CHAPTER 1

INTRODUCTION

1.1 General

Main contractors primarily hire sub-contractors for specialized tasks in construction projects. Choosing a sub-contractor consequently is a process that requires a guideline or factors that are previously determined to aid in selection process. This comes as a crucial rule for a main contractor to ease the process of selecting one from several sub-contractors and to guarantee the accuracy of the selection process. One of the most significant methods that can be used for selecting the best alternative (sub-contractor) is the Multi-Criteria Decision Making (MCDM).

1.2 Problem Definition

The selection of the best alternative to carry out a specific item in the project can be a substantial issue; as the wrong selection can lead to many problems for which the main contractor and the owner are not ready. The owner usually has the target to finish the project in the expected time, with a high quality, and with the expected cost. However, many projects are either not finished with the quality desired or do not meet deadlines. Therefore, in case of the wrong selection of the sub-contractor, one item in the project can actually lead to the whole project's delay.

To avoid many problems that can occur after the selection of a sub-contractor; the main contractor must take into consideration the factors/criteria which control the selection of the sub-contractors. These factors/criteria can be different from one main contractor to another and from one project to another. They are variable because they depend on issues such as: the type of the project, the country in which the project is launched, the temperature of the area of the project, etc.

1.3 Research Objectives

The main objective of this research is:

1- To determine the best sub-contractor to carry out work items in construction projects. A questionnaire was conducted to determine the weight of each criterion to determine the mean score. The weight of each factor is defined to determine its degree of importance. In this research, ELECTRE III decision making technique is used to decide on the best alternative.

2- Another objective of this research is to determine the relationship between the most important factors and their frequencies according to the questionnaire survey.

1.4 Research Methodology

The methodology used in this study to get the scores factors that influence the selection of sub-contractors is the questionnaire survey. A questionnaire survey (as shown in Appendix A and B) was distributed to experts in construction domain. These factors were gathered from previous studies that have been done on the selection of the best alternative. Another questionnaire survey (as shown in Appendix C) was based on interviews with four experts in construction domain. The purpose of the second survey is to determine the weights of the most important factors based on pair-wise comparison. Subsequently, ELECTRE III model is developed to determine the ranking of sub-contractors as different alternatives. Finally, a case study is worked out to determine the use of the proposed ELECTRE III model.

1.5 Thesis Organization

The research work presented in the next chapters is organized as follows:

Chapter (2): Literature Review; it presents a review of previous studies that are relevant to Multi-Criteria Decision Making techniques and the selection of the best alternative. The chapter also reviews previous research efforts that were conducted in the area of contracts and sub-contractors selection. Finally, the chapter presents the studies that used ELECTRE III as a decision making tool.

Chapter (3): Surveying sub-contractors selection factors; it presents the questionnaire survey that has been distributed to the experts in the construction domain. Another questionnaire survey was done to determine the significance of the most important factors.

Chapter (4): Statistics and mathematical calculations; it presents the statistical analysis using SPSS statistical software. These statistical and mathematical calculations include the frequencies and crosstabs of the most suitable factors.

Chapter (5): ELECTRE III Sub-contractor Selection Model; it presents the development made in ELECTRE III model. A case study is presented to illustrate the use of the model in ranking sub-contractors alternatives.

Chapter (6): Conclusions and recommendations; it presents the discussion of the research, conclusions and recommendations for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 General

This chapter demonstrates an overview of previous studies which presented the Multi-Criteria Decision Making method of selecting the alternatives in projects; and the criteria that shall be taken into consideration when selecting one of the sub-contractors for construction projects. This chapter also presents studies that used ELECTRE III model for ranking the alternatives to determine the best one.

2.2 Decision Making Techniques

The decision making process is mainly "the process of selecting one or a few alternatives that should be the most favorable ones to objectives" (Ulubeyli and Kazaz, 2009). Such alternatives can vary based on the project: It can be contractors, sub-contractors, equipment (e.g., tower cranes or concrete pumps, etc). However, in order for the process of decision making to be accurate as much as possible and to match the project's requirements and objectives, it cannot be done randomly. This process, rather, has to be built on a strong base from the beginning in order to reach best decision. Despite the fact that decision problems vary based on the surrounding circumstances and factors, they should all be built on "well-defined criteria" as well as efficient "solution techniques" (Ulubeyli and Kazaz, 2009).

The Multi Criteria Decision Making (MCDM) is a method designed to enable and enhance the process of selecting best alternative (Sage 1977; Bui 1987; Chankong and Haimes 1983; French et al. 1998; Hwang and Lin 1987; and Hwang and Yoon 1981). There are several types of processes that fall under MCDM among which is the Analytic Hierarchy Process (AHP) and the Analytic Network Process (ANP). The AHP includes three main parts; "hierarchic structure, prioritization procedure and calculation of results" (Fong and Choi, 2000). This process was suggested by Al-Harbi (2001); Mahdi et al. (2002) and Topcu (2004). One of the missions the AHP helps accomplish is helping "construction clients to identify contractors with the best potential to deliver satisfactory outcomes in a final contractor selection process which is not based simply on the lowest bid" (Fong and Choi, 2000). This means that the AHP can be presented as a process that aids the owners to select the best alternative (contractor) avoiding basing their choice merely on the low cost. In application, a case study was done on three contractors (alternatives); in which the contractor, who achieves that highest aggregate score, meaning scoring high in all the

criteria, becomes the best option. Consequently a pair-wise comparison is used to reach the best decision (see Tables 2.1 and 2.2) (Fong and Choi, 2000).

Table 2.1: Pair-wise comparison (Fong and Choi, 2000)

	Criterion			
Criterion	**A**	**B**	**C**	**D**
A	1	5	6	7
B	1/5	1	4	6
C	1/6	¼	1	4
D	1/7	1/6	¼	1

Table 2.2: The comparison scale (Fong and Choi, 2000)

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance is demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values	When a compromise is needed

The AHP can also be used as a process to calculate relative importance weights of the selection criteria. For instance, in a study by Cheung *et al*. (2001), eight criteria are introduced; "the speed of the project completion", "the certainty over the cost for completion of the project", "the quality level", "the suitability of the procurement method in handling complex projects", "risk avoidance", "price competition" and "clarity of delineation of responsibility". Pair-wise comparison is utilized to compare between these criteria and determine their ratings besides using a 1 to 5 Likert scale (Cheung *et al.*, 2001). In order to ensure and monitor the pair-wise comparison matrix's consistency, "an inconsistency ratio (IR)" should be calculated through the following equation: IR=II/RI where IR is inconsistency ratio, RI is random index, and II=(λ_{max} - n)/(n – 1) where n is the number of elements in the matrix and λ_{max} is the maximum eigenvalue of the comparison matrix; Saaty (1988) suggests the value of IR should not exceed 0.1. The calculation of the inconsistency ratio helps to "minimize illogical importance ratio assignments" (Saaty, 1988).

Another process that falls under MCDM, as previously mentioned, is the Analytic Network Process (ANP). The ANP can be used for enhancing the process of setting the priorities of contractor selection criteria. The pair-wise comparisons in this study are built on three bases: first, it includes a comparison between the criteria and sub-criteria for three alternatives; second, it has a calculation of relative weights of the criteria and sub-criteria; and third, it blends the relative weights among the criteria (Cheng and Li, 2004).

As previously mentioned, the selection of the alternative, whether a contractor or a sub-contractor, is a necessary process during the cycle of the project and consequently requires specific methods to be used by the main contractor. Besides MCDM, the Multi-Attribute Decision-Making (MADM) is another method used by main contractors for determining the best sub-contractor. Many main contractors and owners are merely interested in the lowest bidders. But there are other criteria that should be taken into consideration. In a study by Turksis (2008), thirteen criteria for selecting the best contractor are introduced such as:

1- History of reasonable bid price submissions.
2- A work history that indicates specialization and quality of workmanship in a particular construction skill.
3- Contractor's degree of quality control.
4- Decorum, conduct and non-disruptiveness of contractor staff and sub-contractors.
5- Coordination of operations that will cause noise, vibrations, dust, odors, safety concerns and other activities.
6- Responsiveness to warranty issues.
7- Flexibility and cooperation when resolving delays.
8- Ability to meet project schedule.

Abiding by such factors, or others depending on the situation, leads to the right selection of the best alternative, which has many benefits for all parties in the construction project; such as high quality finishing, meeting deadlines based on the estimated time, as well as abiding by the estimated cost (Turskis, 2008).

2.3 Selection of the Sub-contractors

The main objectives of contractor selection process are to reduce project risk, maximize the quality and maintain the strong relationships between members of the project. Same applies to the sub-contractor selection process. Wrong selection of a sub-contractor can lead to many problems (Kumaraswamy and Mattews 2000; Ng and Wan 2005). As previously highlighted, some owners regard the cost as the most important criteria to base the contractor selection process on; however, research recommends that multi-criteria selection process should be further taken into consideration. Consequently, there are many methods to be used in the decision making process of selecting a contractor. These methods include: "multi-criteria decision making (MCDM), bespoke approaches (BA), multi-attribute analysis (MAA), multi-attribute utility theory (MAUT), and decision support systems for contractor pre-qualification – an artificial neural network approach" (Darvish *et al.*, 2008). In a study by Darvish *et al.* (2008) multi-criteria decision making (MCDM) method is used, presenting the following criteria of selection: "technology and equipments, management, experience and knowledge of the technical staff, financial stability, quality, being familiar with the area or being domestic, reputation, and creativity and innovation". Despite setting several contractor selection criteria, the final decision should consider both; the criteria set and the competitiveness of the price. In that sense, different countries vary in the approach they follow in order to take the final decision. Countries such as Denmark, Italy, Portugal, South Korea, France, Australia, Saudi-Arabia, Turkey, Canada, the United States of America, Lithuania and Iran, have different approaches as shown in Table 2.3 (Darvish *et al.*, 2008).

According to law 89/1998, in Egypt the choosing of the sub-contractors is according to the lowest price of the tender as the selected sub-contractor is accepted technically.

A study by Walraven and De Vries (2009) further applies the process of selecting the best contractor. The research method of this study is divided into four parts. The first part determines thirty four sub-criteria of contractor selection driven from other studies. Some of these factors resemble those required for choosing the sub-contractor, such as; "prevention of vandalism" and "energy saving materials and installation." These factors were grouped into eleven criteria. The second part is mainly a questionnaire which was conducted with field experts. The third part represents the calculation of the relative weights of the thirty four sub-criteria. The fourth part states that "the value of a bid will be divided by the price resulting in the value-price ratio. The higher the ratio the more value

for money for the client". As shown in Figure 2.1, as α angle increases, this means that the value of the bid increases and so the price will decrease which will be a benefit to the clients. The minimum value/requirements is the related set of minimum necessities, maximum price the client is ready to reimburse, minimum value-price ratio showing the difference between the value and the price.

Table 2.3: Decision making in some countries (Darvish *et al.* 2008)

Country	Decision Making approach
Denmark	Rejecting the highest two and the lowest two and selecting the contractor that offers a price closest to the average. (Hatush, Z. and Skitmore, M. 1998; Kadefors, A. et al. 2007; Zavadaskas, K. and Vilutiene, T. 2006).
Italy, Portugal, South-Korea	Rejecting the highest one and the lowest one and selecting the contractor that offers a price closest to the average. (Hatush, Z. and Skitmore, M. 1998; Zavadaskas, K. and Vilutiene, T. 2006).
France	Rejecting the contractor that offers an abnormally low price. (Hatush, Z. and Skitmore, M. 1998; Zavadaskas, K. and Vilutiene, T. 2006).
Australia	The process is implemented in two stages: first, evaluating the contractor's experience; second, bargaining for a price then occurs. (Kashiwhgi, A. 2002).
Saudi-Arabia	The lowest bidder is selected provided that the bid is not less than 70 percent of the owner's cost estimate. (Hatush, Z. and Skitmore, M. 1998)
Turkey	The lowest price determines the selection. (Topcu, I. 2004; Wong, H. et al. 2003; Zavadaskas, K. and Vilutiene, T. 2006).
Canada, USA	The lowest bidder is selected. (Hatush, Z. and Skitmore, M. 1998; Zavadaskas, K. and Vilutiene, T. 2006).
Lithuania	The lowest bidder is selected.
Iran	The lowest bidder is selected. The process occurs in two stages: first, the contractor's pre-qualification is evaluated; second, the lowest price mechanism works.

An accurate or correct sub-contractor selection process has a direct impact on the extent to which a project turns out successful. Through a "choice-based" experiment, Hartmann *et al*. (2009) set four essential criteria for choosing a sub-contractor; "price, technical know-how, quality and cooperation." In order to determine the relative importance of each criterion, the mean, median and standard deviation were calculated.

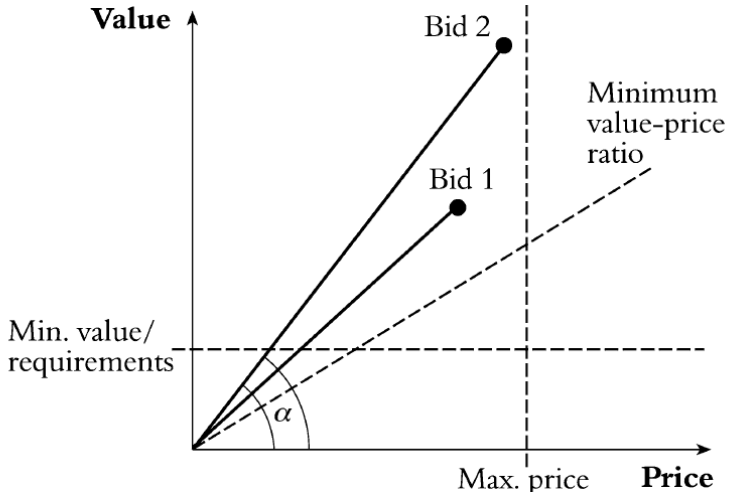

Figure 2.1: Contractor Selection Model (Walraven and De Vries, 2009)

The four criteria are considered essential ones. Usually, maximizing profits and minimizing costs come as crucial objectives of a contractor. Consequently, setting price as one of the criteria of choosing a sub-contractor is essential; in the real world a sub-contractor who offers the lowest price is likely to be selected. However, as previously highlighted, price cannot be the sole criteria based on which selection occurs. Another important criterion is the "technical know-how" (Hartmann *et al*., 2009). As suggested by the criterion, a sub-contractor has to proof professionalism, experience and knowledge of specific technical issues; as a sub-contractor is mainly "hired to perform specific tasks of a project" which require technical knowledge (Hartmann *et al*., 2009). This can be indicated and evaluated through a sub-contractor's past experience in previous projects, and thus indicators include "the applied working methods, materials, machines, and tools" (Hartmann *et al*., 2009). Another criterion that is based on past experience and recommendations is "quality" which is based on, and further complements, a technical know-how of a sub-contractor. Submitting work with a specific standard for quality is a significant indicator of the whole performance of a project; as it demonstrates how far sub-contractors were able to meet the "project requirements" through the delivered work (Hartmann *et al*., 2009). There are mainly four aspects based on which total quality can be evaluated; "technical quality, functional quality, workmanship quality and architectural quality" (Hartmann *et al*., 2009). Despite the fact that high performance in past project does not perfectly guarantee the same level of performance in future ones, this is how main contractors tend to choose sub-contractors as they see it as the best way to predict the professionalism of a sub-contractor. Thus, main contractors tend to choose sub-contractors who display "superior technical and workmanship quality" while demonstrating "good site

management and supervision ability" (Hartmann *et al*., 2009). Cooperation is the third criterion that is measured and evaluated based on the past experiences and past contractor's recommendations which comprises a sub-contractor's reputation. Since any project in the construction field involves several parties, including a contractor and a sub-contractor, a sub-contractor has to show the ability to cooperate with the different parties for the sake of the project's success. This is mainly displayed through how far sub-contractors "fulfill agreements" and the extent to which they "proactively solve and prevent problems" which has its direct impact on the project's "operational efficiency" (Hartmann *et al.*, 2009). A positive attitude along with high responsiveness makes a sub-contractor more likely to be selected by a main contractor (Hartmann *et al*., 2009).

As explained, a sub-contractor who maximizes profits, through high quality work backed with strong technical know-how and a cooperative attitude is considered among the best options. In that sense, a study by Doloi (2009) supported this conclusion through introducing forty-three sub-criteria to determine the best alternative. The study concluded that the low tender price alone is not an indicator of the alternative/contractor's trustiness. The research has three objectives; first, to determine the essential criteria related to the selection of a contractor; second, to examine and evaluate the extent to which these criteria are essential to a successful "project delivery"; and third, to set up "the predictive models" on the contractor selection criteria "influencing target performance and overall success in projects" (Doloi, 2009). In order to get a comprehensive idea about the effect of the different criteria on the contractor selection process, a survey was conducted, which is considered an important tool to identify the significance of each criterion. A questionnaire is also considered the best method to use in cases of non-accessibility to "documented data" (Doloi, 2009). As demonstrated in this section on selecting the best alternative, a single criterion cannot guarantee an accurate sub-contractor selection process, several criteria, that mostly complement each other, should be set to best guarantee choosing the correct sub-contractor.

2.4 ELECTRE III Technique

ELECTRE is an abbreviated word for "Elimination et Choix Traduisant la Realite – Elimination and choice expressing the reality" (Ulubeyli and Kazaz, 2009). Generally, ELECTRE is developed to aid in the selection processes and problems. There are around seven versions of ELECTRE, among which are ELECTRE I, II, III, IV and TRI (Roy, B.

1990; Figueira, J. et al. 2005; Tam, C. et al. 2003; Zavadskas, E. et al. 2004; Ulubeyli, S. and Kazaz, A. 2009; Thiel, T. 2008; Azar, S. and Hauglustaine, J. 2001). All versions are designed and established on the same "fundamental concepts"; the difference between them occurs in operational matters and the "type of the decision problem" (Marzouk, 2010). For instance, ELECTRE TRI aims at solving problems of assignment, ELECTRE I aims at dealing with problems of selection, whereas ELECTRE II, III and IV are designed for problems of ranking.

ELECTRE III is mainly a modified or enhanced version of ELECTRE II, designed to handle problems that occur with qualitative data, such as uncertainty, impreciseness, inaccuracy or "ill-determination of data" (Ulubeyli and Kazaz, 2009). ELECTRE III is a model that is used for determining the best alternative as a Multi Criteria-Decision Making (MCDM) technique (Ulubeyli and Kazaz, 2009). According to Marzouk (2010) ELECTRE III model has several steps: "estimation of concordance indices, estimation of discordance indices, estimation of credibility scores, performing distillation procedure, and performing complete ranking" as shown in Figure 2.2.

