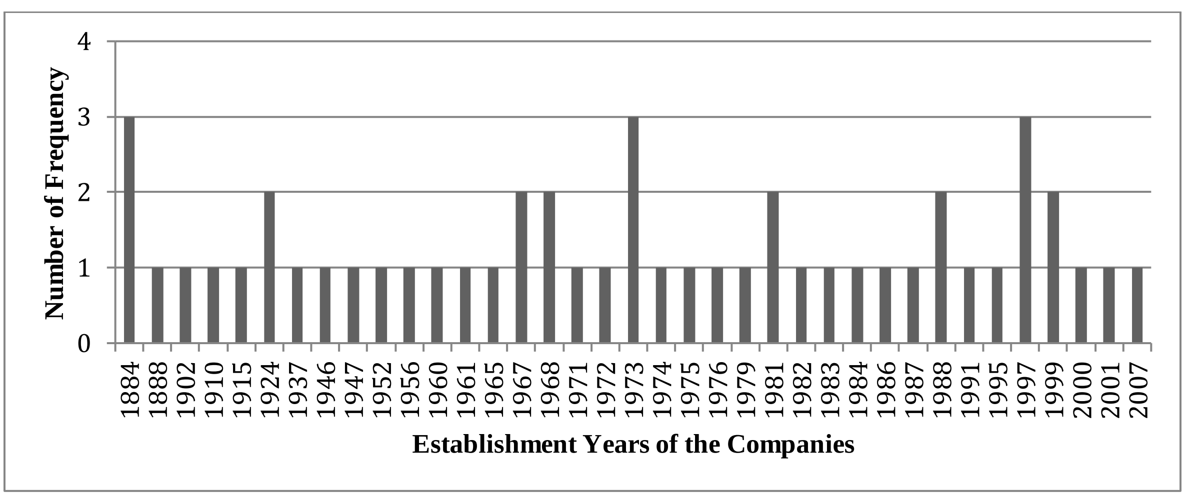
Table 4.2 Years of Experience of the Respondents



4.1.1.3 In What Year Was Your Company Founded?

The establishment years of the companies are given in Table 4.3 below. For the ease of the analyses, the establishment years were converted to the life span of the companies. The results showed that the life span of the companies ranged from 9 to 132 years.

Table 4.3 Establishment Years of the Companies



4.1.1.4 Type of Contractor

Based on the results given in Table 4.4, 39 companies acknowledged themselves as general contractors, while 10 out of 49 companies stated that they are subcontractors. The collected responses in this question are used to determine the contractor type.

Table 4.4 Type of the Contractors

Type of Contractor	**Total Number**
General Contractor	39
Subcontractor	10
Grand Total	**49**

4.1.1.5 Number of Employees

The employee numbers of the companies are given in Table 4.5. The numbers ranged from 1 to 40,000.

Table 4.5 Number of Employees

Number of Employees	**Number of Companies**
1	1
5	1
20	2
31	1
33	1
40	2
45	1
50	3
60	1
80	1
85	2
100	1
115	2
125	1
150	1
200	1
230	1
240	1
250	5

300	1
330	1
350	2
450	2
475	1
600	1
800	1
900	2
1,100	1
1,200	1
2,500	1
2,600	1
2,700	1
3,000	1
8,000	1
10,000	1
40,000	1
Grand Total	**49**

4.1.1.6 The Gross Revenue of Companies in 2014

In this question, the respondents were asked to give their companies' gross revenue information (in 2014) for four different sector categories. Those categories are:

- Residential Construction (Homes and apartments)
- Commercial Construction (Office buildings, stores, schools, libraries, etc.)
- Industrial Construction (Manufacturing plants, refineries, high-tech facilities like laboratories and hospitals, etc.)
- Heavy/Highway Construction (Highways, dams, water/wastewater treatment plants, railroads, bridges, tunnels, etc.)

The contractor size and contractor sector classifications are determined based on the collected information in this question (see Chapter 3, section 3.3.1 see for further explanation). The contractor revenues (e.g., Residential, Commercial, Industrial, Heavy/Highway, Total), types, sectors, and sizes of each company are given in Table 4.6.

Table 4.6 The Gross Revenue of Companies in 2014; Contractor Type, Contractor Size and Contractor Sector Breakdown

Contractor	Residential Construction Revenue (In USD)	Commercial Construction Revenue (In USD)	Industrial Construction Revenue (In USD)	Heavy/Highway Construction Revenue (In USD)	Total Revenue (In USD)	Contractor Type	Contractor Size	Contractor Sector
Company 1	-	42,000,000	5,000,000	-	47,000,000	General Contractor	Small-Medium Size Construction Company	Commercial-Industrial Construction
Company 2	25,000,000	150,000,000	25,000,000	-	200,000,000	General Contractor	Medium-Large Size Construction Company	Residential-Commercial-Industrial Construction
Company 3	-	-	-	450,000,000	450,000,000	General Contractor	Medium-Large Size Construction Company	Heavy Construction
Company 4	-	150,000,000	150,000,000	-	300,000,000	Subcontractor	Medium-Large Size Construction Company	Commercial-Industrial Construction
Company 5	-	300,000,000	300,000,000	-	600,000,000	Subcontractor	Large Size Construction Company	Commercial-Industrial Construction
Company 6	15,000,000	100,000,000	100,000,000	-	215,000,000	General Contractor	Medium-Large Size Construction Company	Residential-Commercial-Industrial Construction
Company 7	-	35,000,000	5,000,000	-	40,000,000	General Contractor	Small-Medium Size Construction Company	Commercial-Industrial Construction
Company 8	30,000,000	370,000,000	-	-	400,000,000	General Contractor	Medium-Large Size Construction Company	Residential-Commercial Construction
Company 9	-	500,000,000	2,000,000,000	3,500,000,000	6,000,000,000	General Contractor	Large Size Construction Company	Commercial-Industrial-Heavy Construction
Company 10	20,000,000	50,000,000	-	-	70,000,000	General Contractor	Small-Medium Size Construction Company	Residential-Commercial Construction
Company 11	2,000,000	44,000,000	-	30,000,000	76,000,000	General Contractor	Small-Medium Size Construction Company	Residential-Commercial-Heavy Construction

Company 12	-	2,800,000,000	-	-	2,800,000,000	General Contractor	Large Size Construction Company	Commercial Construction
Company 13	-	100,000,000	200,000,000	-	300,000,000	General Contractor	Medium-Large Size Construction Company	Commercial-Industrial Construction
Company 14	40,000,000	-	-	-	40,000,000	General Contractor	Small-Medium Size Construction Company	Residential Construction
Company 15	-	-	-	-	-	General Contractor	Small Size Construction Company	N/A
Company 16	30,000,000	30,000,000	20,000,000	8,000,000	88,000,000	Subcontractor	Small-Medium Size Construction Company	Residential-Commercial-Industrial-Heavy Construction
Company 17	-	-	252,000,000	-	252,000,000	Subcontractor	Medium-Large Size Construction Company	Industrial Construction
Company 18	1,000,000,000	2,000,000,000	-	-	3,000,000,000	General Contractor	Large Size Construction Company	Residential-Commercial Construction
Company 19	-	1,200,000,000	-	-	1,200,000,000	General Contractor	Large Size Construction Company	Commercial Construction
Company 20	-	100,000,000	180,000,000	-	280,000,000	General Contractor	Medium-Large Size Construction Company	Commercial-Industrial Construction
Company 21	-	1,000,000,000	4,000,000,000	5,000,000,000	10,000,000,000	General Contractor	Large Size Construction Company	Commercial-Industrial-Heavy Construction
Company 22	-	-	-	126,000,000	126,000,000	General Contractor	Medium-Large Size Construction Company	Heavy Construction
Company 23	-	25,000,000	-	-	25,000,000	Subcontractor	Small Size Construction Company	Commercial Construction
Company 24	40,000,000	20,000,000	-	-	60,000,000	General Contractor	Small-Medium Size Construction Company	Residential-Commercial Construction
Company 25	-	7,000,000	3,000,000	-	10,000,000	Subcontractor	Small Size Construction Company	Commercial-Industrial Construction

Company 26	30,000,000	90,000,000	50,000,000	-	170,000,000	General Contractor	Medium-Large Size Construction Company	Residential-Commercial-Industrial Construction
Company 27	10,000,000	45,000,000	-	-	55,000,000	General Contractor	Small-Medium Size Construction Company	Residential-Commercial Construction
Company 28	-	-	-	24,500,000	24,500,000	General Contractor	Small Size Construction Company	Heavy Construction
Company 29	-	-	-	9,000,000	9,000,000	General Contractor	Small Size Construction Company	Heavy Construction
Company 30	82,000,000	43,000,000	-	-	125,000,000	General Contractor	Small-Medium Size Construction Company	Residential-Commercial Construction
Company 31	-	11,000,000,000	-	-	11,000,000,000	General Contractor	Large Size Construction Company	Commercial Construction
Company 32	-	-	71,892,087	-	71,892,087	Subcontractor	Small-Medium Size Construction Company	Industrial Construction
Company 33	177,500,000	536,000,000	170,000,000	251,000,000	1,134,500,000	General Contractor	Large Size Construction Company	Residential-Commercial-Industrial- Heavy Construction
Company 34	-	1,400,000,000	5,700,000,000	3,200,000,000	10,300,000,000	General Contractor	Large Size Construction Company	Commercial-Industrial-Heavy Construction
Company 35	-	2,630,000,000	-	-	2,630,000,000	General Contractor	Large Size Construction Company	Commercial Construction
Company 36	-	-	-	20,000,000	20,000,000	General Contractor	Small Size Construction Company	Heavy Construction
Company 37	-	5,000,000	3,000,000	-	8,000,000	General Contractor	Small Size Construction Company	Commercial-Industrial Construction
Company 38	-	250,000,000	700,000,000	-	950,000,000	General Contractor	Large Size Construction Company	Commercial-Industrial Construction

Company 39	2,750,000	-	-	-	2,750,000	General Contractor	Small Size Construction Company	Residential Construction
Company 40	-	2,000,000,000	1,500,000,000	500,000,000	4,000,000,000	General Contractor	Large Size Construction Company	Commercial-Industrial-Heavy Construction
Company 41	7,500,000	6,500,000	1,500,000	18,000,000	33,500,000	Subcontractor	Small Size Construction Company	Residential-Commercial-Industrial- Heavy Construction
Company 42	-	30,000,000	50,000,000	-	80,000,000	Subcontractor	Small-Medium Size Construction Company	Commercial-Industrial Construction
Company 43	-	52,000,000	-	-	52,000,000	General Contractor	Small-Medium Size Construction Company	Commercial Construction
Company 44	-	-	-	14,721,435	14,721,435	General Contractor	Small Size Construction Company	Heavy Construction
Company 45	-	38,000,000	-	-	38,000,000	General Contractor	Small Size Construction Company	Commercial Construction
Company 46	100,000	10,000,000	-	-	10,100,000	Subcontractor	Small Size Construction Company	Residential-Commercial Construction
Company 47	126,000,000	112,000,000	92,000,000	-	330,000,000	General Contractor	Medium-Large Size Construction Company	Residential-Commercial-Industrial Construction
Company 48	-	130,000,000	20,000,000	-	150,000,000	General Contractor	Medium-Large Size Construction Company	Commercial-Industrial Construction
Company 49	-	45,000,000	21,000,000	-	66,000,000	General Contractor	Small-Medium Size Construction Company	Commercial-Industrial Construction
Grand Total	**1,637,850,000**	**27,445,500,000**	**15,619,392,087**	**13,151,221,435**	**57,853,963,522**			

As seen in Table 4.6, the commercial construction category has the highest revenue amount, which is the 47 percent of the total revenue amount. On the contrary, the lowest total revenue amount is seen for the residential construction sector (3% of the total revenue amount). As was mentioned before in section 4.1.1.4, most of the contractors are general contractors (80%). For the contractor sector classification, it was found that the different groups under this category have equal participant numbers; the total number of the small size construction companies is 13 while the remaining groups have 12 companies in the groups. The contractors are also divided based on their sectors (see Figure 4.1). The results show that 38 companies work in the commercial construction sector while 17, 25 and 14 companies work in the residential, industrial and heavy/highway construction sectors, respectively. One of the companies, which did not state any revenue information, is excluded; therefore, 48 companies are presented in Figure 4.1.

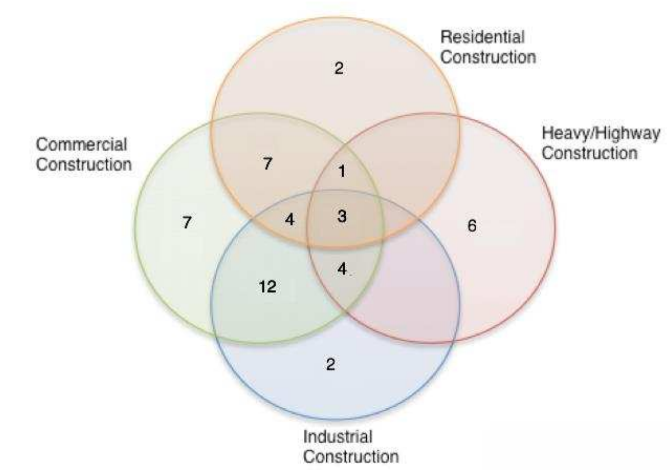


Figure 4.1 The Distribution of the Companies Based on Construction Sectors

The descriptive statistics for each question in "Company Profile Questionnaire" are given in Table 4.7. It is valuable to mention that one company, which does not have any revenue information, is excluded from the descriptive statistic calculations.

Table 4.7 Descriptive Statistics for the Collected Demographic Information

Variable	Mean	Standard Deviation	Minimum	Maximum
Years of experience of the respondent	23.90	11.47	4.00	45.00
Life span of the company	53.85	35.66	9.00	132.00
Number of employees	1,667.19	5,955.09	1.00	40,000.00
Residential Construction Revenue Amount	34,121,875.00	146,268,302.00	-	1,000,000,000.00
Commercial Construction Revenue Amount	571,781,250.00	1,684,875,341.00	-	11,000,000,000.00
Industrial Construction Revenue Amount	325,404,002.00	1,036,106,255.00	-	5,700,000,000.00
Heavy/Highway Construction Revenue Amount	273,983,780.00	972,173,936.00	-	5,000,000,000.00
Total Revenue Amount	1,205,290,907.00	2,682,178,812.00	2,750,000.00	11,000,000,000.00

4.2 Individual AHP Results and Statistical Analyses

As stated in Chapter 1, section 1.5, one of the purposes of this study is to estimate the weights of importance given to the key factors and investigate whether there are statistically significant differences of the respondents' valuations of the key factors, considering their different demographic backgrounds (i.e., contractor type, contractor sector, contractor size). For this purpose, the weights of the key factors based on each contractor's preferences are identified using the AHP methodology (see Chapter 3, section 3.4). The estimated weights of the key factors and the consistency ratios for each contractor are given in Table 4.8 and Table 4.9. The tables are organized under two hierarchies, namely Level 2-A Firm Related Internal Factors and Level 2-B Project Related External Factors.

Table 4.8 Estimated Weights and Consistency Ratios for Level 2-A-Firm Related Internal Key Factors

Contractor	Overall Firm Related-Internal Factors	Level 2-A Firm Related Internal Factors Consistency Ratio	Weight given to the "Current workload" factor	Weight given to the "Experience in similar projects" factor	Weight given to the "Availability of equipment, materials and human resources" factor	Weight given to the "Financia l ability" factor	Weight given to the "Need for work" factor	Weight given to the "Technical knowhow" factor	Weight given to the "Compliance with the business plan" factor
Contractor 1	0.875	12%	0.291	0.100	0.081	0.017	0.203	0.122	0.061
Contractor 2	0.167	11%	0.011	0.043	0.011	0.010	0.019	0.011	0.062
Contractor 3	0.500	15%	0.073	0.029	0.087	0.036	0.119	0.058	0.097
Contractor 4	0.800	48%	0.083	0.043	0.088	0.017	0.292	0.057	0.218
Contractor 5	0.833	11%	0.053	0.225	0.093	0.076	0.133	0.127	0.127
Contractor 6	0.875	18%	0.071	0.181	0.118	0.118	0.114	0.190	0.082
Contractor 7	0.500	44%	0.159	0.034	0.092	0.031	0.135	0.020	0.030
Contractor 8	0.857	20%	0.028	0.092	0.061	0.025	0.275	0.027	0.349
Contractor 9	0.500	3%	0.035	0.122	0.068	0.042	0.042	0.155	0.036
Contractor 10	0.875	36%	0.023	0.109	0.072	0.226	0.014	0.044	0.387
Contractor 11	0.833	7%	0.133	0.027	0.111	0.041	0.147	0.029	0.345
Contractor 12	0.125	48%	0.004	0.032	0.010	0.004	0.005	0.010	0.061
Contractor 13	0.500	14%	0.063	0.132	0.053	0.013	0.107	0.016	0.116
Contractor 14	0.833	18%	0.228	0.074	0.065	0.221	0.173	0.046	0.026
Contractor 15	0.500	32%	0.060	0.058	0.029	0.032	0.209	0.033	0.078
Contractor 16	0.167	73%	0.008	0.022	0.004	0.026	0.049	0.009	0.049
Contractor 17	0.857	11%	0.206	0.047	0.163	0.033	0.267	0.103	0.037
Contractor 18	0.500	10%	0.046	0.024	0.083	0.160	0.144	0.027	0.016
Contractor 19	0.750	7%	0.046	0.050	0.066	0.179	0.058	0.027	0.323
Contractor 20	0.250	15%	0.033	0.073	0.022	0.015	0.069	0.022	0.017
Contractor 21	0.667	17%	0.038	0.059	0.020	0.044	0.243	0.205	0.058
Contractor 22	0.250	15%	0.007	0.024	0.033	0.100	0.012	0.063	0.012
Contractor 23	0.500	15%	0.102	0.024	0.122	0.031	0.170	0.037	0.013
Contractor 24	0.833	75%	0.071	0.158	0.117	0.166	0.113	0.175	0.032
Contractor 25	0.167	83%	0.033	0.018	0.050	0.021	0.021	0.005	0.019
Contractor 26	0.200	14%	0.005	0.014	0.007	0.007	0.099	0.019	0.049
Contractor 27	0.900	33%	0.072	0.077	0.318	0.014	0.066	0.170	0.183
Contractor 28	0.750	36%	0.059	0.102	0.109	0.059	0.316	0.074	0.031
Contractor 29	0.250	12%	0.012	0.005	0.028	0.137	0.037	0.008	0.022

Contractor 30	0.500	26%	0.074	0.141	0.112	0.022	0.017	0.045	0.089
Contractor 31	0.900	137%	0.072	0.132	0.026	0.049	0.046	0.080	0.495
Contractor 32	0.167	31%	0.015	0.007	0.014	0.072	0.043	0.012	0.004
Contractor 33	0.667	19%	0.017	0.072	0.039	0.245	0.187	0.039	0.068
Contractor 34	0.125	40%	0.004	0.020	0.018	0.002	0.006	0.056	0.019
Contractor 35	0.500	10%	0.031	0.079	0.182	0.039	0.023	0.073	0.073
Contractor 36	0.500	33%	0.031	0.020	0.078	0.218	0.091	0.014	0.049
Contractor 37	0.750	42%	0.128	0.101	0.094	0.061	0.168	0.168	0.030
Contractor 38	0.167	12%	0.004	0.036	0.012	0.009	0.009	0.011	0.086
Contractor 39	0.500	13%	0.039	0.013	0.060	0.042	0.232	0.066	0.049
Contractor 40	0.875	7%	0.171	0.069	0.187	0.036	0.313	0.063	0.035
Contractor 41	0.833	16%	0.410	0.084	0.154	0.035	0.063	0.043	0.044
Contractor 42	0.125	21%	0.003	0.007	0.005	0.049	0.019	0.030	0.011
Contractor 43	0.800	25%	0.023	0.071	0.054	0.028	0.084	0.223	0.317
Contractor 44	0.875	33%	0.033	0.043	0.231	0.418	0.092	0.043	0.015
Contractor 45	0.833	14%	0.141	0.039	0.235	0.102	0.246	0.019	0.051
Contractor 46	0.143	79%	0.008	0.006	0.027	0.033	0.020	0.043	0.005
Contractor 47	0.857	97%	0.274	0.236	0.088	0.039	0.097	0.062	0.061
Contractor 48	0.200	19%	0.017	0.031	0.007	0.006	0.012	0.050	0.076
Contractor 49	0.857	29%	0.044	0.054	0.187	0.390	0.083	0.079	0.021

** Company 15, which did not state the revenue information, is excluded from the statistical analyses.*

** The red highlighted cells show the consistency ratios that exceed the recommended 10 % value.*

Table 4.9 The Estimated Weights and the Consistency Ratios for Level 2-B Project Related External Key Factors

Contractor	Overall Project Related-External Factors	Level 2-B Project Related External Factors Consistency Ratio	Weight given to the "Project size" factor	Weight given to the "Project duration" factor	Weight given to the "Location of the project" factor	Weight given to the "Project type" factor	Weight given to the "Contract conditions and type of contract" factor	Weight given to the "Owner identity" factor	Weight given to the "Competition" factor
Contractor 1	0.125	18%	0.007	0.008	0.004	0.009	0.027	0.064	0.006
Contractor 2	0.833	14%	0.057	0.031	0.071	0.046	0.074	0.351	0.203
Contractor 3	0.500	12%	0.016	0.014	0.045	0.032	0.133	0.168	0.092
Contractor 4	0.200	29%	0.011	0.024	0.017	0.023	0.068	0.044	0.013
Contractor 5	0.167	27%	0.005	0.006	0.014	0.028	0.042	0.048	0.023
Contractor 6	0.125	8%	0.004	0.003	0.026	0.031	0.038	0.014	0.010
Contractor 7	0.500	12%	0.073	0.079	0.011	0.014	0.209	0.028	0.085
Contractor 8	0.143	20%	0.003	0.003	0.007	0.012	0.040	0.058	0.019
Contractor 9	0.500	14%	0.020	0.014	0.017	0.040	0.076	0.116	0.216
Contractor 10	0.125	34%	0.003	0.002	0.006	0.009	0.031	0.058	0.016
Contractor 11	0.167	17%	0.007	0.003	0.011	0.008	0.024	0.062	0.052
Contractor 12	0.875	18%	0.027	0.018	0.040	0.088	0.456	0.188	0.058
Contractor 13	0.500	13%	0.039	0.016	0.057	0.089	0.021	0.201	0.077
Contractor 14	0.167	18%	0.006	0.006	0.064	0.033	0.012	0.029	0.017
Contractor 15	0.500	25%	0.027	0.010	0.030	0.021	0.086	0.201	0.125
Contractor 16	0.833	48%	0.047	0.029	0.046	0.040	0.429	0.049	0.193
Contractor 17	0.143	15%	0.003	0.004	0.055	0.009	0.026	0.013	0.033
Contractor 18	0.500	4%	0.029	0.019	0.034	0.041	0.171	0.184	0.022
Contractor 19	0.250	5%	0.013	0.015	0.019	0.021	0.082	0.085	0.014
Contractor 20	0.750	12%	0.021	0.031	0.155	0.243	0.193	0.049	0.059
Contractor 21	0.333	15%	0.026	0.007	0.009	0.016	0.117	0.081	0.077
Contractor 22	0.750	14%	0.046	0.015	0.023	0.055	0.283	0.186	0.142
Contractor 23	0.500	18%	0.030	0.146	0.142	0.060	0.089	0.018	0.016
Contractor 24	0.167	25%	0.008	0.005	0.006	0.064	0.026	0.041	0.016
Contractor 25	0.833	16%	0.017	0.034	0.173	0.110	0.349	0.072	0.079
Contractor 26	0.800	10%	0.050	0.034	0.058	0.034	0.414	0.177	0.034
Contractor 27	0.100	15%	0.002	0.002	0.007	0.007	0.027	0.035	0.020
Contractor 28	0.250	19%	0.022	0.011	0.012	0.057	0.018	0.070	0.061
Contractor 29	0.750	16%	0.019	0.038	0.022	0.133	0.064	0.126	0.348
Contractor 30	0.500	7%	0.020	0.012	0.088	0.079	0.112	0.101	0.088