A case study that was done using ELECTRE III is on the selection of the suitable method for destruction of waste in Lyon city, France. Nine alternatives were available to select among Roussat *et al.* (2008), based on eight sub-criteria including "financial cost of demolition", "quality of life", "lost energy" and others (Roussat *et al.*, 2008) as shown in Figure 2.3.

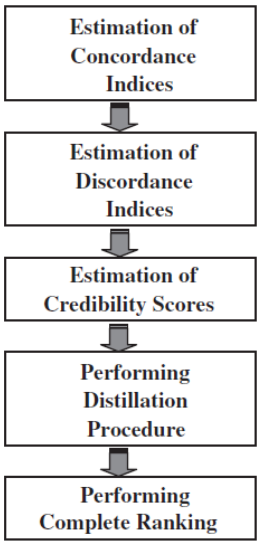

Figure 2.2: Ranking Procedure in ELECTRE III Model (Marzouk, 2010)

ELECTRE III has also been applied in the process of selection of concrete pumps. A case study was done on three alternatives (concrete pumps), while defining five sub-criteria on which the selection of the best alternative is based. The five factors are: “selling price”, “operating cost per day”, “maximum pumping speed”, ‘’second hand”, and “technical services” (Ulubeyli and Kazaz, 2009). These factors are categorized under two main criteria which are: Quantitative and Qualitative criteria, displayed in Table 2.4. The weight of each criterion is calculated for entry in the ELECTRE III model, which ranks the three alternatives “according to the prioritization level” (Ulubeyli and Kazaz, 2009).

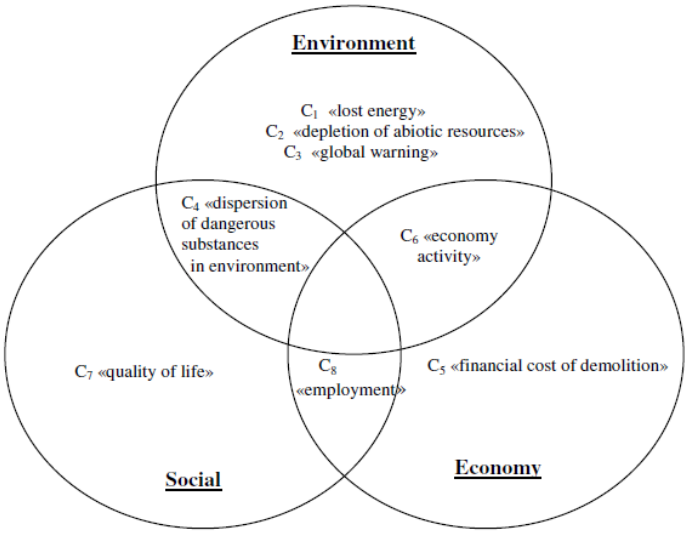

Figure 2.3: Criteria taken into account far a sustainable demolition waste management (Roussat *et al.* 2008)

Marzouk (2010) used ELECTRE III model as a tool for value engineering. He presents an example to analyze the process of selecting glass type to be installed. It included five alternatives, such as clear glass and reflective glass, with four criteria to be taken into consideration while selecting; “initial cost”, “annual savings”, “aesthetics”, and “ease of installation”.

2.5 Summary

This chapter introduced the definition of the decision making process through a review done on previous studies relevant to the Multi Criteria-Decision Making (MCDM) techniques. Also, it presented a review done on previous studies that relevant to the selection of best sub-contractor according to some factors. There were also reviewed previous studies done using ELECTRE III as a model for determining best alternative and

so aiding in the selection process. Applications of ELECTRE III in constructions have been presented.

CHAPTER 3

SURVEYING SUB-CONTRACTORS SELECTION FACTORS

3.1 General

This chapter introduces the survey that was conducted with experts in the construction field. It covers the entire set of categories in the construction field; starting from the owner to the consultant and the main contractor. Also, the chapter presents the criteria and the factors that are used in the study. These factors were gathered from the previous research studies. Based on the survey, the mean score of each factor is calculated then a filtration process of these factors was done based on the calculated mean score.

3.2 Respondents Demographics

In this study a questionnaire survey (as shown in Appendix A and B) was conducted and distributed to experts in the construction field. The questionnaire's distribution process was either hand to hand or via email. These questionnaires were sent to several countries including: Egypt, Saudi Arabia and United Arab of Emirate. The number of respondents is 29 of the experts in the construction projects.

3.3 Findings and Criteria Identification

In this section, the criteria which are used to select the best sub-contractor in this study are presented. These criteria and their factors were gathered from the previous studies done on the selection of sub-contractors (Cheng and Li, 2004; Doloi, 2009; Zou et al. 2007; Turskis, 2008; Cheung et al., 2001; Darvish et al., 2008; Hartmann et al., 2009; Walraven and De Vries, 2009; Fong and Choi, 2000). Ten criteria are used to select sub-contractors as listed in Table 3.1. These ten criteria are:

1- Cost criteria (CC)
2- Quality criteria (QC)
3- Staff's behavior and experiences criteria (SC)
4- Safety criteria (SF)
5- Insurance, repair and warranty for the employees and equipments criteria (IR)
6- Disputes & risks criteria (DR)
7- Time criteria (TC)
8- Experience of the company criteria (EC)
9- Tender criteria (TD)
10- Others criteria (OC)

Each criterion of these criteria has a number of factors. The total number of all factors is forty six.

From the study "Dispute resolution aided tool for construction projects in Egypt" Marzouk et al., (2011), the size of the sample required from the targeted population which is the total number of contractors registered in the Egyptian Federation for Construction and Building Contractors (EFCBC). The minimum size of the sample required from the targeted population was determined statistically according to Kish (1995) as per Equations (1) and (2).

$$n_0 = \frac{p * q}{V^2} \qquad (1)$$

$$n = \frac{n_0}{1 + \frac{n_0}{N}} \qquad (2)$$

Where:

n_0: First estimate of sample size,

p: The proportion of the characteristic being measured in the target population,

q: Complement of p or 1-p,

V: The maximum standard error allowed,

N: The population size, and

n: The sample size

The total number of contractor companies (N), registered in Egyptian Federation for Construction and Building Contractors (EFCBC), in the year 2007 is 58,991, and the first class contractors' companies are 1,716. Hence, p is estimated to be the ratio between the first class of contractors' companies to the total number of contractor companies which is 0.029. To account for possible error in the qualitative answers from the questionnaire, the maximum standard error V was set at 10%. Substituting in Equations (1) and (2), the minimum sample required was calculated to be 2.816. This means that the minimum sample size is approximately 3.0.

Table 3.1 lists the factors along with their definition. The definitions of the factors make them more clear to the respondents/experts who respond to the questionnaire, in order to avoid misunderstandings that might distort the results. Furtheremore, it is important to

have such criteria and factors well explained as a crucial area in the study, meaning that understanding what each factor refers to is an added value to apprehending its significance.

Table 3.1: Factors Influence Sub-contractors Selection

Criterion	Factor	Definition
Cost	Cost overruns	The cost of the project exceeds the expected value of the project during the construction stage
	Flexibility in payment terms and conditions	If there's any flexibility from the sub-contractor to decrease the cost of one item or more
	Tender price	It's the price offered by the sub-contractor to win the tender (the lowest price wins)
	Sub-contractor's difficulty in reimbursement	If the sub-contractor finds any difficulty in reimbursement to the materials' supplier or in paying the salary of his staff each month
	Failure to complete contract	How many projects the sub-contractor failed to complete
	Financial stability	Whether the sub-contractor faces any financial problems that lead to financial instability
	Financial references	What is the source of the funds of the sub-contractor who applied for the tender?
Quality	Quality	What's the standard of quality of the sub-contractor (the standard of quality is determined based on the last projects that the sub-contractor worked on)?
	Sub-contractor's poor management ability	If the laborers of the sub-contractor produce bad quality work
	QA/QC programs	If the sub-contractor has quality assurance and quality control engineers or not
Staff's Behavior and Experiences	Energy saving materials and installations	When the laborers of the sub-contractor are keen on the process of energy saving while working with equipment
	Poor competency of laborers	If the laborers have poor competency especially in time management and work quality
	Experience of technical personnel	The years of experience the technical personnel gained in their field (technical person: professional laborers like the steel fixer, carpenter, painter)
	Decorum, conduct and non-disruptiveness of the staff	The way the sub-contractor's staff deal with others in the projects; whether they maintain appropriate decorum or not
	Prevention of vandalism	If the laborers of the sub-contractor commit any kind of vandalism in the work with other sub-contractors and the main contractor
	Cooperation with the other sub-contractors on the project and in the vicinity	The cooperation attitude with other sub-contractors and vicinity
	Creativity and innovation	Whether the sub-contractor's engineers have the creativity to solve complicated problems that may face the main contractor and the owner, and to find innovative solution
	Labor force retention	The memory of the sub-contractors' laborers when given a specific task
Safety	Jobsite cleanliness during projects and upon leaving jobsites	The keenness of the laborers to leave the jobsite clean during and after their work time
	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities	During the construction stage, does the sub-contractor cause any air or water pollution?
	Safety consciousness on the job site	Does the staff of the sub-contractor maintain safety consciousness on the job site? (such as safety shoes, hard hat, and other safety precautions)
Insurance, Repair and Warranty for the Employees and Equipment	Onsite plant maintenance and repair programs	Is the sub-contractor keen on the maintenance and repairing for his equipment?
	Responsiveness to warranty issues	Is the sub-contractor keen on having equipment with warranty on them?
	Not buying insurance for major equipment and employees	When the sub-contractor does not provide insurance to his staff and equipment.

Table 3.2 lists the mean score of each factor. These scores are identified based on the evaluation of the twenty nine experts (the respondents of the questionnaire). The scores represent the average scores of the factors in order to determine the most important ones out of the forty six. The analysis of these results is further explained later in this chapter.

Table 3.2: Mean Score of the Factors

ID	Factors	Mean Score
CC1	Cost overruns	3.86
CC2	Flexibility in payment terms and conditions	3.90
CC3	Tender price	4.17
CC4	Sub-contractor's difficulty in reimbursement	4.03
CC5	Failure to complete contract	4.28
CC6	Financial stability	3.83
CC7	Financial references	3.07
QC1	Quality	4.31
QC2	Sub-contractor's poor management ability	3.79
QC3	QA/QC programs	3.52
SC1	Energy saving materials and installations	2.69
SC2	Poor competency of laborers	3.79
SC3	Experience of technical personnel	3.97
SC4	Decorum, conduct and non-disruptiveness of the staff	3.34
SC5	Prevention of vandalism	3.83
SC6	Cooperation with the other sub-contractors on the project	3.55
SC7	Creativity and innovation	3.45
SC8	Labor force retention	3.34
SF1	Jobsite cleanliness during projects and upon leaving jobsites	3.28
SF2	Prosecution due to unlawful disposal of construction waste	3.28
SF3	Safety consciousness on the job site	4.00
IR1	Onsite plant maintenance and repair programs	3.59
IR2	Responsiveness to warranty issues	3.21
IR3	Not buying insurance for major equipment and employees	3.24
DR1	Suppliers incompetency to deliver materials on time	4.28
DR2	Disputes and arbitration	3.97
DR3	Failure to comply with the quality specifications	4.31
DR4	Lack of readily available utilities on site	3.34
DR5	Risk avoidance	3.79
TC1	Flexibility and cooperation when resolving delays	4.38
TC2	Delay	4.34
TC3	Length of time in industry	3.86
TC4	Flexibility in critical activities	4.03
TC5	Flexibility in the noncritical activities	3.17
EC1	Reputation	4.38
EC2	Being familiar with the area or being domestic	3.86
EC3	Knowledge of construction regulations	3.93
EC4	Volume of work committed	3.62
EC5	Experience in local area	3.76
EC6	Scale of projects completed	3.83
TD1	Tender quality	3.52
TD2	Willingness to tender	3.66
OC1	Site proximity	2.79
OC2	Ongoing work commitments	3.48
OC3	Physical resources	4.21
OC4	Relationships with the client	3.86

After calculating the mean score for each factor, the selection of the most important factor is done. Any factor that has a mean score equal or greater than 4.00 can be classified among the most important factors. Twelve factors are identified important which are listed in Table 3.3. Subsequently, second survey was conducted in order to determine the ranking of the most important factors according to the experts' viewpoints. The ranking of the factors is done on the criteria level as a first step. For instance, there are three factors under the Cost Criteria; Tender price, Contractor's difficulty in reimbursement and Failure to complete contract. These three factors are ranked separately under their criterion resulting in the Tender price and the Contractor's difficulty in reimbursement as the most important factors equally and the Failure to complete contract as the least important under the cost criteria.

Table 3.3: The twelve most important factors

Criteria	Code	Factors
Cost	CC3	Tender price
	CC4	Contractor's difficulty in reimbursement
	CC5	Failure to complete contract
Disputes and risks	DR1	Suppliers incompetency to deliver materials on time
	DR3	Failure to comply with the quality specifications
Time	TC1	Flexibility & cooperation when resolving delays
	TC2	Delay
	TC4	Flexibility in critical activities
Quality	QC1	Quality
Safety	SF3	Safety consciousness on the job site
Experience of the company	EC1	Reputation
Others	OC3	Physical resources

3.4 Pair-wise Comparison Matrices

The main objectives of the second survey (as shown in Appendix C) are making the pair-wise comparison and calculating the eigenvalue as in the study “Consistency in the analytic hierarchy process: a new approach” Alonso, J. and Lamata M., (2006). This section shows the pair-wise comparison of the twelve factors that are the most important.

The factors and criteria are listed in the pair-wise comparison tables, as the first table lists the cost criterion, the time criterion, then the combined criterion which has the criteria that has only one factor for each criterion, and in the last the other most important criteria. This survey is made on four experts; two of them are sub-contractors, the third is contractor and the forth is consultant.

Table 3.4: Pair-wise comparison for cost criterion for First respondent

Cost Criterion	CC3	CC4	CC5
CC3	1.00	0.50	0.50
CC4	2.00	1.00	2.00
CC5	2.00	0.50	1.00
***Eigenvalue*= 3.054, *CI*= 0.027 and *CR*= 0.030 W_{CC3}= 0.20, W_{CC4}= 0.49, W_{CC5}= 0.31**			
NOTE: CC3: Tender price CC4: Sub-contractor's difficulty in reimbursement CC5: Failure to complete contract			

Table 3.5: Pair-wise comparison for disputes and Risks Criterion for First respondent

Disputes and risks criterion	Suppliers incompetency to deliver materials on time	Failure to comply with the quality specifications
DR1	1.00	2.00
DR3	0.50	1.00
W_{DR1}= 0.67, W_{DR3}= 0.33		
NOTE: DR1: Suppliers incompetency to deliver materials on time DR3: Failure to comply with the quality specifications		

Table 3.6: Pair-wise comparison for Time Criterion for First respondent

Time criterion	TC2	TC1	TC4
TC2	1.00	0.50	0.50
TC1	2.00	1.00	0.50
TC4	2.00	2.00	1.00
***Eigenvalue*= 3.054, *CI*= 0.027 and *CR*= 0.030 W_{TC2}= 0.20, W_{TC1}= 0.31, W_{TC4}= 0.49**			
NOTE: TC2: Delay TC1: Flexibility and cooperation when resolving delays TC4: Flexibility in critical activities			

Tables 3.4 to 3.13 list the pair-wise comparison -for the sub-contractors responses- which are first and second respondents for the cost criterion, disputes and risks criterion, time criterion, combined criteria, the most important criteria, respectively. The tables provide eigenvalue, consistency index (CI) and consistency ratio (CR).

Table 3.7: Pair-wise comparison for combined Criterion for First respondent

Combined criterion	QC	SF	EC	OC
QC	1.00	1.00	2.00	2.00
SF	1.00	1.00	2.00	2.00
EC	0.50	0.50	1.00	2.00
OC	0.50	0.50	0.50	1.00
***Eigenvalue*= 4.060, *CI*= 0.020 and *CR*= 0.020 W_{QC}= 0.33, W_{SF}= 0.33, W_{EC}= 0.20, W_{OC}= 0.14**				
NOTE: QC: Quality SF: Safety EC: Experience of the company OC: Others				

Table 3.8: Pair-wise comparison for the Criteria for First respondent

Criteria	CC	TC	DR	Combined
CC	1.00	0.50	2.00	1.00
TC	2.00	1.00	2.00	1.00
DR	0.50	0.50	1.00	0.50
Combined	1.00	1.00	2.00	1.00
***Eigenvalue*= 4.060, *CI*= 0.020 and *CR*= 0.020 W_{CC}= 0.24, W_{TC}= 0.34, W_{DR}= 0.14, $W_{Combined}$= 0.28**				
NOTE: CC: Cost TC: Time DR: Disputes and risks				

Table 3.9: Pair-wise comparison for cost Criterion for Second respondent

Cost Criterion	CC3	CC4	CC5
CC3	1.00	0.90	0.80
CC4	1.11	1.00	1.10
CC5	1.25	0.91	1.00
***Eigenvalue*= 3.005, *CI*= 0.003 and *CR*= 0.003 W_{CC3}= 0.30, W_{CC4}= 0.36, W_{CC5}= 0.35**			
NOTE: CC3: Tender price CC4: Sub-contractor's difficulty in reimbursement CC5: Failure to complete contract			

Table 3.10: Pair-wise comparison for disputes and risks Criterion for Second respondent

Disputes and risks criterion	DR1	DR3
DR1	1.00	1.20
DR3	0.83	1.00
W_{DR1}= 0.55, W_{DR3}= 0.45		
NOTE: DR1: Suppliers incompetency to deliver materials on time DR3: Failure to comply with the quality specifications		

Table 3.11: Pair-wise comparison for time Criterion for Second respondent

Time criterion	TC2	TC1	TC4
TC2	1.00	0.90	0.80
TC1	1.11	1.00	1.10
TC4	1.25	0.91	1.00
***Eigenvalue*= 3.005, *CI*= 0.003 and *CR*= 0.003** **W_{TC2}= 0.30, W_{TC1}= 0.36, W_{TC4}= 0.35**			
NOTE: TC2: Delay TC1: Flexibility and cooperation when resolving delays TC4: Flexibility in critical activities			

Table 3.12: Pair-wise comparison for combined Criterion for Second respondent

Combined criterion	QC	SF	EC	OC
QC	1.00	0.80	1.10	1.20
SF	1.25	1.00	1.10	1.10
EC	0.50	0.91	1.00	1.20
OC	0.83	0.91	0.83	1.00
***Eigenvalue*= 4.010, *CI*= 0.004 and *CR*= 0.004** **W_{QC}= 0.25, W_{SF}= 0.28, W_{EC}= 0.25, W_{OC}= 0.22**				
NOTE: QC: Quality SF: Safety EC: Experience of the company OC: Others				

Table (3.13): Pair-wise comparison for the Criteria for Second respondent

Criteria	CC	TC	DR	Combined
CC	1.00	0.90	1.10	0.90
TC	1.11	1.00	1.10	1.10
DR	0.91	0.91	1.00	0.90
Combined	1.10	0.91	1.11	1.00
***Eigenvalue*= 4.003, *CI*= 0.001 and *CR*= 0.001 W_{CC}= 0.24, W_{TC}= 0.27, W_{DR}= 0.23, $W_{Combined}$= 0.26**				
NOTE: CC: Cost TC: Time DR: Disputes & risks				

Tables 3.14 to 3.23 list the pair-wise comparison -for a contractor (third respondent) and consultant (forth respondent)- for the cost criterion, disputes and risks criterion, time criterion, combined criteria, the most important criteria, respectively. The tables provide eigenvalue, consistency index (CI) and consistency ratio (CR).