Contractor 31	0.100	37%	0.006	0.001	0.013	0.025	0.048	0.004	0.002
Contractor 32	0.833	10%	0.030	0.021	0.072	0.146	0.264	0.229	0.071
Contractor 33	0.333	15%	0.014	0.007	0.034	0.054	0.082	0.128	0.015
Contractor 34	0.875	26%	0.049	0.020	0.026	0.083	0.382	0.117	0.198
Contractor 35	0.500	13%	0.014	0.016	0.037	0.049	0.134	0.173	0.077
Contractor 36	0.500	30%	0.019	0.027	0.226	0.021	0.133	0.028	0.047
Contractor 37	0.250	16%	0.014	0.006	0.019	0.044	0.023	0.091	0.054
Contractor 38	0.833	18%	0.031	0.019	0.039	0.110	0.069	0.213	0.352
Contractor 39	0.500	16%	0.100	0.032	0.039	0.062	0.058	0.160	0.049
Contractor 40	0.125	11%	0.004	0.005	0.012	0.004	0.025	0.058	0.017
Contractor 41	0.167	15%	0.011	0.010	0.048	0.038	0.016	0.026	0.018
Contractor 42	0.875	12%	0.156	0.027	0.033	0.116	0.394	0.049	0.101
Contractor 43	0.200	31%	0.007	0.004	0.014	0.018	0.084	0.057	0.016
Contractor 44	0.125	10%	0.004	0.007	0.012	0.026	0.030	0.039	0.007
Contractor 45	0.167	37%	0.021	0.033	0.007	0.010	0.005	0.055	0.038
Contractor 46	0.857	64%	0.032	0.021	0.108	0.254	0.087	0.265	0.090
Contractor 47	0.143	45%	0.060	0.035	0.003	0.022	0.012	0.007	0.004
Contractor 48	0.800	21%	0.037	0.028	0.020	0.067	0.205	0.107	0.336
Contractor 49	0.143	43%	0.006	0.004	0.005	0.022	0.031	0.052	0.025

** Company 15, which did not state the revenue information, is excluded from the statistical analyses.*
** The red highlighted cells show the consistency ratios that exceed the recommended 10 % value.*

At this point, it is important to state that many of the consistency ratios in Table 4.8 and Table 4.9 exceed the recommended limit of 0.10. However, keeping in mind that the participants were not given the opportunity to review their consistency ratios of their selections while or after the decision-making processes; all responses are included in the statistical analyses, except for one company which did not state any revenue information. Furthermore, considering that the sample size is very limited, including all participants for the statistical analyses was a necessity for the study. Therefore, 48 responses were used in the statistical analyses.

4.3 Descriptive Statistics for the Individual AHP Results

In Table 4.10, the descriptive statistics are calculated for each key factor weights. The results show that the mean of the overall firm related factors is higher than the overall project related key factors. This finding could explain the respondents' tendency, as they put more value on the overall firm related factors than the overall project related factors. In the firm related factor hierarchy (Level 2-A), the "Need for work" key factor has the highest mean value, while the "Contract conditions and type of contract", key factor has in the project related key factor hierarchy (Level 2-B). On the contrary, the "Technical knowhow" and "Project duration" key factors have the lowest mean values in the firm related key factor and project related key factor hierarchies, respectively. In the data set, the standard deviations also show a wide dispersion that might form an opinion of a non-normal distribution. However, to give a final judgment whether the data is sampled from a normal distribution or not, the test of normality is conducted and the results are explained in section 4.4 in this chapter.

Table 4.10 Descriptive Statistics of the Key Factors Based on the Individual AHP Results

Hierarchy	Variable	Mean	Standard Deviation	Minimum	Maximum
Level 2-A Firm Related Internal Factors	Overall Firm Related-Internal Factors	0.57	0.29	0.13	0.90
	Current workload	0.07	0.09	-	0.41
	Experience in similar projects	0.07	0.06	0.01	0.24
	Availability of equipment, materials and human resources	0.08	0.07	-	0.32
	Financial ability	0.08	0.10	-	0.42
	Need for work	**0.11**	0.09	0.01	0.32
	Technical knowhow	**0.06**	0.06	0.01	0.22
	Compliance with the business plan	0.09	0.12	-	0.49
Level 2-B Project Related External Factors	Overall Project Related-External Factors	0.43	0.29	0.10	0.88
	Project size	0.03	0.03	-	0.16
	Project duration	**0.02**	0.02	-	0.15
	Location of the project	0.04	0.05	-	0.23
	Project type	0.05	0.05	-	0.25
	Contract conditions and type of contract	**0.12**	0.13	-	0.46
	Owner identity	0.10	0.08	-	0.35
	Competition	0.08	0.09	-	0.35

- *The bold cells show the highest and lowest mean values under each hierarchy.*

Based on the results presented in Table 4.10, the key factors could be ordered in accordance with the magnitude of the mean values for each hierarchy groups as following:

Firm Related-Internal Factors:

Need for work > Compliance with the business plan > Financial ability = Availability of equipment, materials and human resources > Experience in similar projects = Current workload > Technical knowhow

Project Related-External Factors:

Contract conditions and type of contract > Owner identity > Competition > Project type > Location of the project > Project size > Project duration

4.4 Testing the Assumptions of One-Way Anova and Two-Sample t-tests

This section discusses the assumptions of One-Way Anova and Two-Sample t-tests in order to select appropriate statistical tests for the data sets. The assumptions are given by following and the results are discussed under each assumption. The assumptions are:

1. Observations are independent.
2. Observations are sampled from a population with a normal distribution.
3. Groups have equal variances.

4.4.1 Independency of the Observations

Although the estimated weights of the key factors are linked to each other because of the reciprocal nature of the AHP methodology, it was assumed that the assumption of independent observations are met in this study. Therefore, the estimated weights of the key factors were inferred to be independent from each other. In order to support this assumption, the analyses are conducted separately for each key factor and the correlation analyses are avoided in the study.

4.4.2 Analysis of the Normality Assumption of One-Way Anova Test and Two-Sample t-test

In an attempt to investigate the differences between the respondents' preferences of the key factors, One-Way Anova Test, Kruskal Wallis (Non-parametric alternative of One-Way Anova), Two-Sample t-test, and Wilcoxon Rank Sum (Non-parametric alternative of Two-Sample t-test) tests are performed. Additionally, to decide which test is suitable for the data sets, the normality assumption is tested for parametric test alternatives.

One of the assumptions of the One-Way Anova test and Two-Sample t-tests is to sample the data from a normal distribution. However, the normality assumption is not required for the Kruskal Wallis and Wilcoxon Rank Sum tests, therefore the results of the normality test is used to determine the test types. To test whether the data sets are samples from normal distributions or not, each data set was analyzed by using the "proc univariate" option of SAS Program. The test statistic (*W*) and the probability values (p-value) are given side by side in Table 4.11. According to the test statistic approach, the test statistic can be greater than zero and less than one or equal to one ($0<W\leq1$). The smaller test statistic indicates that the data is not sampled from a normal distribution. On the other hand, p-values indicate the doubtfulness of normality and can be ranged from zero to one ($0\leq$p-values≤1). The p-values, which are very close to zero, indicates that the data is not sampled from a normal distribution.

Table 4.11 Estimated Test Statistic and P-values to Test the Normality Assumption of One-Way Anova Test and Two-Sample t-test

Variable	Test Statistic	P-value
Overall Firm Related-Internal Factors	0.843527	<0.0001
Current workload	0.750619	<0.0001
Experience in similar projects	0.859831	<0.0001
Availability of equipment, materials and human resources	**0.889471**	**0.0003**
Financial ability	0.723292	<0.0001
Need for work	**0.895922**	**0.0005**
Technical knowhow	0.813723	<0.0001

Compliance with the business plan	0.687704	<0.0001
Overall Project Related-External Factors	0.84342	<0.0001
Project size	0.741495	<0.0001
Project duration	0.614808	<0.0001
Location of the project	0.727714	<0.0001
Project type	0.767164	<0.0001
Contract conditions and type of contract	0.778074	<0.0001
Owner identity	**0.881677**	**0.0002**
Competition	0.721153	<0.0001

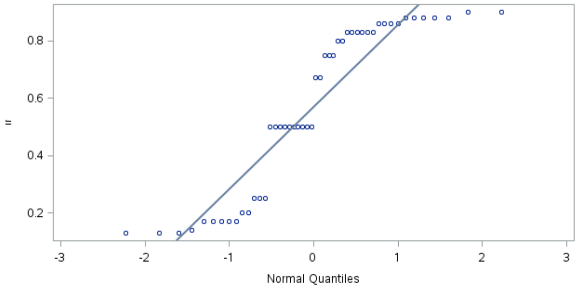
- *The bold cells show the values that support the normality assumption of One-Way Anova Test or Two-Sample t-tests*

Based on the results presented in Table 4.11, the "Availability of equipment, materials and human resources", "Need for work", and "Owner identity" data sets' p-values exceed the <0.0001 level and are suitable for One-Way Anova or Two-Sample t-tests. However, it is worthwhile to mention that the statistical tests for normality can be quite robust. To conclude if the remaining data sets are a sample from a normal distribution, the Q-Q Plots of the data sets are reviewed in section 4.4.3.

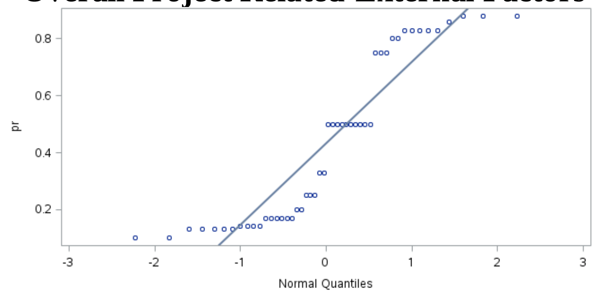
4.4.3 Testing Normality with Q-Q Plots

To test the normality of the data sets in a detailed manner, Q-Q plots are created by using the "plot" option of SAS program and given in Figure 4.2 for each key factor. In the Q-Q plots, the dots represent the sample. If the data is sampled from a normal distribution, the dots form a straight line and get closer to the guideline, which are indicated by the straight blue lines in the plots.