Table 3.14: Pair-wise comparison for cost Criterion for Third respondent

Cost Criterion	CC3	CC4	CC5
CC3	1.00	2.00	2.00
CC4	0.50	1.00	0.50
CC5	0.50	2.00	1.00
***Eigenvalue*= 3.054, *CI*= 0.027 and *CR*= 0.030 W_{CC3}= 0.49, W_{CC4}= 0.20, W_{CC5}= 0.31**			
NOTE: CC3: Tender price CC4: Sub-contractor's difficulty in reimbursement CC5: Failure to complete contract			

Table 3.15: Pair-wise comparison for disputes and risks Criterion for Third respondent

Disputes and risks criterion	DR1	DR3
DR1	1.00	2.00
DR3	0.50	1.00
W_{DR1}= 0.67, W_{DR3}= 0.33		
NOTE: DR1: Suppliers incompetency to deliver materials on time DR3: Failure to comply with the quality specifications		

Table 3.16: Pair-wise comparison for time Criterion for Third respondent

Time criterion	TC2	TC1	TC4
TC2	1.00	2.00	2.00
TC1	0.50	1.00	2.00
TC4	0.50	0.50	1.00
***Eigenvalue*= 3.054, *CI*= 0.027 and *CR*= 0.030 W_{TC2}= 0.49, W_{TC1}= 0.31, W_{TC4}= 0.20**			
NOTE: TC2: Delay TC1: Flexibility and cooperation when resolving delays TC4: Flexibility in critical activities			

Table 3.17: Pair-wise comparison for combined Criterion for Third respondent

Combined criterion	QC	SF	EC	OC
QC	1.00	2.00	2.00	1.00
SF	0.50	1.00	2.00	1.00
EC	0.50	0.50	1.00	1.00
OC	1.00	1.00	1.00	1.00
***Eigenvalue*= 4.012, *CI*= 0.040 and *CR*= 0.045 W_{QC}= 0.34, W_{SF}= 0.24, W_{EC}= 0.17, W_{OC}= 0.24**				
NOTE: QC: Quality SF: Safety EC: Experience of the company OC: Others				

Table 3.18: Pair-wise comparison for the Criteria for Third respondent

Criteria	CC	TC	DR	Combined
CC	1.00	1.00	2.00	2.00
TC	1.00	1.00	2.00	2.00
DR	0.50	0.50	1.00	0.50
Combined	0.50	0.50	2.00	1.00
***Eigenvalue*= 4.060, *CI*= 0.020 and *CR*= 0.020 W_{CC}= 0.33, W_{TC}= 0.33, W_{DR}= 0.14, $W_{Combined}$= 0.20**				
NOTE: CC: Cost TC: Time DR: Disputes & risks				

Table 3.19: Pair-wise comparison for cost Criterion for Forth respondent

Cost Criterion	CC3	CC4	CC5
CC3	1.00	1.25	0.75
CC4	0.80	1.00	0.50
CC5	1.33	2.00	1.00
***Eigenvalue*= 3.004, *CI*= 0.002 and *CR*= 0.002 W_{CC3}= 0.32, W_{CC4}= 0.24, W_{CC5}= 0.45**			
NOTE: CC3: Tender price CC4: Sub-contractor's difficulty in reimbursement CC5: Failure to complete contract			

Table (3.20): Pair-wise comparison for disputes and risks Criterion for Forth respondent

Disputes and risks criterion	DR1	DR3
DR1	1.00	0.50
DR3	2.00	1.00
W_{DR1}= 0.33, W_{DR3}= 0.67		
NOTE: DR1: Suppliers incompetency to deliver materials on time DR3: Failure to comply with the quality specifications		

Table 3.21: Pair-wise comparison for time Criterion for Forth respondent

Time criterion	TC2	TC1	TC4
TC2	1.00	0.75	0.75
TC1	1.33	1.00	1.20
TC4	1.33	0.83	1.00
***Eigenvalue*= 3.004, *CI*= 0.002 and *CR*= 0.002 W_{TC2}= 0.27, W_{TC1}= 0.39, W_{TC4}= 0.34**			
NOTE: TC2: Delay TC1: Flexibility and cooperation when resolving delays TC4: Flexibility in critical activities			

Table 3.22: Pair-wise comparison for combined Criterion for Forth respondent

Combined criterion	QC	SF	EC	OC
QC	1.00	1.00	1.25	1.25
SF	1.00	1.00	1.25	1.25
EC	0.80	0.80	1.00	1.25
OC	0.80	0.80	0.80	1.00
***Eigenvalue*= 4.010, *CI*= 0.002 and *CR*= 0.002 W_{QC}= 0.28, W_{SF}= 0.28, W_{EC}= 0.24, W_{OC}= 0.21**				
NOTE: QC: Quality SF: Safety EC: Experience of the company OC: Others				

Table 3.23: Pair-wise comparison for the Criteria for Forth respondent

Criteria	CC	TC	DR	Combined
CC	1.00	1.20	0.80	0.70
TC	0.83	1.00	0.70	0.70
DR	1.25	1.43	1.00	0.70
Combined	1.43	1.43	1.43	1.00
***Eigenvalue*= 4.010, *CI*= 0.004 and *CR*= 0.005 W_{CC}= 0.22, W_{TC}= 0.20, W_{DR}= 0.26, $W_{Combined}$= 0.32**				
NOTE: CC: Cost TC: Time DR: Disputes & risks				

3.5 Findings and Discussion

As shown in the tables the mean score is calculated for each factor to determine the most important factors according to the experts' opinion. Each factor was given a score by the experts through the surveys. Consequently, the mean score is calculated through getting the summation of the scores of each factor which were ranked by the twenty nine experts, then dividing it by the total number of the respondents which is twenty nine. Any factor that has a mean score greater than 4.00 is among the most important. So this study has twelve factors which are more important than the other thirty four sub-criteria. These twelve factors, arranged from the most important to the least important and displayed in Figure (3.1), are: *Flexibility and cooperation when resolving delays (TC1)* and *Reputation (EC1)* with the same score, followed by *Delay (TC2);* then *Failure to comply with the quality specifications (DR3)* and *Quality (QC1)* with the same score; *Suppliers incompetency to deliver materials on time (DR1)* and *Failure to complete contract (CC5)* with the same

score; *Physical resources (OC3); Tender price (CC3); Contractor's difficulty in reimbursement (CC4)* and *Flexibility in critical activities (TC4)* with the same score; and *Safety consciousness on the job site (SF3).*

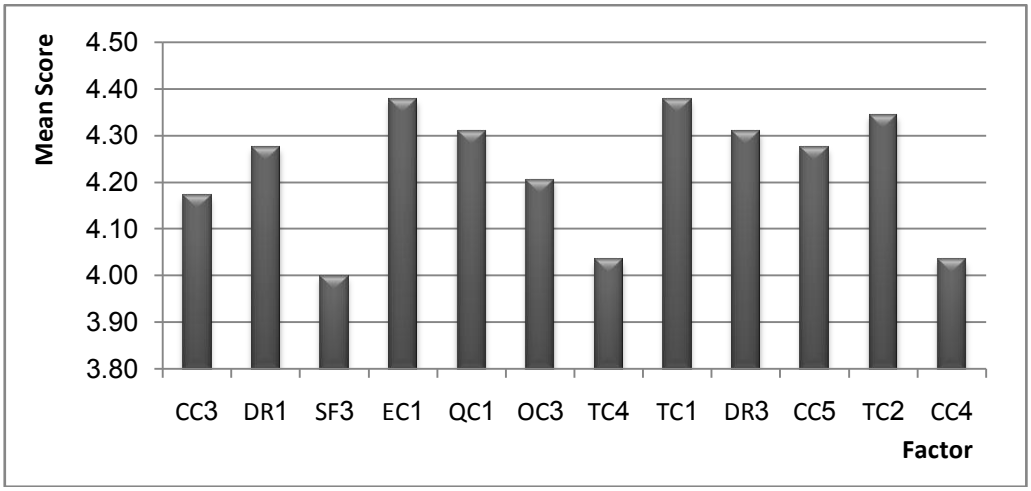

Figure 3.1: Mean Score of Important Factors

The order of these factors is an indicator to the current trend of the sub-contractor selection process in construction field. Since several factors have equal scores, there are eight levels of ranking of the twelve factors. Among the two most important factors is *Reputation*. This factor is one that many contractors highly depend on when deciding whether or not a sub-contractor will be chosen. For instance, as highlighted by Hartmann *et al*. (2009), reputation counts as a significant indicator of the sub-contractor's future work. This occurs through looking at a sub-contractor's past experience in order to determine the degree of professionalism and experience in matters such as quality, cooperation and general attitude in a project besides the technical know-how (Hartmann *et al*., 2009). Consequently, this was supported by this study; as reputation is considered a highly significant matter.

Same applies to *Flexibility and cooperation when resolving delays* factor; as it also came as the first most important factors in twelve factors. A sub-contractor's attitude in a project is crucial especially because he gets to deal with several parties. Therefore, cooperation and flexibility are essential for the project's success; according to Hartmann *et al*. (2009), the extent to which sub-contractors "fulfill agreements" and the extent to which they "proactively solve and prevent problems" has its direct impact on the project's "operational efficiency" (Hartmann *et al*., 2009).

Moreover, as highlighted by many of the previous studies, the tender price should not be the main criterion based on which the selection process occurs. However, in real life it is still an important factor in the sub-contractor's selection process. This was highly supported in this study; as the tender price factor is among the twelve most important factors, yet it came in the sixth rank out of the eight rank of their ranking. Furthermore, surprisingly cost overruns factor is not one of the twelve top factors; its mean score came out to be 3.86. This shows that price and cost are not regarded by main contractors as the best indicators of the most adequate sub-contractor in their decision making process.

The selected factors are used later in this study to determine the best sub-contractor using ELECTRE III decision making technique. From the second survey, the weight of each factor and each criterion is determined from the pair-wise comparison. Also, the consistency of each matrix is calculated. From the calculated weight of each factor, and from the preference of each alternative which will be shown later, the ranking of the alternatives by using ELECTRE III will be determined.

3.6 Summary

This chapter presented the questionnaire survey which was conducted with experts in the construction field in Egypt and other countries including United Arab of Emirates and Kingdom of Saudi Arabia, the results were analyzed the survey. Ten criteria and forty six factors were defined from literature and included in the questionnaire survey. The important factors were determined; which have mean score equal to/or greater than 4.0. Furthermore, a second survey was conducted in order to determine the weights of the factors that deemed important.

CHAPTER 4

STATISTICS AND MATHEMATICAL CALCULATIONS

4.1General

This chapter presents the statistics and mathematical calculations of the first survey that have been performed using SPSS software. The crosstabs and the frequencies are presented for the different considered factors. Significant factors are also distinguished.

4.2 Cross-tabulation calculations

Crosstab is defined as the comparison between two factors. Crosstabs show the relationships between each two factors. Each combination of the scores makes a cell. This cell shows the number of the responses (Huizingh, 2007). Crosstab analysis is considered for the most important factors only in this research. Table 4.1 shows a comparison between two factors which are *Quality QC)* and *Failure to comply with the quality specifications DR3*. When the *QC1* factor has moderate importance, two of the responses indicated that the *DR3* factor has the highest importance. Also, when *QC1* factor has a weak importance, one response gave the *DR3* factor moderate importance. The total number of responses of both factors is twenty nine, which is the total responses number of the questionnaire survey. The *QC1* factor has thirteen responses with the highest importance while the *DR3* factor has different importance rates. On the opposite side there are eighteen responses that gave the *DR3* factor the highest importance while the *QC1* factor has different importance rates.

Table 4.1: Failure to Comply with the Quality Specifications vs. Quality Crosstab

		Failure to comply with the quality specifications (DR3)					**Total**
		1	**2**	**3**	**4**	**5**	
Quality (QC1)	**1**	0	0	0	0	0	0
	2	0	0	1	0	0	1
	3	0	0	0	0	2	2
	4	1	2	1	4	5	13
	5	0	0	0	2	11	13
Total		1	2	2	6	18	29

Table 4.2 shows the relationship between the *Quality QC1* and *the Flexibility and Cooperation when Resolving Delays TC1*. When *QC1* factor has weak importance, *TC1* factor has the highest importance by a total of one response. Also, the table shows that at different importance rates of *QC1* factor, the *TC1* factor has fifteen responses with the highest importance. Whereas, at different importance rates of the *TC1* factor, the *QC1*

factor has thirteen responses with the highest importance.

Table 4.2: Flexibility and Cooperation when Resolving Delays vs. Quality Crosstab

		Flexibility and cooperation when resolving delays (TC1)					Total
		1	**2**	**3**	**4**	**5**	
Quality (QC1)	**1**	0	0	0	0	0	0
	2	0	0	0	0	1	1
	3	0	0	0	1	1	2
	4	0	0	3	6	4	13
	5	0	0	1	3	9	13
Total		0	0	4	10	15	29

Table 4.3 shows the relationships between the *Quality QC1* and the *Delay TC2* factors. As shown in the table when the *QC1* factor has a moderate importance the *TC2* factor has the highest importance by a total of two responses. At different importance rates of the *TC2* factor, the *QC1* factor has the highest importance by thirteen responses. Whereas, at different importance rates of the *QC1* factor, the *TC2* factor has the highest importance by a total of fifteen responses.

Table 4.3: Delay vs. Quality Crosstab

		Delay (TC2)					Total
		1	**2**	**3**	**4**	**5**	
Quality (QC1)	**1**	0	0	0	0	0	0
	2	0	0	0	0	1	1
	3	0	0	0	0	2	2
	4	1	0	2	6	4	13
	5	0	0	0	5	8	13
Total		1	0	2	11	15	29

Table 4.4 shows the relationship between the *Quality QC1* and the *Reputation EC1* factors. As shown in the table there is no response when the *QC1* factor has the highest importance and the *EC1* has a moderate importance. Also, at different importance rates of the *(QC1)* factor, the *EC1* factor has the highest importance by a total of fifteen responses. Whereas, at different importance rates of the *EC1* factor, the *QC1* factor has the highest importance by a total of thirteen responses.

Table 4.4: Reputation vs. Quality Crosstab

		Reputation (EC1)					Total
		1	2	3	4	5	
Quality (QC1)	1	0	0	0	0	0	0
	2	0	0	1	0	0	1
	3	0	0	1	0	1	2
	4	0	0	2	6	5	13
	5	0	0	0	4	9	13
Total		0	0	4	10	15	29

Table 4.5 shows the relationship between the *Suppliers' Incompetency to Deliver Materials on Time DR1* and *Failure to Comply with the Quality Specifications DR3* factors. As shown in the table there is no response when the *DR1* factor has the highest importance and the *DR3* factor has a moderate importance. Also, at different importance rates of the *DR1* factor, the *DR3* factor has the highest importance by a total of eighteen responses. Whereas, at different importance rates of the *DR3* factor, the *DR1* factor has a highest importance by a total of seventeen responses.

Table 4.5: Failure to Comply with the Quality Specifications vs. Suppliers' Incompetency to Deliver Materials on Time Crosstab

		Failure to Comply with the Quality Specifications (DR3)					Total
		1	2	3	4	5	
Suppliers' Incomp. to Deliver Materials on Time (DR1)	1	1	0	0	0	0	1
	2	0	2	0	0	0	2
	3	0	0	0	1	1	2
	4	0	0	2	2	3	7
	5	0	0	0	3	14	17
Total		1	2	2	6	18	29

Table 4.6 shows the relationship between the *Suppliers' Incompetency to Deliver Materials on Time DR1* and *Flexibility and Cooperation when Resolving Delays TC1*. As shown in the table there is no response when the *DR1* factor has the highest importance and the *TC1* factor has a moderate importance. Also, at different importance rates of the *DR1* factor, the *TC1* factor has the highest importance by a total of fifteen responses. Whereas, at different importance rates of the *TC1* factor, the *DR1* factor has the highest importance by a total of seventeen responses.

Table 4.6: Flexibility and Cooperation when Resolving Delays vs. Suppliers' Incompetency to Deliver Materials on Time Crosstab

		Flexibility and Cooperation when Resolving Delays (TC1)					Total
		1	2	3	4	5	
Suppliers' Incomp. to Deliver Materials on Time (DR1)	1	0	0	0	1	0	1
	2	0	0	1	0	1	2
	3	0	0	1	1	0	2
	4	0	0	2	2	3	7
	5	0	0	0	6	11	17
Total		0	0	4	10	15	29

Table 4.7 shows the relationship between the *Suppliers' Incompetency to Deliver Materials on Time DR1* and the *Delay TC2* factors. As shown in the table there is no response when the *DR1* factor has the highest importance and the *TC2* factor has a moderate importance. Also, at different importance rates of the *DR1* factor, the *TC2* factor has the highest importance by a total of fifteen responses. Whereas, at different importance rates of the *TC2* factor, the *DR1* factor has the highest importance by a total of seventeen responses.

Table 4.7: Delay vs. Suppliers' Incompetency to Deliver Materials on Time Crosstab

		Delay (TC2)					Total
		1	2	3	4	5	
Suppliers' Incomp. to Deliver Materials on Time (DR1)	1	0	0	1	0	0	1
	2	0	0	0	1	1	2
	3	0	0	0	1	1	2
	4	0	0	1	3	3	7
	5	1	0	0	6	10	17
Total		1	0	2	11	15	29

Table 4.8 shows the relationship between the *Suppliers' Incompetency to Deliver Materials on Time DR1* and the *Reputation EC1*. As shown in the table there is no response when the *DR1* factor has the lowest importance and the *EC1* factor has a moderate importance. Also, at different importance rates of the *DR1* factor, the *EC1* factor has the highest importance by a total of fifteen responses. Whereas, at different importance rates of the *EC1* factor, the *DR1* factor has the highest importance by a total of seventeen responses.

Table 4.8: Reputation vs. Suppliers' Incompetency to Deliver Materials on Time Crosstab

		Reputation (EC1)					Total
		1	2	3	4	5	
Suppliers' Incomp. to Deliver Materials on Time (DR1)	1	0	0	0	1	0	1
	2	0	0	0	2	0	2
	3	0	0	0	2	0	2
	4	0	0	2	1	4	7
	5	0	0	2	4	11	17
Total		0	0	4	10	15	29

Table 4.9 shows the relationship between the *Failure to Comply with the Quality Specifications DR3* and the *Flexibility and Cooperation when Resolving Delays TC1* factors. As shown in the table, there is no response when the *DR3* factor has the highest importance and the *TC1* factor has a moderate importance. Also at different importance rates of *TC1* factor, the *DR3* factor has a highest importance by a total of eighteen responses. On the opposite side, at different importance rates of the *DR3* factor, the *TC1* factor has the highest importance by a total of fifteen responses.

Table 4.9: Flexibility and Cooperation when Resolving Delays vs. Failure to Comply with the Quality Specifications Crosstab

		Flexibility and Cooperation when Resolving Delays (TC1)					Total
		1	2	3	4	5	
Failure to Comply with the Quality Specif. (DR3)	1	0	0	0	1	0	1
	2	0	0	1	0	1	2
	3	0	0	0	1	1	2
	4	0	0	3	1	2	6
	5	0	0	0	7	11	18
Total		0	0	4	10	15	29

Table 4.10 shows the relationship between the *Failure to Comply with the Quality Specifications DR3* and the *Delay TC2* factors. As shown in the table there is no response when the *DR3* factor has the highest importance and the *TC2* factor has a moderate importance. Also, at different importance rates of the *TC2* factor, the *DR3* factor has the highest importance by a total of eighteen responses. Whereas, at different importance rates of the *DR3* factor, the *TC2* factor has the highest importance by a total of fifteen responses.

Table 4.10: Delay vs. Failure to Comply with the Quality Specifications Crosstab

		Delay (TC2)					Total
		1	**2**	**3**	**4**	**5**	
Failure to Comply with the Quality Specif. (DR3)	**1**	0	0	1	0	0	1
	2	0	0	0	1	1	2
	3	0	0	0	1	1	2
	4	0	0	1	3	2	6
	5	1	0	0	6	11	18
Total		1	0	2	11	15	29

Table 4.11 shows the relationship between the *Failure to Comply with the Quality Specifications DR3* and the *Reputation EC1* factors. As shown in the table there is no response when the *DR3* factor has the lowest importance and the *EC1* factor has a moderate importance. Also, at different importance rates of the *EC1* factor, the *DR3* factor has the highest importance by a total of eighteen responses. Whereas, at different importance rates of the *DR3* factor, the *EC1* factor has the highest importance by a total of fifteen responses.

Table 4.11: Reputation vs. Failure to Comply with the Quality Specifications Crosstab

		Reputation (EC1)					Total
		1	**2**	**3**	**4**	**5**	
Failure to Comply with the Quality Specif. (DR3)	**1**	0	0	0	1	0	1
	2	0	0	0	2	0	2
	3	0	0	1	0	1	2
	4	0	0	1	3	2	6
	5	0	0	2	4	12	18
Total		0	0	4	10	15	29

Table 4.12 shows the relationship between the *Flexibility and Cooperation when Resolving Delays TC1* and the *Delay TC2* factors. As shown in the table there is no response when the *TC1* factor has the highest importance and the *TC2* factor has a moderate importance. Also at different importance rates of the *TC2* factor, the *TC1* factor has the highest importance by a total of fifteen responses. On the opposite side, at different importance rates of the *TC1* factor, the *TC2* factor has the highest importance by a total of fifteen responses.

Table 4.12: Delay vs. Flexibility and Cooperation when Resolving Delays Crosstab

		Delay (TC2)					Total
		1	**2**	**3**	**4**	**5**	
Flexibility and Coop. when Resolving Delays (TC1)	**1**	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	1	3	0	4
	4	1	0	1	3	5	10
	5	0	0	0	5	10	15
Total		1	0	2	11	15	29

Table 4.13 shows the relationship between *the Flexibility and Cooperation when Resolving Delays TC1* and the *Reputation EC1* factors. As shown in the table there is no response when the *TC1* factor has the lowest importance and the *EC1* factor has a lowest importance. Also at different importance rates of the *EC1* factor, the *TC1* factor has the highest importance by a total of fifteen responses. On the opposite side, at different importance rates of the *TC1* factor, the *EC1* factor has the highest importance by a total of fifteen responses.

Table 4.13: Reputation vs. Flexibility and Cooperation when Resolving Delays Crosstab

		Reputation (EC1)					Total
		1	**2**	**3**	**4**	**5**	
Flexibility and coop. when resolving delays (TC1)	**1**	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	1	3	0	4
	4	0	0	2	3	5	10
	5	0	0	1	4	10	15
Total		0	0	4	10	15	29

Table 4.14 shows the relationship between the *Reputation EC1* and the *Delay TC2* factors. As shown in the table there is no response when the *EC1* factor has the highest importance and the *TC2* factor has a moderate importance. Also, at different importance rates of the TC2 factor, the *EC1* factor has the highest importance by a total of fifteen responses. Whereas, at different importance rates of the *EC1* factor, the *TC2* factor has the highest importance by a total of fifteen responses.

Table 4.14: Reputation vs. Delay Crosstab

		Reputation (EC1)					Total
		1	**2**	**3**	**4**	**5**	
Delay (TC2)	**1**	0	0	0	1	0	1
	2	0	0	0	0	0	0
	3	0	0	1	1	0	2
	4	0	0	0	5	6	11
	5	0	0	3	3	9	15
Total		0	0	4	10	15	29

Table 4.15 shows the relationship between the *Tender Price CC3* and the *Failure to complete contract CC5* factors. As shown in the table there is no response when the *CC5* factor has the highest importance and the *CC3* factor has a moderate importance. Also, at different importance rates of the *CC3* factor, the *CC5* factor has the highest importance by a total of eighteen responses. Whereas, at different importance rates of the *CC5* factor, the *CC3* factor has the highest importance by a total of thirteen responses.

Table 4.15: Tender price vs. Failure to complete contract Crosstab

		Failure to complete contract (CC5)					Total
		1	**2**	**3**	**4**	**5**	
Tender price (CC3)	**1**	0	0	0	1	0	1
	2	0	0	0	1	0	1
	3	0	0	1	2	0	3
	4	3	0	0	2	6	11
	5	0	0	0	1	12	13
Total		3	0	1	7	18	29

Table 4.16 shows the relationship between the *Tender price CC3* and the *Quality QC1* factors. As shown in the table there is no response when the *QC1* factor has the moderate importance and the *CC3* factor has a moderate importance. Also, at different importance rates of the *CC3* factor, the *QC1* factor has the highest importance by a total of thirteen responses. Whereas, at different importance rates of the *QC1* factor, the *CC3* factor has the highest importance by a total of thirteen responses.

Table 4.16: Tender Price vs. Quality Crosstab

		Quality (QC1)					Total
		1	**2**	**3**	**4**	**5**	
Tender price (CC3)	**1**	0	0	0	0	1	1
	2	0	0	0	0	1	1
	3	0	1	0	1	1	3
	4	0	0	1	6	4	11
	5	0	0	1	6	6	13
Total		0	1	2	13	13	29

Table 4.17 shows the relationship between the *Tender Price CC3* and the *Suppliers Incompetency to Deliver Materials on Time DR1* factors. As shown in the table there is no response when the *DR1* factor has the least importance and the *CC3* factor has a moderate importance. Also, at different importance rates of the *CC3* factor, the *DR1* factor has the highest importance by a total of seventeen responses. Whereas, at different importance rates of the *DR1* factor, the *CC3* factor has the highest importance by a difference of thirteen responses.

Table 4.17: Tender Price vs. Suppliers Incompetency to Deliver Materials on Time Crosstab

		Suppliers Incompetency to Deliver Materials on Time (DR1)					Total
		1	**2**	**3**	**4**	**5**	
Tender Price (CC3)	**1**	0	0	1	0	0	1
	2	0	0	0	0	1	1
	3	0	0	0	1	2	3
	4	1	1	1	2	6	11
	5	0	1	0	4	8	13
Total		1	2	2	7	17	29

Table 4.18 shows the relationship between the *Tender Price CC3* and the *Failure to comply with the quality specifications DR3* factors. As shown in the table there is no response when the *DR3* factor has the least importance and the *CC3* factor has a moderate importance. Also, at different importance rates of the *CC3* factor, the *DR3* factor has the highest importance by a total of eighteen responses. Whereas, at different importance rates of the *DR3* factor, the *CC3* factor has the highest importance by a total of thirteen responses.

Table 4.18: Tender Price vs. Failure to Comply with the Quality Specifications Crosstab

		Failure to Comply with the Quality Specifications (DR3)					Total
		1	2	3	4	5	
Tender Price (CC3)	1	0	0	0	1	0	1
	2	0	0	0	0	1	1
	3	0	0	1	0	2	3
	4	1	1	1	1	7	11
	5	0	1	0	4	8	13
Total		1	2	2	6	18	29

Table 4.19 shows the relationship between the *Tender Price CC3* and the *Flexibility and Cooperation when Resolving Delays TC1* factors. As shown in the table there is no response when the *TC1* factor has the lowest importance and the *CC3* factor has a moderate importance. Also, at different importance rates of the *CC3* factor, the *TC1* factor has the highest importance by a total of fifteen responses. Whereas, at different importance rates of the *TC1* factor, the *CC3* factor has the highest importance by a total of thirteen responses.

Table 4.19: Tender Price vs. Flexibility and Cooperation when Resolving Delays Crosstab

		Flexibility and Cooperation when Resolving Delays (TC1)					Total
		1	2	3	4	5	
Tender Price (CC3)	1	0	0	1	0	0	1
	2	0	0	0	0	1	1
	3	0	0	0	1	2	3
	4	0	0	1	7	3	11
	5	0	0	2	2	9	13
Total		0	0	4	10	15	29

Table 4.20 shows the relationship between the *Tender Price CC3* and the *Delay TC2* factors. As shown in the table there is no response when the *TC2* factor has the least importance and the *CC3* factor has a moderate importance. Also, at different importance rates of the *CC3* factor, the *TC2* factor has the highest importance by a total of eighteen responses. Whereas, at different importance rates of the *TC2* factor, the *CC3* factor has the highest importance by a total of thirteen responses.

Table 4.20: Tender Price vs. Delay Crosstab

		Delay (TC2)					Total
		1	**2**	**3**	**4**	**5**	
Tender Price (CC3)	**1**	0	0	0	1	0	1
	2	0	0	0	1	0	1
	3	0	0	1	2	0	3
	4	3	0	0	2	6	11
	5	0	0	0	1	12	13
Total		3	0	1	7	18	29

Table 4.21 shows the relationship between the *Tender Price CC3* and the *Reputation EC1* factors. As shown in the table there is no response when the *EC1* factor has the highest importance and the *CC3* factor has a moderate importance. Also, at different importance rates of the CC3 factor, the *EC1* factor has the highest importance by a total of fifteen responses. Whereas, at different importance rates of the *EC1* factor, the *CC3* factor has the highest importance by a total of thirteen responses.

Table 4.21: Tender Price vs. Reputation Crosstab

		Reputation (EC1)					Total
		1	**2**	**3**	**4**	**5**	
Tender Price (CC3)	**1**	0	0	0	1	0	1
	2	0	0	0	0	1	1
	3	0	0	2	1	0	3
	4	0	0	1	5	5	11
	5	0	0	1	3	9	13
Total		0	0	4	10	15	29

Table 4.22 shows the relationship between the *Failure to Complete Contract CC5* and the *Quality QC1* factors. As shown in the table there is no response when the *QC1* factor has the highest importance and the *CC5* factor has a moderate importance. Also, at different importance rates of the *CC5* factor, the *QC1* factor has the highest importance by a total of thirteen responses. Whereas, at different importance rates of the *QC1* factor, the *CC5* factor has the highest importance by a total of eighteen responses.

Table 4.23 shows the relationship between the *Suppliers' Incompetency to Deliver Materials on Time DR1* and *Failure to complete contract* CC5 factors. As shown in the table there is no response when the *DR1* factor has the highest importance and the *CC5* factor has a moderate importance. Also at different importance rates of the *DR1* factor, the *CC5* factor has the highest importance by a total of eighteen responses. On the opposite side, at different importance rates of the *CC5* factor, the *DR1* factor has a highest

importance by a total of seventeen responses.

Table 4.22: Failure to Complete Contract vs. Quality Crosstab

		Quality (QC1)					Total
		1	**2**	**3**	**4**	**5**	
Failure to Complete Contract (CC5)	**1**	0	0	0	3	0	3
	2	0	0	0	0	0	0
	3	0	1	0	0	0	1
	4	0	0	0	4	3	7
	5	0	0	2	6	10	18
Total		0	1	2	13	13	29

Table 4.23: Failure to Complete Contract vs. Suppliers Incompetency to Deliver Materials on Time Crosstab

		Suppliers Incompetency to Deliver Materials on Time (DR1)					Total
		1	**2**	**3**	**4**	**5**	
Failure to Complete Contract (CC5)	**1**	1	1	0	0	1	3
	2	0	0	0	0	0	0
	3	0	0	0	1	0	1
	4	0	0	1	2	4	7
	5	0	1	1	4	12	18
Total		1	2	2	7	17	29

Table 4.24 shows the relationship between the *Failure to Complete Contract CC5* and the *Failure to comply with the quality specifications DR3* factors. As shown in the table there is no response when the *DR3* factor has the highest importance and the *CC5* factor has a moderate importance. Also, at different importance rates of the *CC5* factor, the *DR3* factor has the highest importance by a total of eighteen responses. Whereas, at different importance rates of the *DR3* factor, the *CC5* factor has the highest importance by a total of eighteen responses.

Table 4.25 shows the relationship between the *Failure to complete contract CC5* and the *Flexibility and cooperation when resolving delays TC1* factors. As shown in the table there is no response when the *TC1* factor has the least importance and the *CC5* factor has a moderate importance. Also, at different importance rates of the *CC5* factor, the *TC1* factor has the highest importance by a total of fifteen responses. Whereas, at different importance rates of the *TC1* factor, the *CC5* factor has the highest importance by a total of eighteen responses.

Table 4.24: Failure to Complete Contract vs. Failure to Comply with the Quality Specifications Crosstab

		Failure to Comply with the Quality Specifications (DR3)					Total
		1	2	3	4	5	
Failure to Complete Contract (CC5)	1	1	1	0	0	1	3
	2	0	0	0	0	0	0
	3	0	0	1	0	0	1
	4	0	0	1	3	4	7
	5	0	1	0	3	12	18
Total		1	2	2	6	18	29

Table 4.25: Failure to Complete Contract vs. Flexibility and Cooperation when Resolving Delays Crosstab

		Flexibility and Cooperation when Resolving Delays (TC1)					Total
		1	2	3	4	5	
Failure to Complete Contract (CC5)	1	0	1	1	2	0	3
	2	0	0	0	0	0	0
	3	0	0	0	0	1	1
	4	0	0	2	2	3	7
	5	0	0	1	6	11	18
Total		0	0	4	10	15	29

Table 4.26 shows the relationship between the *Failure to complete contract CC5* and the *Delay TC2* factors. As shown in the table there is no response when the *TC2* factor has the least importance and the *CC5* factor has a moderate importance. Also, at different importance rates of the *CC5* factor, the *TC2* factor has the highest importance by a total of fifteen responses. Whereas, at different importance rates of the *TC2* factor, the *CC5* factor has the highest importance by a total of eighteen responses.

Table 4.26: Failure to Complete Contract vs. Delay Croostab

		Delay (TC2)					Total
		1	2	3	4	5	
Failure to	1	1	0	1	1	0	3

Complete Contract (CC5)	**2**	0	0	0	0	0	0
	3	0	0	0	0	1	1
	4	0	0	1	4	2	7
	5	0	0	0	6	12	18
Total		1	0	2	11	15	29

Table 4.27 shows the relationship between the *Failure to complete contract CC5* and the *Reputation EC1* factors. As shown in the table there is no response when the *EC1* factor has the highest importance and the *CC5* factor has a moderate importance. Also, at different importance rates of the *CC5* factor, the *EC1* factor has the highest importance by a difference of fifteen responses. Whereas, at different importance rates of the *EC1* factor, the *CC5* factor has the highest importance by a difference of eighteen responses.

Table 4.27: Failure to Complete Contract vs. Reputation Crosstab

		Reputation (EC1)					**Total**
		1	**2**	**3**	**4**	**5**	
Failure to Complete Contract (CC5)	**1**	0	0	0	3	0	3
	2	0	0	0	0	0	0
	3	0	0	1	0	0	1
	4	0	0	2	3	2	7
	5	0	0	1	4	13	18
Total		0	0	4	10	15	29

4.3 Frequencies Calculations of Factors

Using SPSS software, the frequency of the results of the questionnaire was determined. This section presents a tabular format of the factors and determines the number of the responses for each score which ranges from 1 (least important) to 5 (most important). The frequencies of importance level and the mean score for the different factors are listed in Table 4.28.

4.4 Determination of Significant Factors

Using the mean score of each factor and calculating the *p-value* by using SPSS software, the significance of each factor used in the questionnaire is determined. Any factor that has a *p-value* less than 0.05 is considered a significant one. As shown in Table 4.29, the significant factors are determined based on the *p-value* and the mean score. Any factor that has *p-value* less than 0.05 and a mean score more than 3.00 is considered significant. As per Table 4.29, there are thirteen factors with a *p-value* more than 0.05, so they are not significant factors. Although some of the non significant factors have a mean score more

than 3.00 but this is not an indicator that these factors are significant. The *p-value* result is a crucial indicator to the significance of factors.