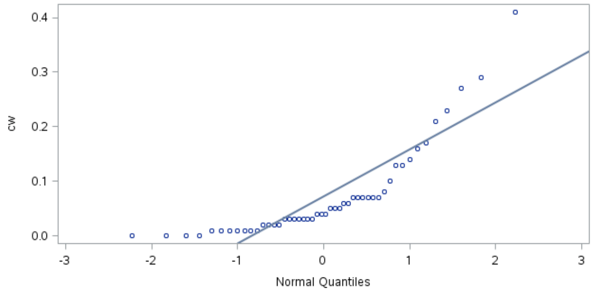
Overall Firm Related-Internal Factors



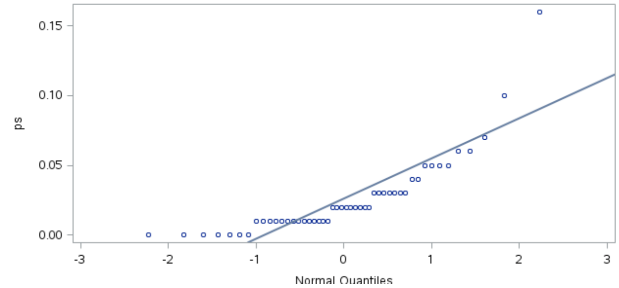
Overall Project Related-External Factors



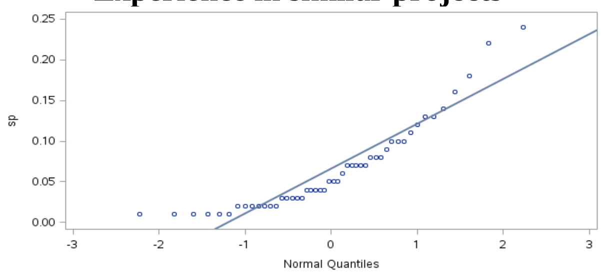
Current workload



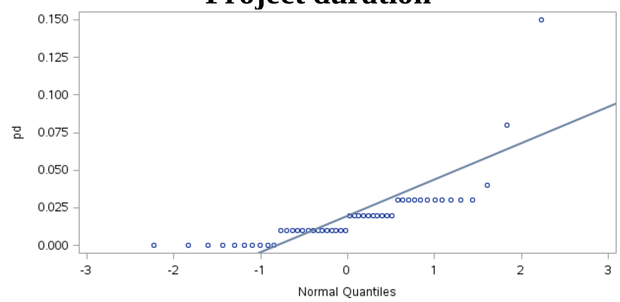
Project size



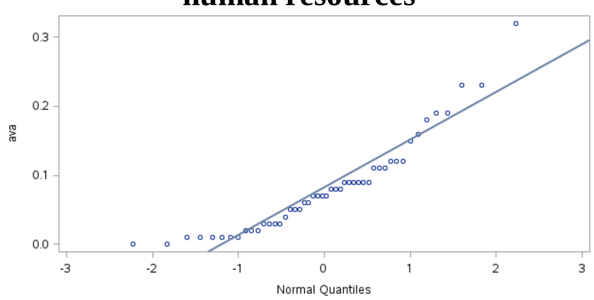
Experience in similar projects



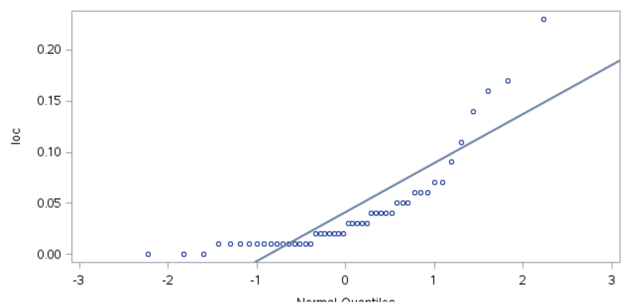
Project duration



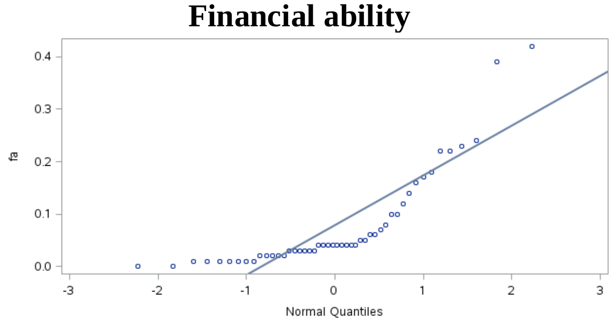
Availability of equipment, materials and human resources



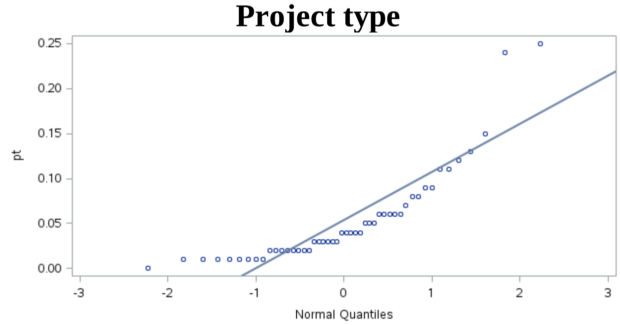
Location of the project



Financial ability



Project type



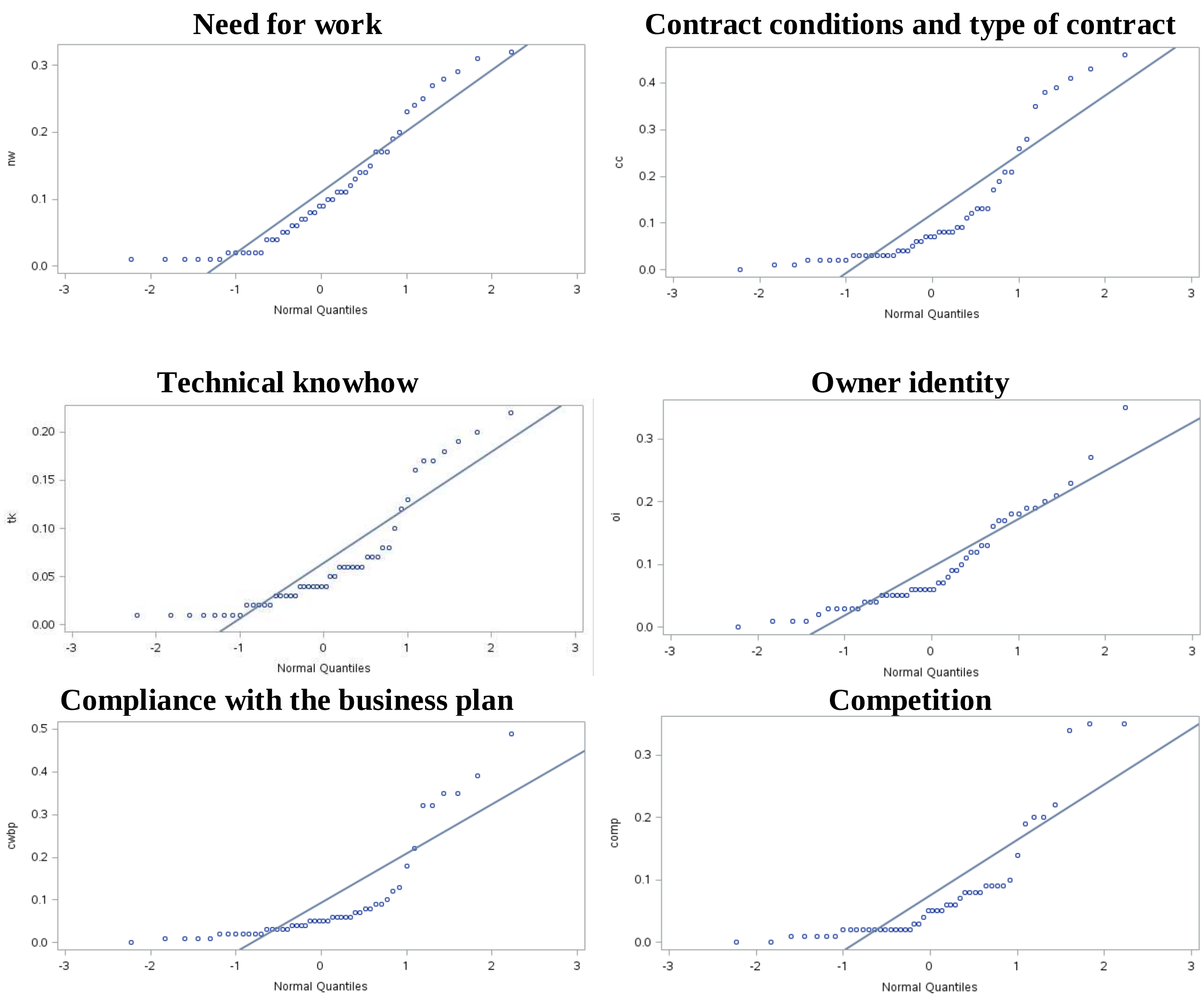


Figure 4.2 Plotted Q-Q Plots to Test the Normality of the Key Factor Data Sets

The “Availability of equipment, materials and human resources”, “Need for work”, and “Owner identity” data sets form a straight line therefore, it can be concluded that the data sets are sampled from the normal distributions and are suitable for One-Way Anova Test or Two-Sample t-tests. Although, the test of normality results did not provide enough evidence that the “Experience in similar projects” key factor is sampled from a normal distribution, the Q-Q Plot results show a straight data dispersion, therefore that key factor is also treated as a normally distributed data set.

4.4.4 Equal Variances of the Groups

One of the assumptions of the One-Way Anova Test and Two-Sample t-tests is that the different groups have equal variances. The equal variances of the contractor classification groups are tested and the corresponding p-values for each group are given in Table 4.12. The red highlights show that the p-values are greater than the reference probability value, which is 0.05. Therefore, the groups, which have p-values greater than 0.05, have equal variances and are suitable for parametric statistical tests.

Table 4.12 Estimated P-values to Test Equal Variances Assumption of One-Way Anova Test and Two-Sample t-test for Each Key Factor under Each Contractor Classification Group

Key Factors	Contractor Type	Contractor Sector	Contractor Size
Current workload	0.0134	0.0024	0.5409
Experience in similar projects	0.3632	0.0504	0.3752
Availability of equipment, materials and human resources	0.6267	0.8629	0.5339
Financial ability	0.0001	0.8404	0.3293
Need for work	0.4883	0.5518	0.2954
Technical knowhow	0.1771	0.5854	0.4903
Compliance with the business plan	0.0725	0.0013	0.2253
Project size	0.0017	0.7669	0.4131
Project duration	0.0001	0.3874	0.3329
Location of the project	0.4238	0.5816	0.0086
Project type	0.0243	0.5628	0.6113
Contract conditions and type of contract	0.1235	0.535	0.746
Owner identity	0.361	0.0128	0.2424
Competition	0.0858	0.5445	0.6237

**The red highlighted cells show the p-values greater than 0.05.*

4.4.5 Deciding Which Statistical Test to Use for the Analysis

In deciding which test to use for each key factor and contractor classification groups, three assumptions of the One-Way Anova Test and Two-Sample t-tests are considered. The test selections for each key factor situation are given in Table 4.13.

Table 4.13 Determined Statistical Tests for Key Factor Analysis

Key Factors	Contractor Type	Contractor Sector	Contractor Size
Current workload	Wilcoxon Rank Sum Test	Kruskal Wallis Test	Kruskal Wallis Test
Experience in similar projects	Two-sample t-test	One-Way Anova Test	One-Way Anova Test
Availability of equipment, materials and human resources	Two-sample t-test	One-Way Anova Test	One-Way Anova Test
Financial ability	Wilcoxon Rank Sum Test	Kruskal Wallis Test	Kruskal Wallis Test
Need for work	Two-sample t-test	One-Way Anova Test	One-Way Anova Test
Technical knowhow	Wilcoxon Rank Sum Test	Kruskal Wallis Test	Kruskal Wallis Test
Compliance with the business plan	Wilcoxon Rank Sum Test	Kruskal Wallis Test	Kruskal Wallis Test
Project size	Wilcoxon Rank Sum Test	Kruskal Wallis Test	Kruskal Wallis Test
Project duration	Wilcoxon Rank Sum Test	Kruskal Wallis Test	Kruskal Wallis Test
Location of the project	Wilcoxon Rank Sum Test	Kruskal Wallis Test	Kruskal Wallis Test
Project type	Wilcoxon Rank Sum Test	Kruskal Wallis Test	Kruskal Wallis Test
Contract conditions and type of contract	Wilcoxon Rank Sum Test	Kruskal Wallis Test	Kruskal Wallis Test
Owner identity	Two-sample t-test	Kruskal Wallis Test	One-Way Anova Test
Competition	Wilcoxon Rank Sum Test	Kruskal Wallis Test	Kruskal Wallis Test

4.5 The Differences in Contractors' Valuation of Key Factors

Taking the contractor type, sector, and size classifications into the consideration: the differences in the contractors' valuation of the bid/no bid decision-making key factors are investigated. For this purpose, the hypotheses of whether the means of given weights to the key factors by various contractors are same or at least one of the means are different are tested.