Table 4.28: Frequencies of Importance Level for the Different Factors

ID	Factors	Least……..…..Most				
		1	**2**	**3**	**4**	**5**
CC1	Cost overruns	3	2	4	7	13
CC2	Flexibility in payment terms and conditions	0	2	8	10	9
CC3	Tender price	1	1	3	11	13
CC4	Sub-contractor's difficulty in reimbursement	1	1	6	9	12
CC5	Failure to complete contract	3	0	1	7	18
CC6	Financial stability	2	1	6	11	9
CC7	Financial references	4	5	10	5	5
QC1	Quality	0	1	2	13	13
QC2	Sub-contractor's poor management ability	2	2	6	9	10
QC3	QA/QC programs	2	3	10	6	8
SC1	Energy saving materials and installations	7	3	11	8	0
SC2	Poor competency of laborers	0	2	9	11	7
SC3	Experience of technical personnel	0	2	3	18	6
SC4	Decorum, conduct and non-disruptiveness of the staff	1	1	17	7	3
SC5	Prevention of vandalism	2	0	7	12	8
SC6	Cooperation with the other sub-contractors on the project	1	2	10	12	4
SC7	Creativity and innovation	0	4	12	9	4
SC8	Labor force retention	3	2	11	8	5
SF1	Jobsite cleanliness during projects and upon leaving jobsites	3	4	8	10	4
SF2	Prosecution due to unlawful disposal of construction waste	3	5	5	13	3
SF3	Safety consciousness on the job site	0	3	6	8	12
IR1	Onsite plant maintenance and repair programs	0	2	12	11	4
IR2	Responsiveness to warranty issues	3	5	8	9	4
IR3	Not buying insurance for major equipment and employees	3	3	10	10	3
DR1	Suppliers incompetency to deliver materials on time	1	2	2	7	17
DR2	Disputes and arbitration	1	2	2	7	17
DR3	Failure to comply with the quality specifications	1	2	2	6	18
DR4	Lack of readily available utilities on site	1	7	8	7	6
DR5	Risk avoidance	2	2	5	11	9
TC1	Flexibility and cooperation when resolving delays	0	0	4	10	15
TC2	Delay	1	0	2	11	15
TC3	Length of time in industry	0	2	7	13	7
TC4	Flexibility in critical activities	0	1	7	11	10
TC5	Flexibility in the noncritical activities	4	5	8	6	6
EC1	Reputation	0	0	4	10	15
EC2	Being familiar with the area or being domestic	0	2	7	13	7
EC3	Knowledge of construction regulations	0	3	5	12	9
EC4	Volume of work committed	1	2	7	16	3
EC5	Experience in local area	0	1	9	15	4
EC6	Scale of projects completed	1	2	5	14	7
TD1	Tender quality	2	3	10	6	8
TD2	Willingness to tender	3	1	7	10	8
OC1	Site proximity	6	4	11	6	2
OC2	Ongoing work commitments	1	4	10	8	6
OC3	Physical resources	0	0	4	15	10
OC4	Relationships with the client	1	1	9	8	10

Table 4.29: The significant factors

Factor	Mean score	SD	*p-val.*	State
Cost overruns	3.86	1.36	0.004	Significant
Flexibility in payment terms and conditions	3.90	0.96	0.000	Significant

Tender price	4.17	1.01	0.000	Significant
Sub-contractor's difficulty in reimbursement	4.03	1.05	0.000	Significant
Failure to complete contract	4.28	1.27	0.000	Significant
Financial stability	3.83	1.16	0.001	Significant
Financial references	3.07	1.24	0.547	Not Significant
Quality	4.31	0.76	0.000	Significant
Sub-contractor's poor management ability	3.79	1.21	0.003	Significant
QA/QC programs	3.52	1.20	0.051	Not Significant
Energy saving materials and installations	2.69	1.11	0.244	Not Significant
Poor competency of laborers	3.79	0.92	0.000	Significant
Experience of technical personnel	3.97	0.77	0.000	Significant
Decorum, conduct and non-disruptiveness of the staff	3.34	0.81	0.073	Not Significant
Prevention of vandalism	3.83	1.07	0.001	Significant
Cooperation with the other sub-contractors on the project	3.55	0.92	0.008	Significant
Creativity and innovation	3.45	0.88	0.025	Significant
Labor force retention	3.34	1.15	0.200	Not Significant
Jobsite cleanliness during projects and upon leaving jobsites	3.28	1.17	0.339	Not Significant
Prosecution due to unlawful disposal of construction waste	3.28	1.13	0.106	Not Significant
Safety consciousness on the job site	4.00	0.98	0.000	Significant
Onsite plant maintenance and repair programs	3.59	0.83	0.001	Significant
Responsiveness to warranty issues	3.21	1.15	0.200	Not Significant
Not buying insurance for major equipment and employees	3.24	1.06	0.119	Not Significant
Suppliers incompetency to deliver materials on time	4.28	1.11	0.000	Significant
Disputes and arbitration	3.97	1.09	0.000	Significant
Failure to comply with the quality specifications	4.31	1.12	0.000	Significant
Lack of readily available utilities on site	3.34	1.19	0.125	Not Significant
Risk avoidance	3.79	1.18	0.002	Significant
Flexibility and cooperation when resolving delays	4.38	0.73	0.000	Significant
Delay	4.34	0.91	0.000	Significant
Length of time in industry	3.86	0.88	0.000	Significant
Flexibility in critical activities	4.03	0.86	0.000	Significant
Flexibility in the noncritical activities	3.17	1.32	0.670	Not Significant
Reputation	4.38	0.73	0.000	Significant
Being familiar with the area or being domestic	3.86	0.86	0.000	Significant
Knowledge of construction regulations	3.93	0.96	0.001	Significant
Volume of work committed	3.62	0.91	0.000	Significant

Table 4.29: The significant factors cont'd

Experience in local area	3.76	0.75	0.000	Significant
Scale of projects completed	3.83	1.01	0.000	Significant
Tender quality	3.52	1.20	0.051	Not Significant

Willingness to tender	3.66	1.23	0.014	Significant
Site proximity	2.79	1.23	0.364	Not Significant
Ongoing work commitments	3.48	1.11	0.024	Significant
Physical resources	4.21	0.67	0.000	Significant
Relationships with the client	3.86	1.06	0.000	Significant

4.5 Discussion of the Results

From the frequency table, it is concluded that the Quality factor and Delay factor are the most important factors because 89.66% of the respondents gave them the scores four and five. As shown in the crosstabs tables, these tables create a comparison between each two factors of the most important factors in this study. The comparisons did not show which factor dominates the other; as a comparison between the total numbers of respondents of both factors is done. For instance if we have factor A and factor B, and at score 4 the total number of respondents of factor B is 7, the distribution of these respondents on the different scores of factor A is noticed. From the previous tables of the crosstabs, it is concluded that the significance of the factors related to Cost criteria, such as Tender price, is not as high as other factors, such as Failure to complete contract. In determination of the significant factors, the mean score and *p-value* are used for determining the significant factors. Any factor of the forty six factors is considered significant if its mean score is greater than or equals 3.00 and its *p-value* less than 0.05. In some cases however, a factor can be considered as not significant even if its mean score is greater than 3.00 and this occurs in case its *p-value* is greater than 0.05. According to this table, thirteen factors can be identified as not significant factors because their *p-value* is greater than 0.05.

4.6 Summary

This chapter presented the statistical calculations for the first survey in this study. It presented crosstabs calculations frequencies significance of factors. The crosstabs tables display a comparison between some of the most important factors in this study. The frequency table illustrates the level of importance for all the factors. Finally the significance factors were determined based on *p-value* and mean score. The third section presented a table which categorized the forty six factors as significant or not. Any factor with a mean score greater than or equal to 3.00 and has *p-value* less than or equal to 0.05 is defined as a significant factor. The mean score 3.00 is chosen to compare with the factors

because it considered to be an intermediate score (i.e., not with high importance or not with low importance).

CHAPTER 5

ELECTRE III SUB-CONTRACTOR SELECTION MODEL

5.1 General

This chapter presents a case study of four sub-contractors carrying out a specific item in a project. This case study uses two inputs; the weights of each factor of the twelve most important factors, and the score of each sub-contractor according to each factor. By using ELECTRE III technique, outputs include the ranking of each sub-contractor and credibility score. There are four responses (representing four scenarios) for the second questionnaire; however, there are three scenarios since two respondents have the same results. In each scenario, the coefficient of indifference and coefficient of preference were changed, which led to changing the ranking of the alternatives.

5.2 ELECTRE III Description

5.2.1 Concordance index

It is a comparison between the two alternatives a and b as this comparison done according to all factors. This index is range from 0 to 1 where the value 0 is indicating that alternative a is worse than alternative b. It is calculated according to the weight over each factor as per Eq. (1).

$$C(a,b) = \frac{1}{W} \sum_{j=1}^{n} w_j c_j(a,b) \quad (1)$$

where; $W = \sum_{j=1}^{n} w_j$

j=1

The comparison between the two alternatives for each factor is calculated according to the three following cases:

Case 1: Alternative a is valent to or better than b minus the indifference threshold for factor j as per Eq. (2).

$c_j(a,b) = 1$ if $g_j(a) + q(g_j(a)) \geq g_j(b)$ (2)

Case 2: When the performance of alternative a and the performance threshold is less than the performance of b then alternative a is less than alternative b for this factor as per Eq. (3).

$c_j(a,b) = 0$ if $g_j(a) + q(g_j(a)) \leq g_j(b)$ (3)

Case 3: Furthermore, the relationship is between these two alternatives and is represented as a linear variation as per Eq. (4).

$$c_j(a,b) = \frac{g_j(a) - g_j(b) + p_j(g_j(a))}{p_j(g_j(a)) - q_j(g_j(a))} \quad (5)$$

5.2.2 Discordance index

The presence of the discordance index into outranking relations is relevant to the veto threshold. The outranking of b by a that indicated by concordance index can be canceled when there is any factor used the veto threshold which alternative a outperforms alternative b if all factors favor the opposite as per Eq. (5).

$$g_j(b) \geq g_j(a) + v_j(g_j(a)) \quad (5)$$

The discordance index is from 0 to 1 and calculated according to the following two cases:

Case 1: Alternative b is not better than alternative a by a footnote greater than the veto threshold as per Eq. (6).

$$D_j(a,b) = 0 \text{ if } g_j(b) \leq g_j(a) + p_j(g_j(a)) \quad (6)$$

Case 2: Alternative b is better than alternative a by a footnote greater than the veto threshold as per Eq. (7).

$$D_j(a,b) = 1 \text{ if } g_j(b) \geq g_j(a) + v_j(g_j(a)) \quad (7)$$

Case 3: Else the relationship is linear between the two as per Eq. (8).

$$D_j(a,b) = \frac{g_j(b) - g_j(a) + p_j(g_j(a))}{v_j(g_j(a)) - p_j(g_j(a))} \quad (8)$$

5.2.3 Credibility score

According to "ELECTRE III model for value engineering applications" Marzouk (2010), the score of credibility is calculated based on discordance and concordance according to the following two cases:

Case 1: The score of the credibility is not equal to the concordance if a veto threshold is used as per Eq. (9)

$$S(a,b) = C(a,b) \text{ if } D_j(a,b) \leq C(a,b) \quad (9)$$

Case 2: The score of the credibility is equal to the concordance if there is no veto threshold or when there is no factor discordant.

$$S(a,b) = C(a,b) \prod_{j \in \Psi(a,b)} \frac{1 - D_j(a,b)}{1 - C(a,b)} \quad (10)$$

where $\Psi(a,b)$ is a group of factors when $D_j(a,b) > c_j(a,b)$

As shown in the figures 5.6-5.9 the matrix degree of concordance and matrix of the credibility are calculated for the three scenarios by using ELECTRE III. When there is a comparison between the matrix of degree of the credibility and the matrix of concordance for the same scenario it will be shown that there is no difference between them. This is because there is no veto threshold and also there is no factor discordant.

5.2.4 Distillation procedure

This section presents a procedure which is ranked the alternatives in two pre-orders which are descending distillation and ascending distillation. The descending distillation means that ranked the alternatives from the best to the worst, while the ascending distillation means that ranked the alternatives from the worst to the best. The two pre-orders are followed the below steps:

Step 1: As per Eq. (11) the λ_0 equals to the maximum value of S(a,b) in the credibility matrix (A).

$$\lambda_0 = \max_{a,b \in A} S(a,b) \quad (11)$$

Step 2: λ_1 is the largest outranking score (S(a,b)) as it is less than the maximum outranking score minus the discrimination threshold as per Eq. (12).

$$\lambda_0 = \max_{\{S(a,b) < \lambda_0 - s(\lambda_0)\} \in A} S(a,b) \quad (12)$$

where $s(\lambda_0)$ is the discrimination threshold at the maximum level of λ_0. When S(a,b) is greater than the cutoff then a top ranking b and S(a,b) more than S(b,a) see Eq. (13, 14)

$$s(\lambda) = 0.3 - 0.15\lambda \quad (13)$$

$$aSb \text{ if } S(a,b) > \lambda_1 \text{ and } S(a,b) - S(b,a) > s(\lambda) \quad (14)$$

Step 3: When a top ranking b then a is taken a score + 1 (strength) and b is taken – 1 (weakness). For all alternatives, both scores are combined together to give the final qualification score.

Step 4: In case of a descending distillation, the highest qualification score alternative is removed from the procedure and the process is repeated.

Step 5: In case of an ascending distillation, the lowest qualification score alternative is removed from the procedure and the process is repeated.

5.2.5 Complete Ranking

The results of the two procedures are combined to form the complete ranking which is harmonic with these two procedure.

5.3 Case study

The score of each factor in sub-contractor's evaluation process is determined by experts in the construction field, to determine the ranking of each sub-contractor. As listed in Table 5.1, four sub-contractors submitted a tender in a project to perform waterproofing.

Table 5.1: ELECTRE III Model Inputs

Criteria	Scenarios Weights				Unit	Alternatives			
	1	2	3	4		A-Build	Beta Misr	De-Target	Sodeco
Tender price	0.048	0.072	0.162	0.070	L.E million	2.20	2.23	2.46	2.23
Sub-contractor's difficulty in reimbursement	0.118	0.086	0.066	0.053	%	40	60	90	10
Failure to complete contract	0.074	0.084	0.102	0.099	%	20	70	80	10
Delay	0.068	0.081	0.162	0.054	%	80	80	90	10
Flexibility & cooperation when resolving delays	0.105	0.097	0.102	0.078	%	80	80	60	20
Flexibility in critical activities	0.167	0.095	0.066	0.068	%	85	85	90	10
Suppliers incompetency to deliver materials on time	0.094	0.127	0.094	0.086	%	60	70	90	15
Failure to comply with the quality specifications	0.046	0.104	0.046	0.174	%	65	80	70	10
Quality	0.092	0.065	0.068	0.090	%	60	75	85	5
Safety consciousness on the job site	0.092	0.073	0.048	0.090	%	70	80	75	70
Reputation	0.056	0.065	0.034	0.077	%	90	85	80	90
Physical resources	0.039	0.057	0.048	0.067	%	85	90	80	80

Each of these sub-contractors valued the factors differently; as these values are determined from an expert in the construction field. As displayed in the table, concerning the first factor which is the "tender price", the sub-contractor that has a lowest price is Sodeco. Meanwhile, when it comes to the fifth factor which is "safety consciousness on the job site", the alternative (sub-contractor) which is considered to be the best in this factor – according to the past works on other projects – is BetaMisr, having the highest value.

There are four scenarios of ranking of the sub-contractors from the four responses of the second survey. In each of these four scenarios the value of α was manipulated from 0.01 to 0.50. Based on this manipulation, the results of the sub-contractors ranking are changed for each scenario**.** It has been proven that the cost factors should not be the only factors taken into consideration.

5.3.1 Analysis of First Scenario

Figure 5.1 shows six graphs for the first scenario representing values / ranges for α parameter; 0.01, 0.02 – 0.05, 0.06, 0.07 – 0.13, 0.14 – 0.49, and 0.50. This graph shows that BetaMisr comes first in ranking although its tender price has the lowest score. This proves that cost factors should not merely have higher importance than other factors. The alternative Sodeco, with the lowest tender price, is the worst alternative in the six graphs; as it has low weight in the other factors. Also BetaMisr and DeTarget, the two alternatives with the highest tender price came in the first and second ranking. Concerning Tender price, and Failure to comply with the quality specifications factors; the values of the three alternatives BetaMisr, DeTarget, and Sodeco in the Tender price are 2.23×10^6, 2.46×10^6, and 2.23×10^6 respectively. Whereas, for the Failure to comply with the quality specifications are the values for the three alternatives 80%, 70%, and 10%, respectively. This proves that Tender price is not the most important factor; although Sodeco has the lowest value in the tender price it came in the last rank. This occurred because it has the lowest value in other factors like Failure to comply with the quality specifications.

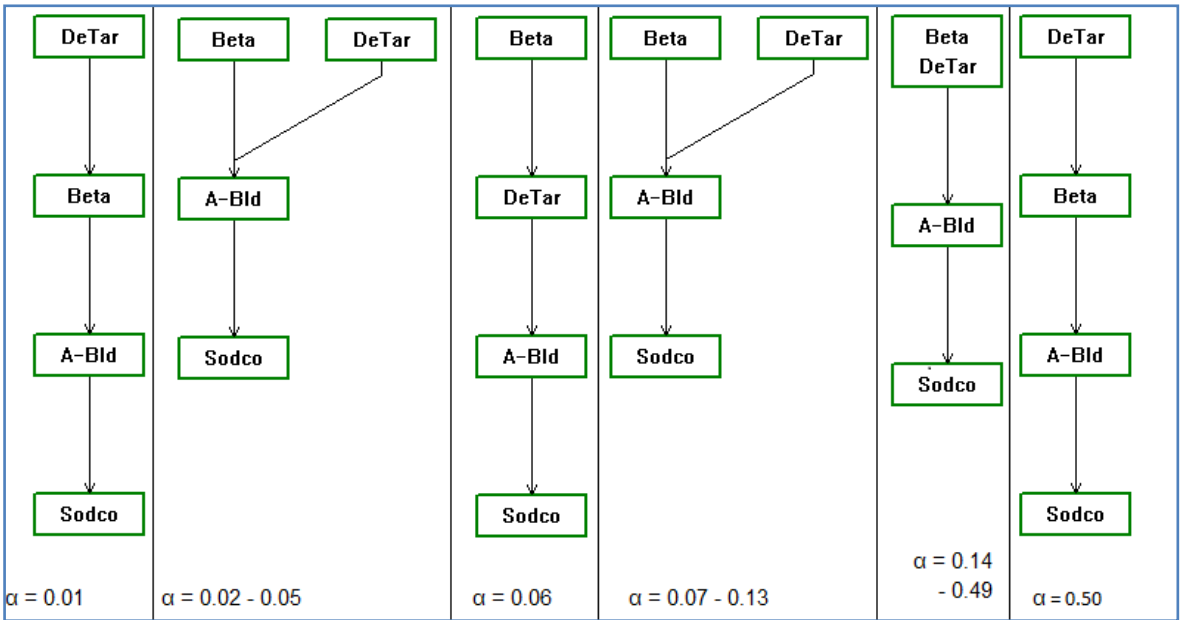

Figure 5.1: Ranking of Sub-Contractors - First Response

5.3.2 Analysis of Second Scenario

Figure 5.2 shows seven graphs for the second scenario, representing values / ranges for α parameter; 0.01, 0.02 – 0.05, 0.06, 0.07 – 0.10, 0.11 – 0.12, 0.13 – 0.49 and 0.50. This graph shows that BetaMisr and DeTarget are in the first rank. This figure shows that Sodeco is the worst alternative in all the graphs although it has the lowest tender price.