A total of 14 different analyses were conducted for each demographic classification (i.e., Contractor Type, Contractor Sector and Contractor Size). For each analysis, 0.05 is set as the reference probability level and used to compare with the estimated p-values. The estimated p-values, which are the results of Two-sample t-test, Wilcoxon Rank Sum Test, One-Way Anova, and Kruskal-Wallis tests, are presented in Table 4.14, Table 4.15, Table 4.16 and Table 4.17. The highlighted cells in the tables show the p-values less than 0.05 reference probability value.

Considering that the weights given to the overall firm related-internal factors and overall project related-external factors are already distributed on the key factors, any statistical analysis were not conducted at the aggregate level for the overall firm related-internal factors and overall project related-external factors.

Table 4.14 Two-Sample t-test Results

Variables	Contractor Type
Experience in similar projects	0.4451
Availability of equipment, materials and human resources	0.5331
Need for work	0.8960
Owner identity	0.5344

Table 4.15 Wilcoxon Rank Sum Test Results

Variables	Contractor Type
Current workload	0.8884
Financial ability	0.4983
Technical knowhow	0.3192
Compliance with the business plan	0.0428
Project size	0.6047
Project duration	0.1746
Location of the project	0.0107
Project type	0.119
Contract conditions and type of contract	0.1811
Competition	0.8473

Table 4.16 One-Way Anova Test Results

Variables	Contractor Sector	Contractor Size
Experience in similar projects	0.3099	0.9181
Availability of equipment, materials and human resources	0.9386	0.3392
Need for work	0.9091	0.6151
Owner identity		0.289

Table 4.17 Kruskal Wallis Test Results

Variables	Contractor Sector	Contractor Size
Current workload	0.9566	0.6268
Financial ability	0.3467	0.1028
Technical knowhow	0.7291	0.6839
Compliance with the business plan	0.3319	0.0356
Project size	0.7456	0.8164
Project duration	0.3818	0.0862
Location of the project	0.6129	0.2157
Project type	0.8858	0.4098
Contract conditions and type of contract	0.8693	0.3679
Owner identity	0.9977	
Competition	0.5885	0.9829

Table 4.18 Estimated P-values Based on the Analysis between the Weights of the Key Factors and Contractor Classification

Variables	Contractor Type	Contractor Sector	Contractor Size
Current workload	0.8884	0.9566	0.6268
Experience in similar projects	0.4451	0.3099	0.9181
Availability of equipment, materials and human resources	0.5331	0.9386	0.3392
Financial ability	0.4983	0.3467	0.1028

Need for work	0.896	0.9091	0.6151
Technical knowhow	0.3192	0.7291	0.6839
Compliance with the business plan	0.0428	0.3319	0.0356
Project size	0.6047	0.7456	0.8164
Project duration	0.1746	0.3818	0.0862
Location of the project	0.0107	0.6129	0.2157
Project type	0.119	0.8858	0.4098
Contract conditions and type of contract	0.1811	0.8693	0.3679
Owner identity	0.5344	0.9977	0.289
Competition	0.8473	0.5885	0.9829

Table 4.18 summarizes the results given in Table 4.14, Table 4.15, Table 4.16 and Table 4.17. As seen in Table 4.18, the compliance with the business plan and location of the project factors were found statistically significantly different for the "Contractor Type" classification. The p-values (0.0428 and 0.0107) give the information that there is enough evidence to conclude that the weight of importance given to the compliance with the business plan and location of the project factors by general contractors and subcontractors are statistically significantly different from each other.

The "Contractor Sector" classification group includes ten subgroups which were determined based on the company revenues: Residential, Commercial, Industrial, Heavy, Residential-Commercial, Residential-Commercial-Industrial, Residential-Commercial-Heavy, Residential-Commercial-Industrial-Heavy, Commercial-Industrial, Commercial-Industrial-Heavy Construction. Based on both One-Way Anova and Kruskal Wallis test results, none of the contractor sector groups are statistically significant from each other; evidently, the results didn't provide enough evidence to support the hypothesis, which is at least one of the groups, is significantly different (see Table 4.18).

The "Contractor Size" classification group is also investigated in the same manner. The respondents are divided into four groups as shown in Table 3.3. Based on the results, the compliance with the business plan factor was found statistically significantly different for the "Contractor Size" classification. To determine, which of the groups in the "Contractor Size" differ from each other; the Bonferroni correction/adjustment multiple testing procedure was performed. However, even though the compliance with the business plan key factor was found to be statistically significantly different for the "Contractor Size" group as indicated by the Kruskal Wallis test results, the different groups were not captured by the adjusted multiple testing procedure because of the conservativeness of the Bonferroni correction method.

4.6 Group AHP results

The weights given to the key factors from the contractors are combined into one final judgment for each subgroup under contractor type, contractor sector and contractor size classifications. The Group AHP results are calculated using Group AHP approach, which is explained in Chapter 3, section 3.4.2. As was mentioned before, making a decision could be the responsibility of a committee instead of individuals. Therefore, combining judgments considering contractor type, contractor sector and contractor size classifications enables performing analyses at the aggregate level as opposed to individual level and provide an overview of contractors as to how they value/weigh key factors based on their similar attributes. The combined judgments of the respondents are given in Table 4.19, Table 4.20, Table 4.21 and Table 4.22. Number of the combined judgments and consistency ratios for firm related-internal and project related-external factors are also provided in the tables.

Table 4.19 The Group AHP Results When All Companies Included in the Analysis

Key Factors	All Companies Included
Level 1	
Overall Firm Related-Internal Factors	0.602
Overall Project Related-External Factors	0.398
Level 2-A Firm Related Internal Factors Consistency Ratio	**0.69%**
Current workload	0.069
Experience in similar projects	0.082
Availability of equipment, materials and human resources	0.093
Financial ability	0.073
Need for work	0.120
Technical knowhow	0.075
Compliance with the business plan	0.090
Level 2-B Project Related External Factors Consistency Ratio	**0.38%**
Project size	0.025
Project duration	0.019
Location of the project	0.039
Project type	0.054
Contract conditions and type of contract	0.101
Owner identity	0.100
Competition	0.061
Number of Respondents	48

Table 4.20 The Group AHP Results Based on the Contractor Type Classification

Key Factors	Contractor Type	
	General Contractor	Subcontractor
Level 1		
Overall Firm Related-Internal Factors	0.621	0.526
Overall Project Related-External Factors	0.379	0.474
Level 2-A Firm Related Internal Factors Consistency Ratio	**0.75%**	**2.63%**
Current workload	0.066	0.080
Experience in similar projects	0.090	0.055
Availability of equipment, materials and human resources	0.096	0.079
Financial ability	0.074	0.067
Need for work	0.116	0.131
Technical knowhow	0.078	0.061
Compliance with the business plan	0.102	0.053
Level 2-B Project Related External Factors Consistency Ratio	**0.67%**	**1.95%**
Project size	0.023	0.027
Project duration	0.016	0.028
Location of the project	0.031	0.086
Project type	0.048	0.077
Contract conditions and type of contract	0.093	0.124
Owner identity	0.107	0.069
Competition	0.060	0.063
Number of Respondents	38	10

Table 4.21 The Group AHP Results Based on the Contractor Sector Classification

Key Factors	Contractor Sector									
	Residential Construction	**Commercial Construction**	**Industrial Construction**	**Heavy/Highway Construction**	**Residential-Commercial Construction**	**Residential-Commercial-Heavy Construction**	**Residential-Commercial-Industrial Construction**	**Commercial-Industrial Construction**	**Commercial-Industrial-Heavy Construction**	**Residential-Commercial-Industrial-Heavy Construction**
Level 1										
Overall Firm Related-Internal Factors	0.691	0.650	0.846	0.535	0.695	0.833	0.546	0.504	0.543	0.558
Overall Project Related-External Factors	0.309	0.350	0.154	0.465	0.305	0.167	0.454	0.496	0.457	0.442
Level 2-A Firm Related Internal Factors Consistency Ratio	**9.47%**	**2.64%**	**6.04%**	**6.19%**	**3.12%**	**5.71%**	**5.08%**	**1.56%**	**3.18%**	**9.39%**
Current workload	0.113	0.063	0.235	0.038	0.061	0.133	0.054	0.066	0.046	0.062
Experience in similar projects	0.037	0.087	0.064	0.037	0.098	0.027	0.119	0.083	0.085	0.083
Availability of equipment, materials and human resources	0.075	0.106	0.112	0.104	0.147	0.111	0.050	0.068	0.070	0.049
Financial ability	0.116	0.062	0.093	0.167	0.092	0.041	0.040	0.045	0.031	0.100
Need for work	0.241	0.087	0.233	0.101	0.091	0.147	0.113	0.105	0.102	0.136
Technical knowhow	0.066	0.071	0.074	0.047	0.094	0.029	0.066	0.061	0.156	0.041
Compliance with the business plan	0.043	0.174	0.034	0.041	0.112	0.345	0.105	0.076	0.052	0.086

Level 2-B Project Related External Factors Consistency Ratio	**8.14%**	**2.10%**	**4.71%**	**1.59%**	**4.28%**	**14.65%**	**3.49%**	**0.54%**	**4.60%**	**6.08%**
Project size	0.030	0.023	0.005	0.024	0.011	0.007	0.055	0.032	0.025	0.029
Project duration	0.016	0.022	0.005	0.022	0.008	0.003	0.036	0.026	0.013	0.019
Location of the project	0.060	0.038	0.062	0.043	0.024	0.011	0.045	0.038	0.020	0.064
Project type	0.054	0.048	0.018	0.062	0.044	0.008	0.062	0.075	0.029	0.066
Contract conditions and type of contract	0.032	0.111	0.019	0.105	0.073	0.024	0.118	0.128	0.131	0.124
Owner identity	0.082	0.076	0.021	0.115	0.108	0.062	0.095	0.110	0.121	0.083
Competition	0.035	0.032	0.025	0.093	0.038	0.052	0.044	0.087	0.117	0.057
Number of Respondents	2	7	2	6	7	1	4	12	4	3

Table 4.22 The Group AHP Results Based on the Contractor Size Classification

Key Factors	Contractor Size			
	Small Size Construction Company	**Small-Medium Size Construction Company**	**Medium-Large Size Construction Company**	**Large Size Construction Company**
Level 1				
Overall Firm Related-Internal Factors	0.565	0.718	0.544	0.557
Overall Project Related-External Factors	0.435	0.282	0.456	0.443
Level 2-A Firm Related Internal Factors Consistency Ratio	**5.07%**	**1.78%**	**0.96%**	**0.91%**
Current workload	0.075	0.095	0.060	0.041
Experience in similar projects	0.040	0.095	0.089	0.100
Availability of equipment, materials and human resources	0.128	0.105	0.063	0.073
Financial ability	0.101	0.102	0.036	0.061
Need for work	0.137	0.121	0.124	0.082
Technical knowhow	0.047	0.092	0.066	0.084
Compliance with the business plan	0.037	0.108	0.106	0.115
Level 2-B Project Related External Factors Consistency Ratio	**1.03%**	**1.92%**	**1.16%**	**1.72%**
Project size	0.030	0.016	0.030	0.023
Project duration	0.033	0.011	0.023	0.014
Location of the project	0.062	0.024	0.047	0.031
Project type	0.079	0.035	0.059	0.050
Contract conditions and type of contract	0.067	0.078	0.121	0.142
Owner identity	0.097	0.070	0.106	0.124
Competition	0.068	0.047	0.070	0.059
Number of Respondents	11	13	12	12

Based on the results given in in Table 4.19, Table 4.20, Table 4.21 and Table 4.22, it was found that the given importance to the weights to the overall firm related-internal factors are higher than the weights given to the overall project related-external factors for each subgroup. This result supports the idea that the firm related factors are more influential on bidding decisions than the project related factors regardless of any contractor classifications.