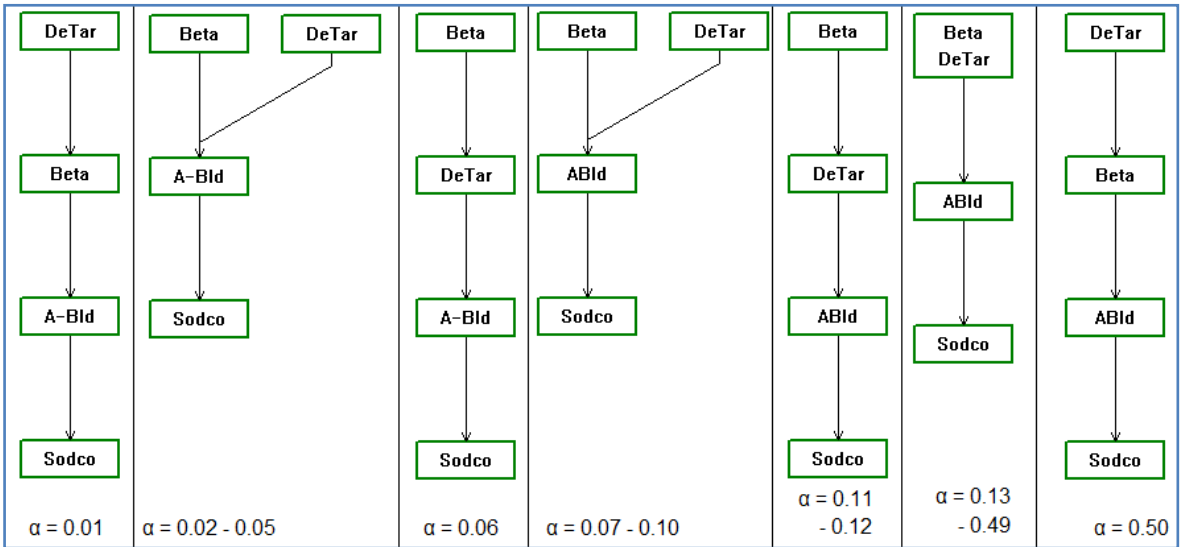

Figure 5.2: Ranking of Sub-Contractors - Second Response

5.3.3 Analysis of Third Scenario

Figure 5.3 shows five graphs for the third scenario, representing values / ranges for α; 0.01, 0.02 – 0.06, 0.07 – 0.13, 0.14 – 0.49 and 0.50. This figure shows that sub-contractors DeTarget is best sub-contractor.

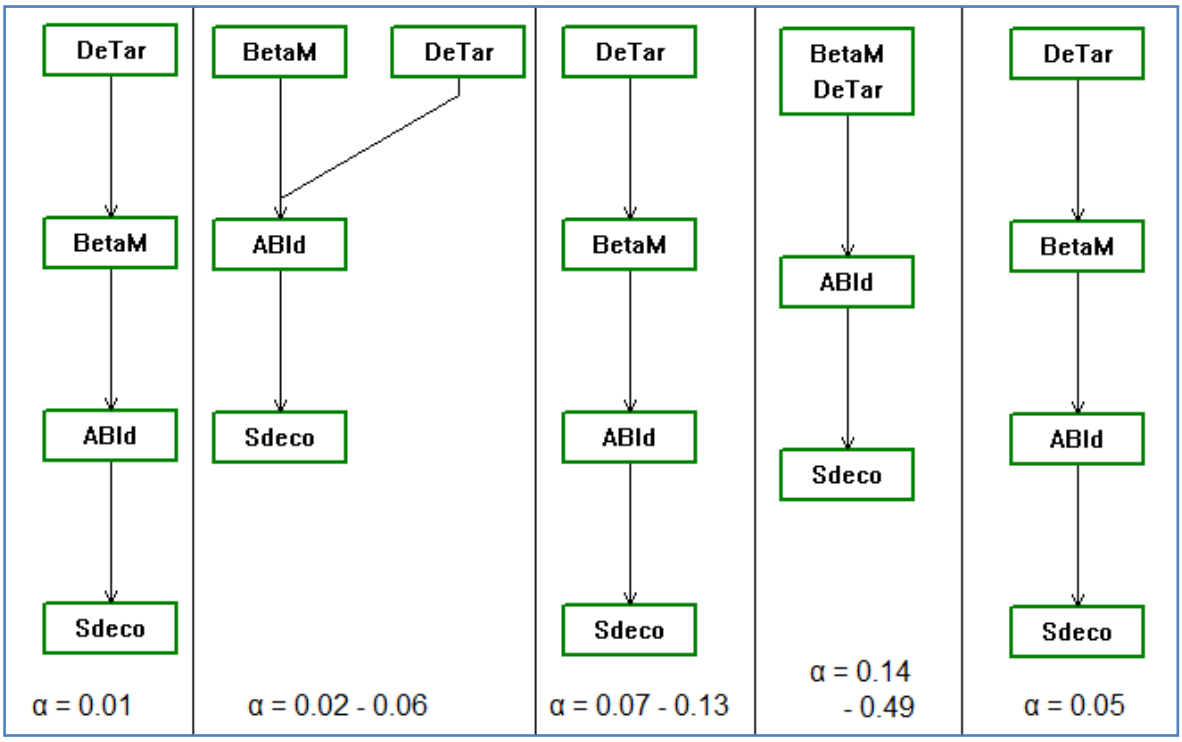

Figure 5.3: Ranking of Sub-Contractors - Third Response

5.3.4 Analysis of Forth Scenario

Figure 5.4 shows four graphs for the forth scenario, representing values / ranges for α; 0.01, 0.02 – 0.12, 0.13 – 0.49 and 0.50. This figure shows that the two sub-contractors BetaMisr and DeTarget can be equivalent in the top of the ranking.

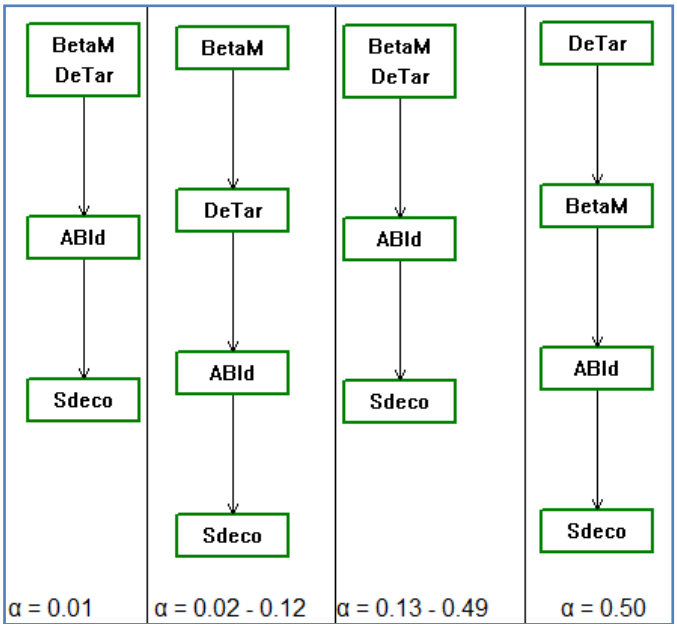

Figure 5.4: Ranking of Sub-Contractors - Fourth Response

5.4 User Interfaces of ELECTRE III Model

The Sub-contractors selection model was implemented in ELECTRE III software. Figure 5.5, there are four alternatives and twelve criteria that used in this technique. Figure 5.6 shows the criteria that are used in ELECTRE III technique along with their weights that have been obtained from the second questionnaire. Figure 5.7 shows the four alternatives that used in ELECTRE III technique. Figure 5.8 shows a table that lists the score of the alternatives in each considered criterion. Figure 5.9 shows a snapshot of the coefficient of the threshold difference and coefficient of the threshold preference for the criteria. Figure 5.10 to 5.13 depict concordance and degree of credibility matrices for the four scenarios. Wheras, Figures 5.14 to 5.17 depict descending and ascending for the four scenarios. The distillation figures show the ascending and descending ranking of the alternatives for the four respondents as the ascending distillation ranked the alternatives from the worst to the best. While the descending distillation ranked the alternatives from the best alternatives to the worst.