In Table 4.19, when all companies are included in the analysis and regardless of the contractor classification, it was seen that the need for work key factor has the highest weight value, while the project duration and project size key factors have the lowest weights. Similarly, for the general contractors and subcontractors (see Table 4.20), the need for work key factor maintains its' highest importance and the project duration and project size key factors have the lowest weights. The owner identity key factor has the second highest weight for the general contractors. For the subcontractors, it was found that the contract conditions and type of contract key factor has the second highest weight and comparatively to the general contractors, the owner identity key factor does not have an important place for the subcontractors.

As can be seen in Table 4.21, the subgroups under contractor sector classification do not show a pattern for the higher weights given to the key factors. However, again the project duration and project size key factors have the lowest weights for all contractor sectors. It could be seen from the Level 2-A firm related internal and Level 2-B project related external factors hierarchies, most of the higher weights are aggregated under firm related internal factors and the lower ones are formed under project related external factors hierarchies. Only Residential-Commercial-Industrial Construction, Commercial-Industrial Construction, Commercial-Industrial-Heavy Construction and Residential-Commercial-Industrial-Heavy Construction sectors make an exception by putting higher importance to the contract conditions and type of contract and owner identity key factors.

In the contractor size classification (see Table 4.22), most of the contractors under different classification groups put more importance to the need for work key factor. The large size construction companies put the highest importance to the contract conditions and type of contract key factor, which is also an important decision-making criteria for medium-large size construction companies. It could also be seen that the availability of equipment, materials and human resources key factor is a very important key factor to make bidding decisions for small size construction companies. In a similar manner with the contractor type and contractor sector groups, the lowest importance weights belong to the project duration and project size key factors.

4.7 The Validation Process of the Bid/No Bid Decision-Making Tool

As was mentioned in Chapter 3, section 3.5, a pilot group, which includes five construction companies was selected for the validation purpose of the decision-making tool. Those five companies were contacted for the second time and provided with the hypothetical case studies and bid/no bid decision-making tool.

Out of five, only two companies submitted their final bidding decisions for the first step of the validation process, which asked the participants' bidding decisions on the four-hypothetical case study conditions without using any decision-making tools.

In the second step of the validation process, those two companies were provided with the bid/no bid decision-making tool and were asked to give their final decisions, again based on the four-hypothetical case study conditions, but this time using the bid/no bid decision-making tool itself. One company, who did provide the weights to the key factors by using the pairwise comparison tool in Phase II- Step 1 (see section 3.3) and the final decisions for the hypothetical case study comparisons (without using any decision-making tools or statistical approaches) in Phase II, Step 2 (see section 3.5), found the validation process very complicated, and did not complete the final step of the validation process, which asked to make a bidding decision using bid/no bid decision-making tool. Therefore, this company was excluded from the validation of the decision-making tool process. As a result, only one company provided adequate information that could be used towards the validation process. Considering the fact that, one participant may be insufficient to validate a tool in a research study, another company outside of the pilot group, was requested to participate in the validation process. Therefore, two different companies are included in the validation of the bid/no bid decision-making tool and the results for each company are provided below. In order to maintain the confidentiality of the personal identifiers, the results are provided by using aliases as Company X and Company Y.

4.7.1 The Results for Company X

4.7.1.1 Phase II, Step-1: Estimated Weights of the Key Factors Using Pairwise Comparison Tool

The given weights to the key factors are collected with the pairwise comparison tool and estimated in accordance with the AHP methodology. The estimated weights based on the preferences of Company X are given in Table 4.23.

Table 4.23 Estimated Weights of the Key Factors Using Pairwise Comparison Tool Based on the Preferences of Company X

Key Factors	Estimated Weights
Overall Firm Related-Internal Factors	0.875
Overall Project Related-External Factors	0.125
Level 2-A Firm Related Internal Factors Consistency Ratio	**18.02%**
Current workload	0.071
Experience in similar projects	0.181
Availability of equipment, materials and human resources	0.118
Financial ability	0.118
Need for work	0.114
Technical knowhow	0.190
Compliance with the business plan	0.082
Level 2-B Project Related External Factors Consistency Ratio	**8.02%**
Project size	0.004
Project duration	0.003
Location of the project	0.026
Project type	0.031
Contract conditions and type of contract	0.038
Owner identity	0.014
Competition	0.010

Based on the results given in Table 4.23, experience in similar projects and technical knowhow key factors have the highest weights, while project size and project duration have the lowest weights in the key factors list. As can be seen from the overall weights given to the firm related-internal and project related-external factors, it could be concluded that Company X put more value on to the firm related-internal factors than the project related-internal factors. The consistency ratio of the firm related-internal factors exceeded the 0.1 reference value, while the consistency ratio for project related-external factors remained under the acceptable limit. The estimated weights of the key factors is implemented in the bid/no bid decision-making tool in order to rank four hypothetical case studies and the results will be explained in section 4.7.1.3.

4.7.1.2 Phase II-Step 2: Comparison of the Hypothetical Case Studies without Using Any Decision-Making Tools

In the Hypothetical Case Studies document (see Appendix D), the participants were asked to give their final bidding decision by ranking the four provided hypothetical case studies by considering the project and firm-related conditions. In addition, they were also asked to comment for each case study whether they would bid or not bid on. For the confidentiality purposes, the participants' willingness to give permission to share the comments in this study were asked and Company X agreed to share his/her comments. The comments of Company X for each case study are given in Table 4.24 below.

Table 4.24 The Comments of Company X on the Hypothetical Case Studies

Company X Responses	**I would bid on this project because**	**I would bid not on this project because**
Hypothetical Case Study 1	Workload, Contract, Resources, Experience, Business Plan	Client, Competition
Hypothetical Case Study 2	Competition, Resources	Client, Experience
Hypothetical Case Study 3	Client, Resources, Experience	Competition, Contract
Hypothetical Case Study 4	Competition, Workload, Business Plan, Experience	Duration ties up resources too long, Difficult Client, Little technical Knowledge, Contract, Resources

It can be seen from Table 4.24 that the current workload, contract conditions and type of contract, availability of equipment, materials and human resources, experience in similar projects, compliance with the business plan, competition, owner identity key factors are important factors for Company X for bidding on a project. Similarly, the owner identity, competition, experience in similar projects, contract conditions and type of contract, project duration, technical knowhow and availability of equipment, materials and human resources key factors also have important places for Company X to avoid to bid on a project. On the contrary, the project type, project size, location of the project and financial ability key factors were not mentioned in the notes. Even though the Likert scale approach was implemented for the financial ability key factor, it can be seen that this key factor was not found as a reason by Contractor X to bid or not to bid on a project. The final bidding decision of the Company X is given in Table 4.25.

Table 4.25 The Final Bidding Decision of the Company X without Using Any Decision-Making Tools

The first choice (Bidding decision)	**The second choice (Bidding decision)**	**The third choice (Bidding decision)**	**The fourth choice (Bidding decision)**
Hypothetical Case Study **3**	Hypothetical Case Study **2**	Hypothetical Case Study **1**	Hypothetical Case Study **4**

4.7.1.3 Phase II-Step 2: Comparison of the Hypothetical Case Studies Using Bid/No Bid Decision-Making Tool

In Phase II, Step 2, the pilot study participants were asked to compare the case studies under each key factor. For instance, considering the project size conditions of the case studies, the case studies were pair wisely compared with each other and this process was repeated for each key factor. In order to complete the bid/no bid decision-making tool, Contractor X completed 84 pairwise comparisons. The weights given to the key factors were included from Phase II-Step 1 of the study and provided a basis for the case study selections (see Table 4.23). The given weights to the case studies are estimated based on the preferences of Contractor X using AHP methodology and presented in Table 4.26.

Table 4.26 Estimated Weights of the Case Studies Using Bid/No Bid Decision-Making Tool Based on the Preferences of Company X

Case Study/ Key Factor	Current workload	Experience in similar projects	Availability of equipment, materials and human resources	Financial ability	Need for work	Technical knowhow	Compliance with the business plan	Project size	Project duration	Location of the project	Project type	Contract conditions and type of contract	Owner identity	Competition
Case 1	0.124	0.162	0.524	0.434	0.071	0.158	0.070	0.250	0.185	0.250	0.078	0.395	0.375	0.137
Case 2	0.094	0.062	0.151	0.291	0.192	0.502	0.160	0.250	0.172	0.250	0.078	0.368	0.125	0.306
Case 3	0.163	0.194	0.244	0.127	0.179	0.274	0.160	0.250	0.579	0.250	0.261	0.123	0.375	0.090
Case 4	0.619	0.581	0.081	0.148	0.559	0.065	0.609	0.250	0.064	0.250	0.583	0.114	0.125	0.467

To determine which the bidding priority for projects for Company X, the estimated weights for key factors (the results of the pairwise comparison tool, see Table 4.23) and case studies (the results of bid/no bid decision-making tool, see Table 4.26) were multiplied and the results were summed for each case study following the AHP methodology. The results are shown in Table 4.27.

Table 4.27 Estimated Weights of the Key Factors under Each Case Study Based on the Preferences of Company X

Case Study/ Key factor	Current workload	Experience in similar projects	Availability of equipment, materials and human resources	Financial ability	Need for work	Technical knowhow	Compliance with the business plan	Project size	Project duration	Location of the project	Project type	Contract conditions and type of contract	Owner identity	Competition	Sum
Case 1	0.009	0.029	0.062	0.051	0.008	0.030	0.006	0.001	0.001	0.006	0.002	0.015	0.005	0.001	0.227
Case 2	0.007	0.011	0.018	0.034	0.022	0.096	0.013	0.001	0.001	0.006	0.002	0.014	0.002	0.003	0.230
Case 3	0.012	0.035	0.029	0.015	0.020	0.052	0.013	0.001	0.002	0.006	0.008	0.005	0.005	0.001	0.204
Case 4	0.044	0.105	0.010	0.017	0.064	0.012	0.050	0.001	0.000	0.006	0.018	0.004	0.002	0.005	0.339

The bid/no bid decision-making tool results shows that the project represented in Case Study 4 is the most suitable to bid on based on the preferences of Contractor X and the rank order is given by following:

Case 4>Case2>Case 1>Case 3

When we compare Phase II, Step 1 and Step 2 results, it can be seen that Case 3 and Case 4 changed orders with each other, while Case 2 and Case 1 remained in the same order. This result might point out a failure of the decision-making tool in providing accurate results. One possible but unverifiable explanation is that the Contractor X might get confused and put Case 3 instead of Case 4 mistakenly.

4.7.2 The Results of the Company Y

Different from Company X, a meeting was scheduled with Company Y and all study phases (Phase II- Step 1 and Phase II-Step 2) were completed on the same day. Before completing the study documents, the researcher gave a brief explanation on how to complete the tools, however did not interrupt the decision-making process. Given the fact that the participants are able to comprehend which case study is beneficial to bid on in step 1, a different approach was held in an attempt to prevent bias in step 2, therefore step 2 documents were provided before completing step 1 documents.

4.7.2.1 Phase II, Step-1: Estimated Weights of the Key Factors Using Pairwise Comparison Tool

The given weights to the key factors are collected with the pairwise comparison tool and estimated in accordance with the AHP methodology. The estimated weights based on the preferences of Company Y are given in Table 4.28.

Table 4.28 Estimated Weights of the Key Factors Using Pairwise Comparison Tool Based on the Preferences of Company Y

Key Factors	**Estimated Weights**
Overall Firm Related-Internal Factors	0.857
Overall Project Related-External Factors	0.143
Level 2-A Firm Related Internal Factors Consistency Ratio	**28.72%**
Current workload	0.044
Experience in similar projects	0.054
Availability of equipment, materials and human resources	0.187
Financial ability	0.390
Need for work	0.083
Technical knowhow	0.079
Compliance with the business plan	0.021

Level 2-B Project Related External Factors Consistency Ratio	**42.95%**
Project size	0.006
Project duration	0.004
Location of the project	0.005
Project type	0.022
Contract conditions and type of contract	0.031
Owner identity	0.052
Competition	0.025

According to the results given in Table 4.28, the financial ability key factor has the highest weight, while the project duration key factor has the lowest importance based on the estimated weights. The comparison of the weights given to the overall firm related-internal and project related-external factors shows that firm related-internal factors are more important than the project related–external factors according to Company Y's preferences. It is also important to discuss that both Level 2A and Level 2B consistency ratios exceed the AHP's recommended 10% value. However, considering the low participation rate for the validation process, the results were included.

4.7.2.2 Phase II-Step 2: Comparison of the Hypothetical Case Studies without Using Any Decision-Making Tools or Statistical Approaches

As was mentioned before, the participants were required to give their final bidding decision by ranking the four hypothetical case studies considering project conditions. The final bidding decision of the Contractor Y is given in Table 4.29.

Table 4.29 The Final Bidding Decision of the Company Y without Using any Decision-Making Tools

The first choice (Bidding decision)	**The second choice (Bidding decision)**	**The third choice (Bidding decision)**	**The fourth choice (Bidding decision)**
Hypothetical Case Study **3**	Hypothetical Case Study **1**	Hypothetical Case Study **2**	Hypothetical Case Study **4**

4.7.2.3 Phase II-Step 2: Comparison of the Hypothetical Case Studies Using Bid/No Bid Decision-Making Tool

The given weights to the case studies are estimated based on the preferences of Contractor Y using AHP methodology and presented in Table 4.30.

Table 4.30 Estimated Weights of the Case Studies Using Bid/No Bid Decision-Making Tool Based on the Preferences of Company Y

Case Study/Key factors	Current workload	Experience in similar projects	Availability of equipment, materials and human resources	Financial ability	Need for work	Technical knowhow	Compliance with the business plan	Project size	Project duration	Location of the project	Project type	Contract conditions and type of contract	Owner identity	Competition
Case 1	0.266	0.219	0.134	0.265	0.188	0.176	0.246	0.291	0.547	0.250	0.177	0.233	0.125	0.134
Case 2	0.095	0.280	0.189	0.119	0.135	0.288	0.125	0.115	0.259	0.250	0.108	0.441	0.125	0.598
Case 3	0.573	0.443	0.592	0.560	0.561	0.464	0.558	0.533	0.137	0.250	0.561	0.221	0.625	0.179
Case 4	0.067	0.057	0.085	0.056	0.116	0.073	0.071	0.061	0.058	0.250	0.153	0.104	0.125	0.089

To estimate which case study is beneficial for Company Y, the estimated weights of the key factors (the results of the pairwise comparison tool, see Table 4.28) and case studies (the results of bid/no bid decision-making tool, see Table 4.30) were multiplied and the results were summed for each case study. The results are given in Table 4.31.

Table 4.31 Estimated Weights of the Key Factors under Each Case Study Based on the Preferences of Company Y

Case Study/ Key factors	Current workload	Experience in similar projects	Availability of equipment, materials and human resources	Financial ability	Need for work	Technical knowhow	Compliance with the business plan	Project size	Project duration	Location of the project	Project type	Contract conditions and type of contract	Owner identity	Competition	Sum
Case 1	0.012	0.012	0.025	0.103	0.016	0.014	0.005	0.002	0.002	0.001	0.004	0.007	0.006	0.003	0.211
Case 2	0.004	0.015	0.035	0.046	0.011	0.023	0.003	0.001	0.001	0.001	0.002	0.013	0.006	0.015	0.177
Case 3	0.025	0.024	0.111	0.218	0.046	0.036	0.011	0.003	0.000	0.001	0.012	0.007	0.032	0.004	0.533
Case 4	0.003	0.003	0.016	0.022	0.010	0.006	0.001	0.000	0.000	0.001	0.003	0.003	0.006	0.002	0.077

The results of the analysis show that Case study 3 is the most suitable to bid on based on the preferences of Company Y and the case study order is given by following:

Case 3>Case1>Case 2>Case 4

The comparison of the section 4.7.2.2 and section 4.7.2.3 results show the exact case study order and it can be concluded that the bid/no bid decision-making tool provides accurate results for the Company Y's preferences.

The overall purpose of the validation process is to test the accuracy of the decision-making tool, which provides precise results in different bidding situations regardless of different demographic backgrounds of decision-makers. In this study, the validation of the decision-making tool is analyzed based on two pilot participants' submittals. The results showed that Company Y's results validated the bid/no bid decision-making tool; while Company X's results failed in providing accurate results. Based on the results provided, it can be concluded that the validation of the bid/no bid decision-making tool is not accomplished because of a lack of extra data points. However, these mixed results point out the need for further research to validate the tool by including more data points.

Chapter 5. Discussion

5.1 Summary of the Research

In today's competitive business environment, bidding decisions are vital for construction companies to preserve their existence in the industry. Given the fact that a new project is the life-blood of a company, the bidding decisions should be made attentively, yet very strategically. To date, more than 100 factors, which are influential on bidding decisions, have been identified in the literature. However, considering the complex structure of decision-making process and human's bounded rationality for comparing multiple factors at once, a simple and accurate solution was deemed necessary.

In this research, a bid/no bid decision-making tool is created as a tool for decision-makers to select the most appropriate projects to bid on in bidding situations. Analytic Hierarchy Process is used as the methodology of the research and formed the basis of the framework. For the purpose of this research the following steps are taken:

1. A literature review was conducted to determine the most commonly identified and utilized factors when making bid/no bid decisions. As a result, a total of 14 key factors were determined and grouped under two hierarchies as firm-related and project-related factors, those are:

   Firm Related (Internal) Factors

   - Current workload
   - Experience in similar projects
   - Availability of equipment, materials and human resources
   - Financial ability

- Need for work
- Technical knowhow
- Compliance with the business plan

Project Related (External) Factors

- Project size
- Project duration
- Location of the project
- Project type
- Contract conditions and type of contract
- Owner identity
- Competition

2. Based on the participants' preferences, the weights of importance given to the key factors were evaluated by using the AHP methodology for each construction company. In addition, the demographic information of the participants was collected and used to sort the construction companies based on:

- **Contractor type**
  - General contractor
  - Subcontractor
- **Contractor sector**
  - Residential Construction
  - Commercial Construction
  - Industrial Construction
  - Heavy/Highway Construction

  - Residential-Commercial Construction
  - Residential-Commercial-Heavy Construction
  - Residential-Commercial-Industrial Construction
  - Commercial-Industrial Construction
  - Commercial-Industrial-Heavy Construction
  - Residential-Commercial-Industrial-Heavy Construction
- **Contractor size**
  - Small Size Construction Company
  - Small-Medium Size Construction Company
  - Medium-Large Size Construction Company
  - Large Size Construction Company

3. Based on the Group AHP methodology, the judgments of the participants were combined under each contractor type, sector and size subgroups.
4. To validate bid/no bid decision-making tool, a pilot group, which consists of five construction companies, was selected. In the first step of the validation process, the respondents were asked to make their bidding decisions based on the four hypothetical case study conditions without using any decision-making tools or statistical approaches. In the next step, the decision-making tool was provided to the participants and they were asked to make a decision with using the tool. Consequently, the results of the two approaches were compared and the accuracy of the decision-making tool was reported.

5.2 Concluding Remarks

A practical bid/no bid decision-making tool was developed to assist decision-makers to decide which project(s) to bid on given a few candidate projects. The validation of the bid/no bid decision-making tool was performed based on two participants' responses and the tool provided accurate results for one of the evaluations. Because of insufficient response rate to the validation process, it cannot be concluded that the bid/no bid decision-making tool is validated, however the participants' results point out the need for further research.

One of the advantages of the bid/no bid decision-making tool is that it reflects decision-makers' subjective preferences and the results are unique for each individual. For this reason and due to its practicality, the decision-making tool can be completed by any individual without requiring specific training. For example, in case of decision-making dilemmas, the decision-making tool enables decision-makers to run the tool independently; therefore, individuals can compare their results with each other and make their final bidding decisions.

It was observed that the comparison of the hypothetical case studies using bid/no bid decision-making tool took less time than the comparison of the hypothetical case studies without using any decision-making tools (based on observations of the researcher). In this sense, the bid/no bid decision-making tool is practical for comparing many factors simultaneously and it provides a list of factors to be compared to bid on a project.

The estimated weights of the key factors and the participants' demographic information were also analyzed concurrently in this study. One-Way Anova Test, Kruskal Wallis (Non-parametric alternative of -Way Anova), Two-Sample t-test, and Wilcoxon Rank Sum (Non-parametric alternative of Two-Sample t-test) tests were performed in order to test the hypothesis of whether the given importance to the key factors by various groups of contractors are significantly different or not. The results showed that the compliance with the business plan and location of the project factors were found statistically significantly different for the "Contractor Type" classification. On the contrary, none of the key factors was found statistically significantly different for the “Contractor Sector” groups. For the “Contractor Size” classification, the compliance with the business plan factor was found statistically significantly different. In an attempt to determine which of the groups in the “Contractor Size” differ from each other; the Bonferroni correction/adjustment multiple testing procedure was employed. However, the different groups were not captured by the adjusted multiple testing procedure because of the conservativeness of the Bonferroni correction method (see Chapter 4 for a more detailed explanation of the results of this research).

The Group AHP approach also allows construction companies to come with a combined bidding judgment instead of using the tool individually. An important finding of this study is that the contractors grouped under each construction classifications (i.e., Contractor Type, Contractor Sector and Contractor Size) put more value on the overall firm related-internal factors than the overall project related-external factors based on the Group AHP results. It is also found that project duration and project size key factors have the lowest weights for all contractor classification groups.

A limitation of this study was the small response rate (n=49), however, in spite of the small sample size, the results provided sufficient information that statistically significant differences exist in the weights of importance given to the bid/no bid decision-making key factors based on the contractor type and contractor size classifications and point out the need for further research. On the contrary, the results did not provide enough evidence to support if there is a significant difference on the valuation of the key factors based on the contractors’ sector.

Another limitation of the study was that the consistency ratios of the respondents exceeded the recommended value for AHP studies. Again, considering the small response rate, all of the evaluations, except for one company’s, were included in the analyses.

This research contributes to the construction engineering and management body of knowledge by providing a practical decision-making tool to assist decision-makers to select most beneficial project(s) to bid. Additionally, this study introduces Group AHP approach to combine importance weights of the construction professionals who have different demographic background (e.g., sector, size, type). Lastly, the statistically significant differences between different groups of construction companies in how much /value weight they put on a bid/no bid decision factor are identified in this study.

5.3 Future Research

To expedite research process, the key factors were determined from the literature review; therefore, investigation of the potential key factors that might affect bidding decisions is beyond the scope of this project. However, to better represent the current condition of the ever-changing construction industry, conducting a questionnaire that investigates new key factors or having face-to-face interviews with construction professionals is recommended.

As was mentioned before, most of the consistency ratios exceeded the recommended upper limit of 0.10 improved AHP results could be achieved by encouraging participants to review their selections while making their decisions. Furthermore, informative notification systems could be added to the decision-making tool to warn the user when the consistency ratio exceeds the recommended limit.

Since, this study solely provided an overview for the companies in the U.S., additional research is also recommended to include decision-makers in the study who work for construction companies in other countries. This attempt would aid in assessing how differently construction companies in the world value the key factors that are commonly identified to make bid/no bid decisions.