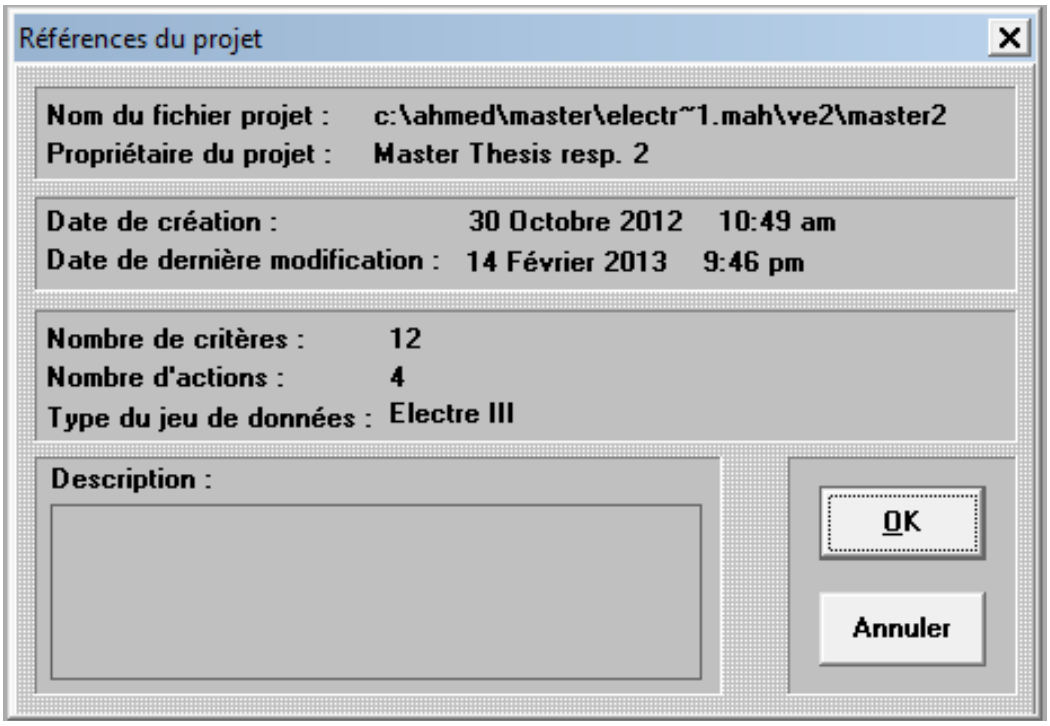

Figure 5.5: Project Information for the Case Study

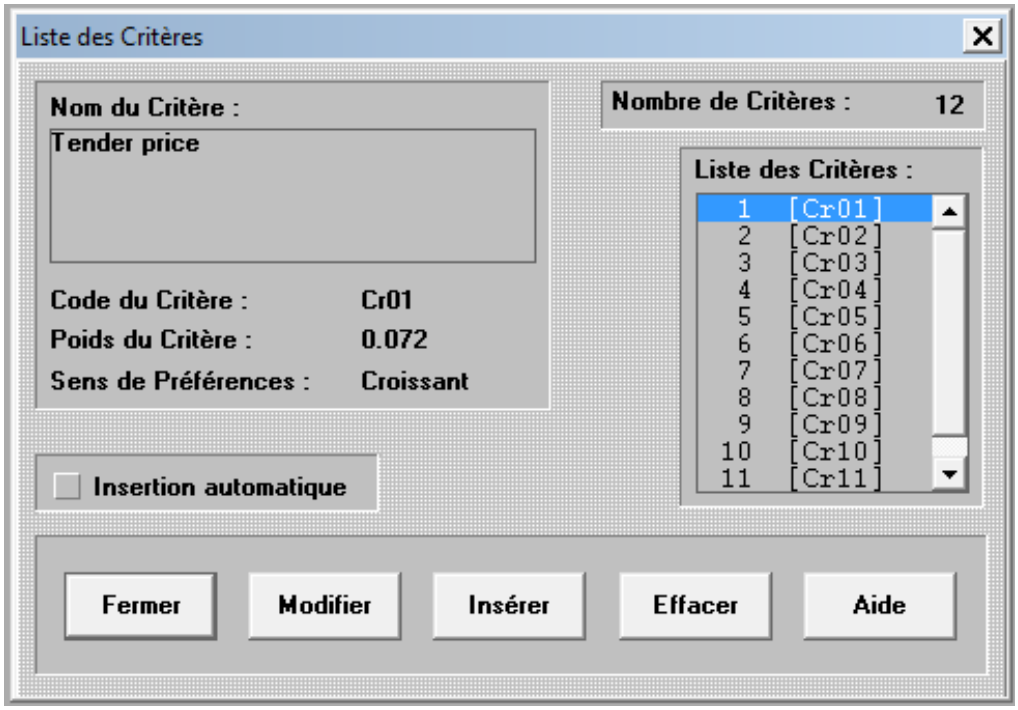

Figure 5.6: Define Case Study Criteria

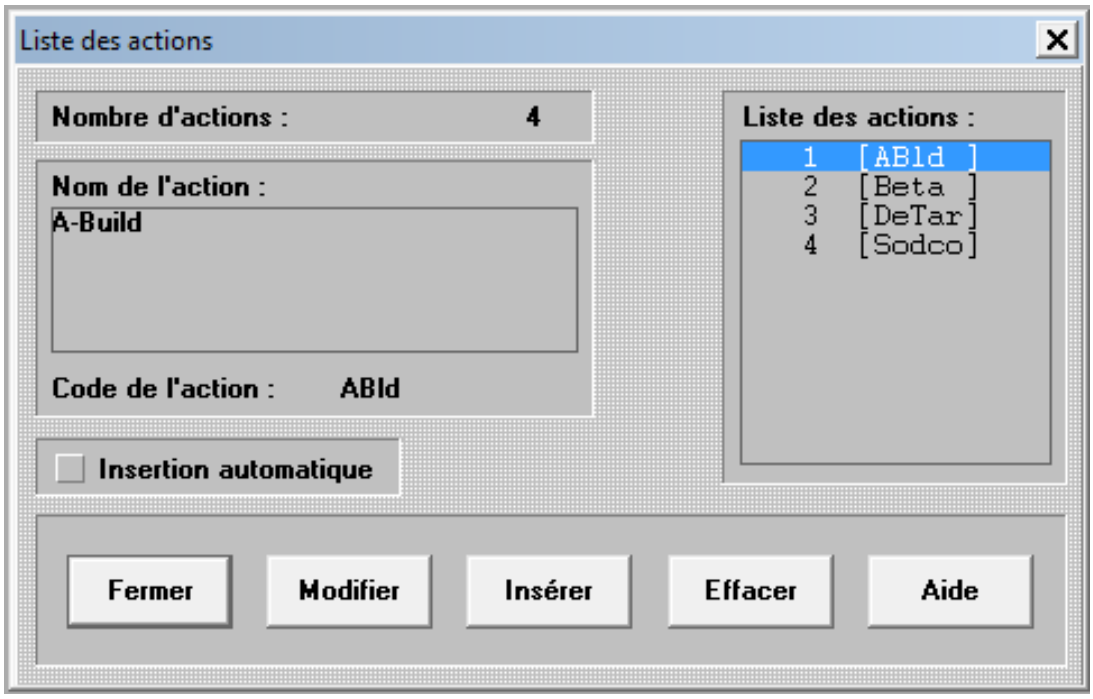

Figure 5.7: Define Case Study Alternatives

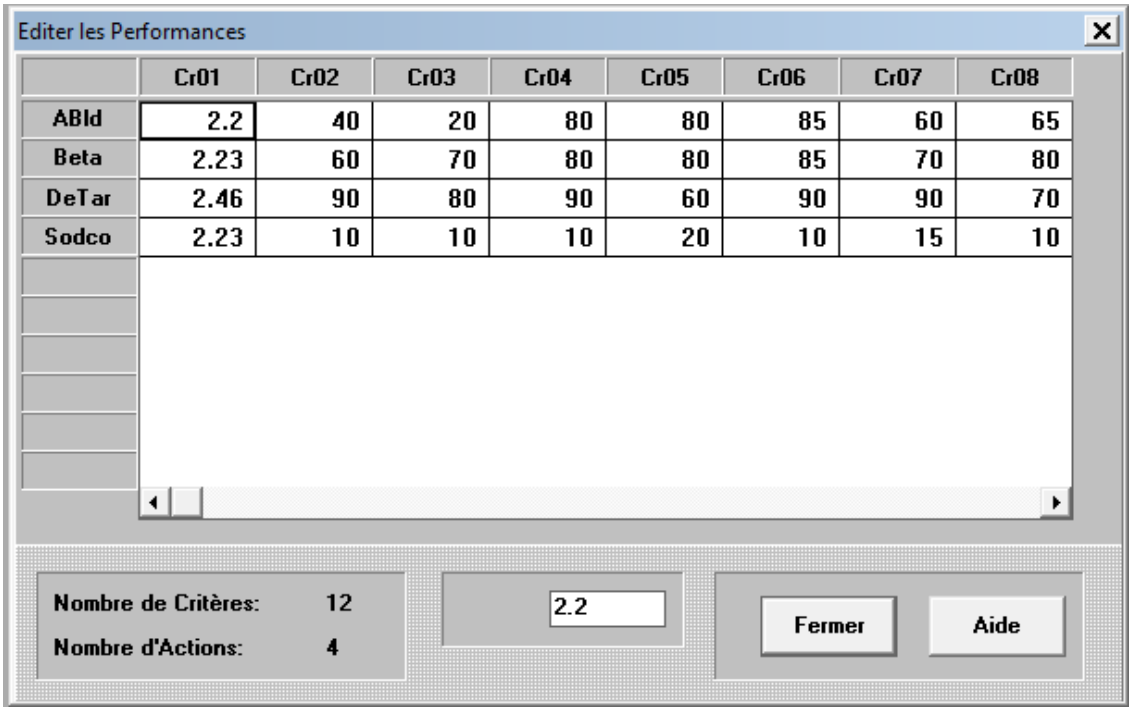

Figure 5.8: Alternatives Scores against Each Criterion

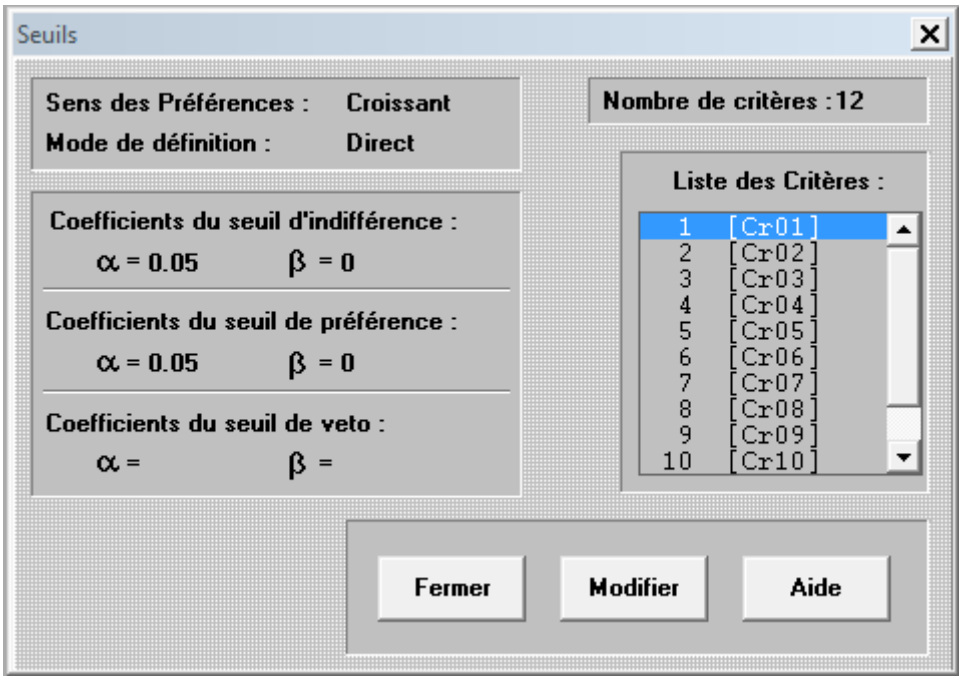

Figure 5.9: Difference and Preference Thresholds for the Criteria

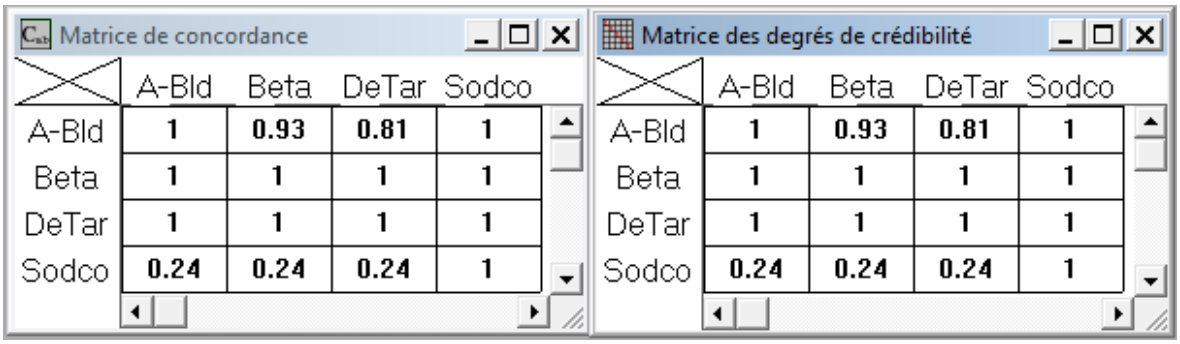

Figure 5.10: Concordance and Degree of the Credibility Matrices - First Response

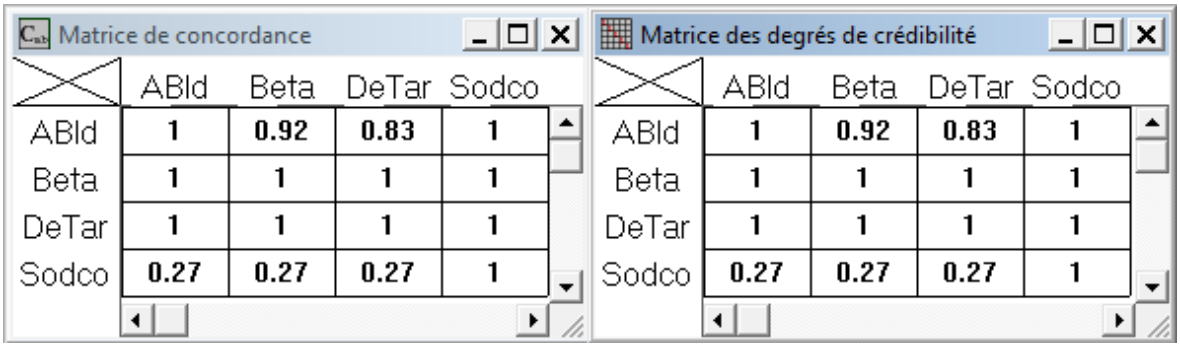

Figure 5.11: Concordance and Degree of the Credibility Matrices - Second Response

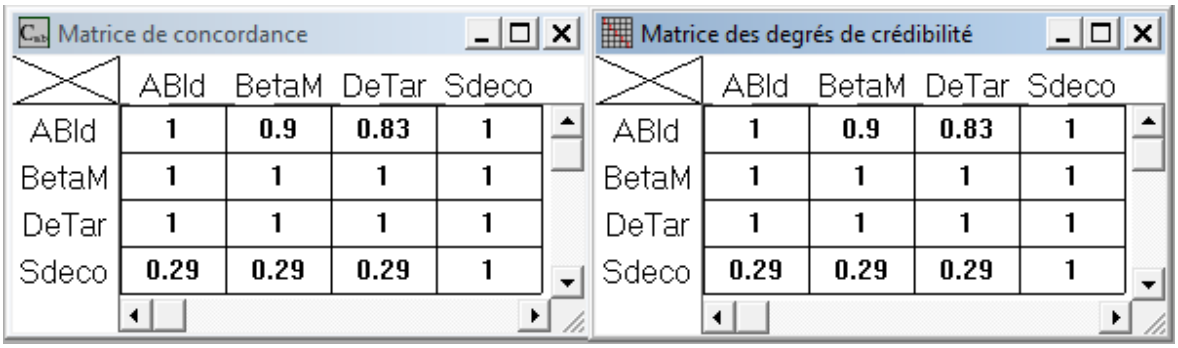

Figure 5.12: Concordance and Degree of the Credibility Matrices - Third Response

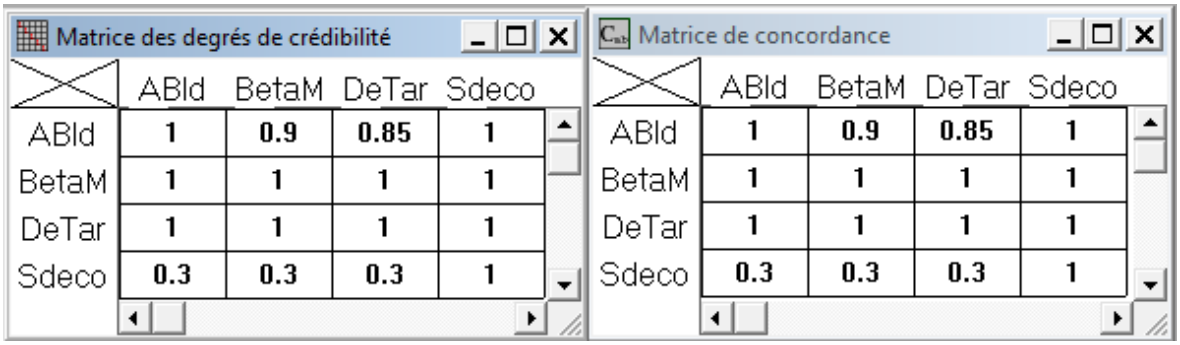

Figure 5.13: Concordance and Degree of the Credibility Matrices - Fourth Response

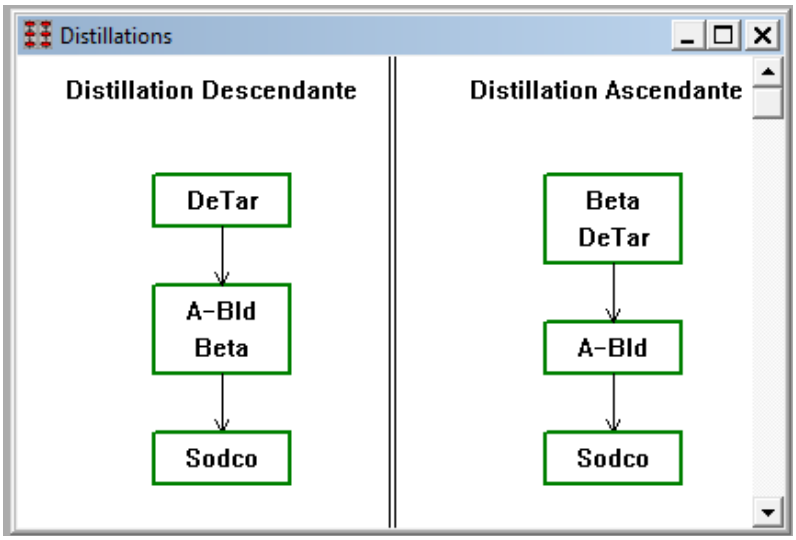

Figure 5.14: Descending and Ascending distillation - First Response

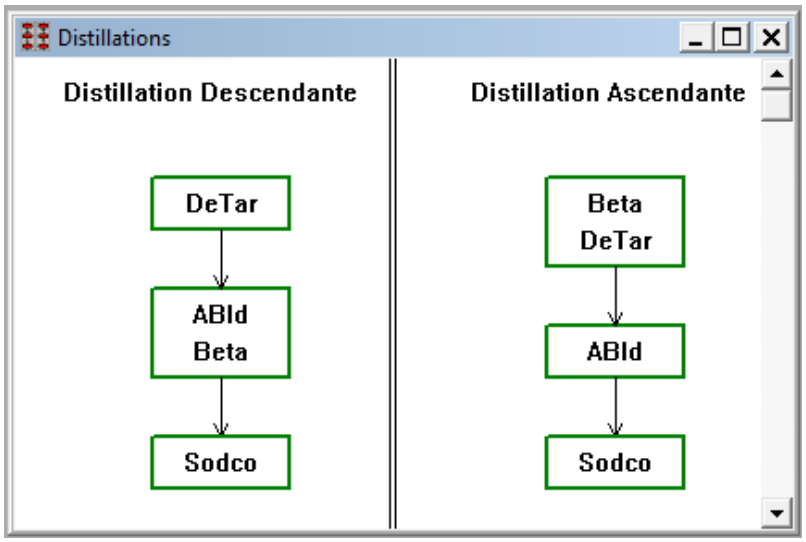

Figure 5.15: Descending and Ascending distillation - Second Response

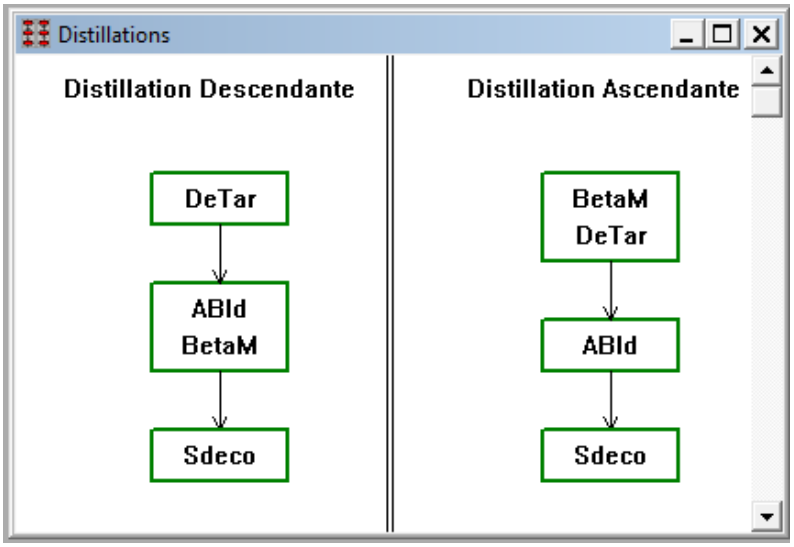

Figure 5.16: Descending and Ascending distillation - Third Response

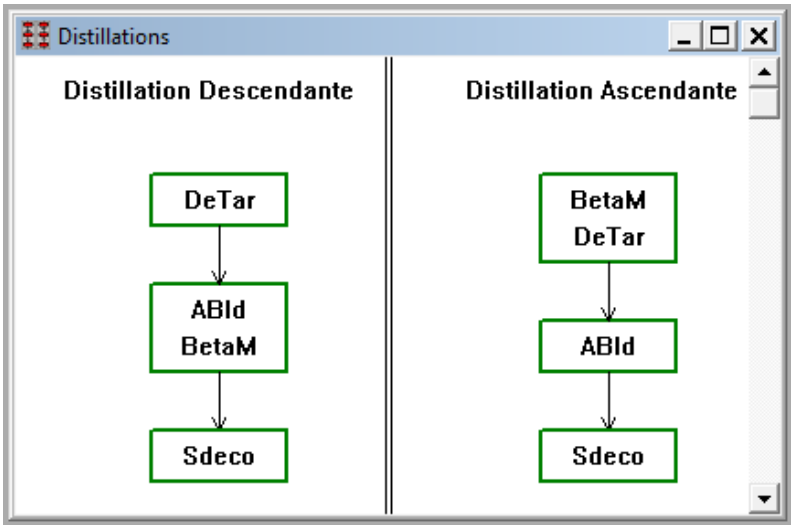

Figure 5.17: Descending and Ascending distillation - Fourth Response

5.5 Discussions of the Results

As shown from the results of credibility score, and the four scenarios the *tender price, sub-contractor's difficulty in reimbursement and failure to complete contract* factors are not the most important factors. There are a lot of factors that can make the cost increases during the project, negatively impact the work quality or cause delay in the duration of the project. So, it is crucial that the contractor puts into consideration other factors along with the cost factors; in order to minimize the conflict between the contractor and the sub-contractor or the contractor and the consultant.

The credibility score figures show that there are no differences between the matrix of concordance and the matrix of the degree of the credibility in each scenario; as veto is not used in the calculations and the factors are concordant with each other. In first and second scenarios BetaMisr and DeTarget are the best two alternatives. The four scenarios indicate that the best alternatives are; BetaMisr, and DeTarget. Despite manipulating the value α, the alternative Sodeco was ranked as the worst in the four scenarios.

5.6 Summary

This chapter presented a case study of four alternatives (sub-contractors) who applied for tender. Each of these alternatives has different values according to the considered twelve factors. Credibility score section shows that there is no difference between the matrix of concordance and the matrix of degree of the credibility since no veto is used and the factors are concordant. Four scenarios were considered in the case study for the four responses in the second survey; four scenarios the coefficient α is manipulated from 0.01 to 0.50, while monitoring the change in the ranking of the alternatives.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary and conclusions

Appropriate selection of sub-contractors in construction industry aids in achieving success for projects. Wrong selection of a sub-contractor can lead to many problems such as losing lives, delays in the project's deadlines leading to conflicts between the contractor and the sub-contractor. This leads to an increase in cost and poor quality of work and other problems that result from inaccurate selection. A common reason behind such problems is that some contractors still choose the sub-contractors merely based on the price factor. However, there are a lot of factors that should be taken into consideration while choosing the sub-contractor.

Forty six factors that affect the process of choosing sub-contractors were gathered from literature. Two questionnaire surveys were conducted. The first questionnaire was completed by twenty nine experts in the construction field. The purpose of the first questionnaire is to gather professional opinions about the identified forty six factors through requiring respondents to identify their importance in a scale that ranges from 1 (Least importance) to 5 (Most importance). The mean score of each factor was calculated. Factors that have a mean score greater than or equal to 4.00 were identified as most important factors.

Statistical analysis was performed by providing crosstabs, frequency, and the significant factors. The crosstab is a comparison between two factors of the most important factors. Then, the frequency was performed to determine the number of responses each factor got in each of the five scores. Finally, the significant and non-significant factors were determined based on the *p-value* and the mean scores. The factor that has a *p-value* less than 0.05 and mean score more than 3.00 is considered to be a significant factor.

Furthermore, the research introduced a case study of four sub-contractors who applied to a tender on an item – waterproofing – in a given project. Using the most important factors that were previously determined and their weight along with the value of each factor for each sub-contractor, ELECTRE III technique is used to determine the rank of the alternatives. From ELECTRE III, the credibility score – which determined from the output of ELECTRE III technique – was calculated based on two cases; first the score of the credibility is not equal to the concordance if there is a veto threshold used, second the score of the credibility is equal to the concordance if there is no veto threshold, or when

there is no factor discordant. The weights of the most important factors were determined from this survey. Four scenarios were considered in the case study. In each scenario, the coefficient of indifference and coefficient of preference were changed, which led to changing the ranking of the alternatives.

In conclusion, this research proposed a study of selecting the best sub-contractors taking into consideration many factors that influence the selection process rather than limiting them to the bid price only.

6.2 Recommendations for Future Research

The research can be extended in the future to address the following aspects:

1) Generalize the proposed methodology to other problems in construction such as procurement of equipment, consultants' selection, etc.
2) Set a rational or a procedure for determining the value of the identified factors (e.g., using utility theory) to capture the actual behavior of the factors that influence sub-contractors selections.