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Appendix A

Pairwise Comparison Tool

The **objective** of this tool is to collect information from construction companies on their decision making practices with respect to bidding on projects. This information will enable the CSU research team to prioritize the factors that were developed to answer to the questions of (i) whether to bid or not on a project and (ii) which project(s) to bid on given a few candidate projects. This tool will help us determine how important one factor is compared to others based on your company's preferences. This survey is a part of a structured technique, Analytic Hierarchy Process (AHP), which will be used to assign a quantitative value (i.e., a weight) to each factor. We will, then, use these weights to develop the Bid/No Bid Decision Making tool with the ultimate purpose of minimizing the risks in bidding decisions and selecting the most appropriate projects to bid on.

Instructions: Please perform pairwise comparisons between the factors shown below in columns A and B by considering your company's preferences with respect to bidding on projects. To see the explanations of the factors please refer to the Definitions of Factors worksheet. In making pairwise comparisons, first you need to identify which factor is more important to consider than the other (in making a bid decision) and indicate that selection in the "More Important Factor" column. Then, you need to determine how much more important that factor is over the other one and indicate that selection in the "Scale" column. Table-1 provides information on the scale to be used for those comparisons. There are 16 factors resulting in 43 pairwise comparisons. It is estimated that completing the survey will take approximately 25 minutes. If you have any questions with respect to this survey, please contact the graduate research assistant, Duygu Akalp (d.akalp@colostate.edu).

Table-1 Pairwise Comparison Scale

Intensity of importance	Definition	Explanation
1	**Equal** importance	Two criteria contribute **equally** to the objective
3	**Moderate** importance	Experience and judgment **slightly** favor one element over another
5	**Strong** Importance	Experience and judgment **strongly** favor one element over another
7	**Very strong** importance	An activity is favored **very strongly** over another, its dominance is demonstrated in practice
9	**Extreme** importance	The evidence favoring one activity over another is of the **highest possible order** of affirmation

Only input data in the red fields!

Levels	Factors A	Factors B	More Important Factor A or B	Scale (1-9)
Level 1	Firm Related-Internal Factors	Project Related-External Factors		
Level 2-A Firm Related Internal Factors	Current workload	Experience in similar projects		
	Current workload	Availability of equipment, materials and human resources		
	Current workload	Financial ability		
	Current workload	Need for work		
	Current workload	Technical knowhow		
	Current workload	Compliance with the business plan		
	Experience in similar projects	Availability of equipment, materials and human resources		
	Experience in similar projects	Financial ability		
	Experience in similar projects	Need for work		
	Experience in similar projects	Technical knowhow		
	Experience in similar projects	Compliance with the business plan		
	Availability of equipment, materials and human resources	Financial ability		
	Availability of equipment, materials and human resources	Need for work		
	Availability of equipment, materials and human resources	Technical knowhow		
	Availability of equipment, materials and human resources	Compliance with the business plan		
	Financial ability	Need for work		
	Financial ability	Technical knowhow		
	Financial ability	Compliance with the business plan		
	Need for work	Technical knowhow		
	Need for work	Compliance with the business plan		
	Technical knowhow	Compliance with the business plan		
Level 2-B Project Related External Factors	Project size	Project duration		
	Project size	Location of the project		
	Project size	Project type		
	Project size	Contract conditions and type of contract		
	Project size	Owner identity		
	Project size	Competition		
	Project duration	Location of the project		
	Project duration	Project type		
	Project duration	Contract conditions and type of contract		
	Project duration	Owner identity		
	Project duration	Competition		
	Location of the project	Project type		
	Location of the project	Contract conditions and type of contract		
	Location of the project	Owner identity		
	Location of the project	Competition		
	Project type	Contract conditions and type of contract		
	Project type	Owner identity		
	Project type	Competition		
	Contract conditions and type of contract	Owner identity		
	Contract conditions and type of contract	Competition		
	Owner identity	Competition		

Please check your data ensuring all required cells are completed and all the red cells are turned to green!

When you complete, please save your file and send to d.akalp@colostate.edu

Appendix B

Company Profile Questionnaire			
Please respond in the red highlighted cells below. All responses will remain fully confidential and will only be used for company classification purposes during the analysis of data.			
No.	**Questions**	**Insert or select value from here**	
1	Title or position of the respondent		
2	Years of experience of the respondent		
3	In what year was your company founded?		
4	Type of Contractor (primarily). Please select from the **drop-down** menu.		
5	Number of employees		
6	What was your firm's gross revenue in 2014? Please specify the amounts according to the market categories below.		
		Total	
6.1	Residential Construction (Homes and apartments)	$	
6.2	Commercial Construction (Office buildings, stores, schools, libraries, etc.)	$	
6.3	Industrial Construction (Manufacturing plants, refineries, high-tech facilities like laboratories and hospitals, etc.)	$	
6.4	Heavy/Highway Construction (Highways, dams, water/wastewater treatment plants, railroads, bridges, tunnels, etc.)	$	

Please continue to the "Pairwise Comparison Tool" worksheet!

Appendix C

Bid/No Bid Decision Making Tool

Instructions: Please perform pairwise comparisons between the hypothetical case studies using the columns A and B below by considering the given project conditions. To review the case study conditions please refer to the "Hypothetical Case Studies" word document. In making pairwise comparisons, first you need to consider the key factor that you are comparing the projects under (To see the explanations of the factors, please refer to the Definitions of Factors tab). Next, you need to identify which project has more attractive conditions to bid on than the other one based on the key factor and indicate that selection in the "More Attractive Project" column. Then, you need to determine how much more attractive that project is over the other one and indicate that selection in the "Scale" column. Table-1 provides information on the scale to be used for those comparisons. There are 14 factors resulting in 84 pairwise comparisons. It is estimated that completing the survey will take approximately 30 minutes. If you have any questions with respect to this survey, please contact the graduate research assistant, Duygu Akalp (d.akalp@colostate.edu).

Table-1 Pairwise Comparison Scale		
Intensity of	**Definition**	**Explanation**
1	**Equal** importance	Two criteria contribute **equally** to the objective
3	**Moderate** importance	Experience and judgment **slightly** favor one element over another
5	**Strong** Importance	Experience and judgment **strongly** favor one element over another
7	**Very strong** importance	An activity is favored **very strongly** over another, its dominance is demonstrated in practice
9	**Extreme** importance	The evidence favoring one activity over another is of the **highest possible order** of affirmation

Only input data in the red fields!

Levels	Project A	Project B	More Attractive Project (A or B)	Scale (1-9)
Current workload	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Experience in similar projects	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Availability of equipment, materials and human resources	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Financial ability	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Need for work	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Technical knowhow	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Compliance with the business plan	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Project size	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Project duration	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Location of the project	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Project type	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Contract conditions and type of contract	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Owner identity	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		
Competition	Case 1	Case 2		
	Case 1	Case 3		
	Case 1	Case 4		
	Case 2	Case 3		
	Case 2	Case 4		
	Case 3	Case 4		

Please check your data ensuring all required cells are completed and all the red cells are turned to green!

When you complete, please save your file and send to d.akalp@colostate.edu

Appendix D
Hypothetical Case Studies

In this second and the last phase of our study, we would like you to give your bidding decision (i) whether to bid on a project or not and (ii) which project(s) to bid based on the information given in the four-hypothetical case studies herein. Hypothetical case studies were created by considering the key factors that affect bid/no bid decisions and are defined in the "Definitions of Factors" document (please refer to the excel file).

Hypothetical Case Study 1

A four-story, 52,000 SF commercial office building will be built 60 miles away from your headquarters in a suburban area, within the anticipated project duration of 15 months. The building will be fully fitted out with interior finishes. This project was requested by the client/owner XYZ; and you have been somewhat dissatisfied with this client in your previous projects. Based on your market research, you have figured out that it is difficult to get this project by looking at the status of the potential competitors. Your company's current workload is moderately suitable to bid on this project; and your company thinks that getting this project is slightly important for the continuity of employment of the workforce in your company.

You also notice that your company's financial status is highly suitable to bid on this project; and the contract conditions are very easy to modify and flexible. You also assess that your company has all of the equipment, materials and human resources required by this project. The project slightly fits your company's business plan and you have moderate experience with this type of projects. The project requires special technical knowhow; and your company has some of that technical knowhow to be able to execute this project.

I would bid on this project because:
I would not bid on this project because:

Hypothetical Case Study 2

A two-story, 50,000 SF commercial athletics center will be built 65 miles away from your headquarters in a suburban area, within the anticipated project duration of 16 months. The building will be fully fitted out with interior finishes. This project was requested by the client/owner ABC; and you have been mostly dissatisfied with this client in your previous projects. Based on your market research, you have figured out that your company can easily get this project by looking at the status of the potential competitors. Your company's current workload is slightly suitable to bid on this project; and your company thinks that getting this project is moderately important for the continuity of employment of the workforce in your company.

You also notice that your company's financial status is moderately suitable to bid on this project; and that the contract conditions are easy to modify and flexible. You also assess that your company has some of the equipment, materials and human resources required by this project. The project moderately fits your company's business plan and you have low experience with this type of projects. The project requires for special technical knowhow; and your company has all of that technical knowhow to be able to execute this project.

I would bid on this project because:
I would not bid on this project because:

Hypothetical Case Study 3

A single-level, 65,000 SF commercial big box store will be built 55 miles away from your headquarters in a suburban area, within the anticipated project duration of 12 months. The building will be fully fitted out with interior finishes. This project was requested by the client/owner PQR; and you have been somewhat satisfied with this client in your previous projects. Based on your market research, you have figured out that it is very difficult to get this project by looking at the status of the potential competitors. Your company's current workload is very suitable to bid on this project; and your company thinks that getting this project is somewhat important for the continuity of employment of the workforce in your company.

You also notice that your company's financial status is slightly suitable to bid on this project. On the other hand, the contract conditions are difficult to modify and not flexible. You also assess that your company has most of the equipment, materials and human resources required by this project. The project somewhat fits your company's business plan and you have moderate experience with this type of projects. The project requires for special technical knowhow; and your company has most of that technical knowhow to be able to execute this project.

I would bid on this project because:
I would not bid on this project because:

Hypothetical Case Study 4

A three-story, 60,000 SF commercial real estate office building will be built 75 miles away from your headquarters in a suburban area, within the anticipated project duration of 18 months. The building will be fully fitted out with interior finishes. This project was requested by the client/owner MNO; and you have been completely dissatisfied with this client in your previous projects. Based on your market research, you have figured out that your company can very easily get this project by looking at the status of the potential competitors. Your company's current workload is extremely suitable to bid on this project; and your company thinks that getting this project is highly important for the continuity of employment of the workforce in your company. You also notice that your company's financial status is somewhat suitable to bid on this project. On the other hand, the contract conditions are very difficult to modify and not flexible. You also assess that your company has only a few of the equipment, materials and human resources required by this project. The project highly fits your company's compliance with the business plan even though you have extreme experience with this type of projects. The project requires for special technical knowhow; and your company has a little of that technical knowhow to be able to execute this project.

I would bid on this project because:
I would not bid on this project because:

Final Decision

Please rank the projects in order to bid. (Please put a number 1 to 4 in the determined area below by X).

The first choice (Bidding decision)	**The second choice (Bidding decision)**	**The third choice (Bidding decision)**	**The fourth choice (Bidding decision)**
Hypothetical Case Study **X**	Hypothetical Case Study **X**	Hypothetical Case Study **X**	Hypothetical Case Study **X**

Please share your ideas on the key factors that affect bidding decisions that could be considered to improve Bid/No Bid Decision-Making Tool.

To indicate your willingness to give permission to share your comments as a part of the final report, please check the box below:

☐ Yes
☐ No

*Please note that your personal identifiers will be kept as confidential and will not be shared with third parties and other companies. When we report the data, it will be published anonymously.