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APPENDICES

APPENDIX A
First Questionnaire Survey

Arab Academy for Science & Technology
Faculty of Engineering
Construction Engineering & Management Department

1)Master's Thesis Questionnaire

This questionnaire is designed to take no more than 10 minutes of your valuable time.

Dear Sir,

I am preparing my Master's thesis in the field of Construction Engineering & Management, specifically in the decision making in choosing the sub-contractors; highlighting the most and the least important criteria.

During my research, I have assembled 46 different criteria on which the decision making analysis will be based on. The criteria are divided into ten clusters; Cost, Quality, Staff's Behavior & Experiences, Safety, Insurance, Repair & Warranty for the Employees & Equipments, Disputes & risks, Time, Experience of the company, Tender, and Others. Later, these criteria are found to be too much complicated for the decision making process. The main purpose of this questionnaire is to specify the importance for the factors that belong to the above listed clusters.

The word "sub-contractor" you will find in the definitions -in the bottom- is referring to each sub-contractor who applied into the tender.

Thank you very much in advance for your kind assistance & precious time.

Ahmed A.Basset El Kherbawy

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1) PERSONAL INFORMATION

Profession: Owner/Consultant/Contractor/Project Manager /University Professor

Field of Experience: Years of Experience:

Position:

2) CONTACT INFORMATION (*Optional*)

Name: Mobile phone:

E-mail:

If you have any suggestions or comments, please feel free to contact me:
Mobile phone: +2 (010) 0655-088 E-mail: ahmed.nashaat83@hotmail.com

3) EVALUATION

Criteria	Code	Factors	The score of each factor				
			Low..Medium...High				
			1	2	3	4	5
Cost	CC1	Cost overruns					
	CC2	Flexibility in payment terms and conditions					
	CC3	Tender price					
	CC4	Sub-contractor's difficulty in reimbursement					
	CC5	Failure to complete contract					
	CC6	Financial stability					
	CC7	Financial references					
Quality	QC1	Quality					
	QC2	Sub-contractor's poor management ability					
	QC3	QA/QC programs					
Staff's behavior & there experiences	SC1	Energy saving materials and installations					
	SC2	Poor competency of laborers					
	SC3	Experience of technical personnel					
	SC4	Decorum, conduct and non-disruptiveness of the staff					
	SC5	Prevention of vandalism					
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity					
	SC7	Creativity and innovation					
	SC8	Labor force retention					
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites					
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities					
	SF3	Safety consciousness on the job site					
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs					
	IR2	Responsiveness to warranty issues					
	IR3	Not buying insurance for major equipment and employees					
Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					
	DR2	Disputes and arbitration					
	DR3	Failure to comply with the quality					

		specifications					
	DR4	Lack of readily available utilities on site					
	DR5	Risk avoidance					
Time	TC1	Flexibility and cooperation when resolving delays					
	TC2	Delay					
	TC3	Length of time in industry					
	TC4	Flexibility in critical activities					
	TC5	Flexibility in the noncritical activities					
Experience of the company	EC1	Reputation					
	EC2	Being familiar with the area or being domestic					
	EC3	Knowledge of construction regulations					
	EC4	Volume of work committed					
	EC5	Experience in local area					
	EC6	Scale of projects completed					
Tender	TD1	Tender quality					
	TD2	Willingness to tender					
Other	OC1	Site proximity					
	OC2	Ongoing work commitments					
	OC3	Physical resources					
	OC4	Relationships with the client					

APPENDIX B
Responses of the first Questionnaire

Response 1

Criteria	Code	Factors	The score of each factor (Q1)					The score of each factor (Q2)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns					5					5
	CC2	Flexibility in payment terms and conditions			3						4	
	CC3	Tender price			3						4	
	CC4	Sub-contractor's difficulty in reimbursement				4					4	
	CC5	Failure to complete contract			3						4	
	CC6	Financial stability	1									5
	CC7	Financial references		2					2			
Quality	QC1	Quality		2							4	
	QC2	Sub-contractor's poor management ability			3					3		
	QC3	QA/QC programs	1							3		
Staff's behavior & there experiences	SC1	Energy saving materials and installations	1						2			
	SC2	Poor competency of laborers			3					3		
	SC3	Experience of technical personnel		2							4	
	SC4	Decorum, conduct and non-disruptiveness of the staff			3					3		
	SC5	Prevention of vandalism			3					3		
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity			3					3		
	SC7	Creativity and innovation			3					3		
	SC8	Labor force retention			3					3		
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites	1						2			
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities		2					2			
	SF3	Safety consciousness on the job site					5			3		
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs					5				4	
	IR2	Responsiveness to warranty issues					5		2			
	IR3	Not buying insurance for major equipment and employees			3					3		

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time				4					4	
	DR2	Disputes and arbitration					5			3		
	DR3	Failure to comply with the quality specifications			3					3		
	DR4	Lack of readily available utilities on site			3				2			
	DR5	Risk avoidance					5			3		
Time	TC1	Flexibility and cooperation when resolving delays					5				4	
	TC2	Delay					5				4	
	TC3	Length of time in industry					5				4	
	TC4	Flexibility in critical activities					5			3		
	TC5	Flexibility in the noncritical activities					5			3		
Experience of the company	EC1	Reputation			3							5
	EC2	Being familiar with the area or being domestic			3						4	
	EC3	Knowledge of construction regulations					5				4	
	EC4	Volume of work committed				4					4	
	EC5	Experience in local area			3						4	
	EC6	Scale of projects completed					5					5
Tender	TD1	Tender quality		2								5
	TD2	Willingness to tender			3					3		
Other	OC1	Site proximity			3			1				
	OC2	Ongoing work commitments			3					3		
	OC3	Physical resources				4					4	
	OC4	Relationships with the client					5				4	

Response 2

Criteria	Code	Factors	The score of each factor (Q3)					The score of each factor (Q4)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns					5	1				
	CC2	Flexibility in payment terms and conditions				4						5
	CC3	Tender price				4					4	
	CC4	Sub-contractor's difficulty in reimbursement					5			3		
	CC5	Failure to complete contract					5	1				
	CC6	Financial stability					5				4	
	CC7	Financial references			3						4	
Quality	QC1	Quality					5				4	
	QC2	Sub-contractor's poor management ability				4		1				
	QC3	QA/QC programs				4				3		
Staff's behavior & there experiences	SC1	Energy saving materials and installations				4				3		
	SC2	Poor competency of laborers					5				4	
	SC3	Experience of technical personnel				4					4	
	SC4	Decorum, conduct and non-disruptiveness of the staff		2						3		
	SC5	Prevention of vandalism				4				3		
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity			3						4	
	SC7	Creativity and innovation				4					4	
	SC8	Labor force retention					5				4	
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites				4					4	
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities				4					4	
	SF3	Safety consciousness on the job site					5				4	
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs					5				4	
	IR2	Responsiveness to warranty issues	1								4	

	IR3	Not buying insurance for major equipment and employees			3						4	
Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					5					5
	DR2	Disputes and arbitration					5			3		
	DR3	Failure to comply with the quality specifications					5					5
	DR4	Lack of readily available utilities on site					5				4	
	DR5	Risk avoidance				4					4	
Time	TC1	Flexibility and cooperation when resolving delays					5				4	
	TC2	Delay				4		1				
	TC3	Length of time in industry					5				4	
	TC4	Flexibility in critical activities				4					4	
	TC5	Flexibility in the noncritical activities			3						4	
Experience of the company	EC1	Reputation					5				4	
	EC2	Being familiar with the area or being domestic				4					4	
	EC3	Knowledge of construction regulations				4					4	
	EC4	Volume of work committed				4					4	
	EC5	Experience in local area			3				2			
	EC6	Scale of projects completed				4			2			
Tender	TD1	Tender quality				4			2			
	TD2	Willingness to tender					5	1				
Other	OC1	Site proximity				4			2			
	OC2	Ongoing work commitments					5			3		
	OC3	Physical resources					5				4	
	OC4	Relationships with the client			3						4	

Response 3

Criteria	Code	Factors	The score of each factor (Q5)					The score of each factor (Q6)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns			3							5
	CC2	Flexibility in payment terms and conditions				4					4	
	CC3	Tender price				4						5
	CC4	Sub-contractor's difficulty in reimbursement				4						5
	CC5	Failure to complete contract					5					5
	CC6	Financial stability					5				4	
	CC7	Financial references				4					4	
Quality	QC1	Quality					5					5
	QC2	Sub-contractor's poor management ability					5					5
	QC3	QA/QC programs				4						5
Staff's behavior & there experiences	SC1	Energy saving materials and installations			3						4	
	SC2	Poor competency of laborers				4					4	
	SC3	Experience of technical personnel				4					4	
	SC4	Decorum, conduct and non-disruptiveness of the staff			3					3		
	SC5	Prevention of vandalism				4					4	
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity				4					4	
	SC7	Creativity and innovation			3						4	
	SC8	Labor force retention				4				3		
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites				4					4	
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities					5				4	
	SF3	Safety consciousness on the job site					5					5
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs			3							5
	IR2	Responsiveness to warranty issues				4						5
	IR3	Not buying insurance for major equipment and employees				4					4	

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					5					5
	DR2	Disputes and arbitration				4						5
	DR3	Failure to comply with the quality specifications					5					5
	DR4	Lack of readily available utilities on site					5					5
	DR5	Risk avoidance				4						5
Time	TC1	Flexibility and cooperation when resolving delays				4						5
	TC2	Delay				4						5
	TC3	Length of time in industry				4					4	
	TC4	Flexibility in critical activities				4						5
	TC5	Flexibility in the noncritical activities				4					4	
Experience of the company	EC1	Reputation					5					5
	EC2	Being familiar with the area or being domestic				4					4	
	EC3	Knowledge of construction regulations				4						5
	EC4	Volume of work committed				4						5
	EC5	Experience in local area				4					4	
	EC6	Scale of projects completed					5					5
Tender	TD1	Tender quality				4						5
	TD2	Willingness to tender					5				4	
Other	OC1	Site proximity				4				3		
	OC2	Ongoing work commitments					5				4	
	OC3	Physical resources				4						5
	OC4	Relationships with the client					5					5

Response 4

Criteria	Code	Factors	The score of each factor (Q7)					The score of each factor (Q8)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns				4						5
	CC2	Flexibility in payment terms and conditions					5				4	
	CC3	Tender price					5					5
	CC4	Sub-contractor's difficulty in reimbursement				4						5
	CC5	Failure to complete contract					5					5
	CC6	Financial stability					5				4	
	CC7	Financial references					5					5
Quality	QC1	Quality					5					5
	QC2	Sub-contractor's poor management ability					5					5
	QC3	QA/QC programs					5					5
Staff's behavior & there experiences	SC1	Energy saving materials and installations	1								4	
	SC2	Poor competency of laborers					5					5
	SC3	Experience of technical personnel					5				4	
	SC4	Decorum, conduct and non-disruptiveness of the staff				4					4	
	SC5	Prevention of vandalism				4						5
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity					5				4	
	SC7	Creativity and innovation			3						4	
	SC8	Labor force retention				4						5
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites			3						4	
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities				4					4	
	SF3	Safety consciousness on the job site					5					5
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs				4					4	
	IR2	Responsiveness to warranty issues				4					4	
	IR3	Not buying insurance for major equipment and employees				4					4	

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					5					5
	DR2	Disputes and arbitration				4					4	
	DR3	Failure to comply with the quality specifications				4						5
	DR4	Lack of readily available utilities on site			3							5
	DR5	Risk avoidance				4						5
Time	TC1	Flexibility and cooperation when resolving delays				4						5
	TC2	Delay					5				4	
	TC3	Length of time in industry			3						4	
	TC4	Flexibility in critical activities				4					4	
	TC5	Flexibility in the noncritical activities			3					3		
Experience of the company	EC1	Reputation					5					5
	EC2	Being familiar with the area or being domestic			3						4	
	EC3	Knowledge of construction regulations		2								5
	EC4	Volume of work committed		2							4	
	EC5	Experience in local area			3						4	
	EC6	Scale of projects completed		2							4	
Tender	TD1	Tender quality				3				3		
	TD2	Willingness to tender				3					4	
Other	OC1	Site proximity	1					1				
	OC2	Ongoing work commitments			3					3		
	OC3	Physical resources					5				4	
	OC4	Relationships with the client				4				3		

Response 5

Criteria	Code	Factors	The score of each factor (Q9)					The score of each factor (Q10)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns				4			2			
	CC2	Flexibility in payment terms and conditions			3						4	
	CC3	Tender price				4						5
	CC4	Sub-contractor's difficulty in reimbursement					5				4	
	CC5	Failure to complete contract					5					5
	CC6	Financial stability				4					4	
	CC7	Financial references			3			1				
Quality	QC1	Quality			3					3		
	QC2	Sub-contractor's poor management ability		2							4	
	QC3	QA/QC programs		2					2			
Staff's behavior & there experiences	SC1	Energy saving materials and installations	1						2			
	SC2	Poor competency of laborers				4			2			
	SC3	Experience of technical personnel				4					4	
	SC4	Decorum, conduct and non-disruptiveness of the staff			3					3		
	SC5	Prevention of vandalism				4					4	
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity				4					4	
	SC7	Creativity and innovation		2					2			
	SC8	Labor force retention			3			1				
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites		2					2			
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities		2					2			
	SF3	Safety consciousness on the job site			3							5
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs				4					4	
	IR2	Responsiveness to warranty issues				4				3		
	IR3	Not buying insurance for major equipment and employees				4				3		

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					5				4	
	DR2	Disputes and arbitration					5				4	
	DR3	Failure to comply with the quality specifications					5					5
	DR4	Lack of readily available utilities on site					5			3		
	DR5	Risk avoidance				4			2			
Time	TC1	Flexibility and cooperation when resolving delays				4						5
	TC2	Delay					5					5
	TC3	Length of time in industry		2							4	
	TC4	Flexibility in critical activities			3					3		
	TC5	Flexibility in the noncritical activities			3			1				
Experience of the company	EC1	Reputation			3							5
	EC2	Being familiar with the area or being domestic		2							4	
	EC3	Knowledge of construction regulations				4				3		
	EC4	Volume of work committed				4				3		
	EC5	Experience in local area			3						4	
	EC6	Scale of projects completed				4					4	
Tender	TD1	Tender quality				4				3		
	TD2	Willingness to tender				4		1				
Other	OC1	Site proximity			3					3		
	OC2	Ongoing work commitments				4					4	
	OC3	Physical resources				4					4	
	OC4	Relationships with the client				4				3		

Response 6

Criteria	Code	Factors	The score of each factor (Q11)					The score of each factor (Q12)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns			3							5
	CC2	Flexibility in payment terms and conditions					5			3		
	CC3	Tender price					5			3		
	CC4	Sub-contractor's difficulty in reimbursement					5				4	
	CC5	Failure to complete contract					5				4	
	CC6	Financial stability				4				3		
	CC7	Financial references			3				2			
Quality	QC1	Quality				4						5
	QC2	Sub-contractor's poor management ability					5					5
	QC3	QA/QC programs					5				4	
Staff's behavior & there experiences	SC1	Energy saving materials and installations			3					3		
	SC2	Poor competency of laborers				4						5
	SC3	Experience of technical personnel				4					4	
	SC4	Decorum, conduct and non-disruptiveness of the staff			3					3		
	SC5	Prevention of vandalism					5					5
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity					5			3		
	SC7	Creativity and innovation			3				2			
	SC8	Labor force retention				4			2			
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites			3						4	
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities				4					4	
	SF3	Safety consciousness on the job site					5					5
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs			3					3		
	IR2	Responsiveness to warranty issues		2						3		
	IR3	Not buying insurance for major equipment and employees					5				4	

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					5					5
	DR2	Disputes and arbitration					5					5
	DR3	Failure to comply with the quality specifications					5					5
	DR4	Lack of readily available utilities on site				4				3		
	DR5	Risk avoidance				4					4	
Time	TC1	Flexibility and cooperation when resolving delays					5					5
	TC2	Delay				4					4	
	TC3	Length of time in industry			3					3		
	TC4	Flexibility in critical activities			3						4	
	TC5	Flexibility in the noncritical activities	1						2			
Experience of the company	EC1	Reputation					5				4	
	EC2	Being familiar with the area or being domestic			3							5
	EC3	Knowledge of construction regulations					5			3		
	EC4	Volume of work committed			3				2			
	EC5	Experience in local area			3						4	
	EC6	Scale of projects completed				4		1				
Tender	TD1	Tender quality					5			4		
	TD2	Willingness to tender				4				4		
Other	OC1	Site proximity				4				4		
	OC2	Ongoing work commitments					5		3			
	OC3	Physical resources			3						4	
	OC4	Relationships with the client					5			3		

Response 7

Criteria	Code	Factors	The score of each factor (Q13)					The score of each factor (Q14)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns					5					5
	CC2	Flexibility in payment terms and conditions			3							5
	CC3	Tender price					5					5
	CC4	Sub-contractor's difficulty in reimbursement					5					5
	CC5	Failure to complete contract					5					5
	CC6	Financial stability				4				3		
	CC7	Financial references			3				2			
Quality	QC1	Quality				4					4	
	QC2	Sub-contractor's poor management ability				4					4	
	QC3	QA/QC programs			3					3		
Staff's behavior & there experiences	SC1	Energy saving materials and installations		2						3		
	SC2	Poor competency of laborers			3					3		
	SC3	Experience of technical personnel				4				3		
	SC4	Decorum, conduct and non-disruptiveness of the staff			3					3		
	SC5	Prevention of vandalism			3						4	
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity			3				2			
	SC7	Creativity and innovation			3					3		
	SC8	Labor force retention			3			1				
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites			3			1				
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities			3			1				
	SF3	Safety consciousness on the job site				4			2			
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs		2					2			
	IR2	Responsiveness to warranty issues			3				2			
	IR3	Not buying insurance for major equipment and employees				4			2			

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time				4						5
	DR2	Disputes and arbitration				4				3		
	DR3	Failure to comply with the quality specifications				4					4	
	DR4	Lack of readily available utilities on site				4					4	
	DR5	Risk avoidance			3							5
Time	TC1	Flexibility and cooperation when resolving delays			3							5
	TC2	Delay				4						5
	TC3	Length of time in industry			3							5
	TC4	Flexibility in critical activities			3							5
	TC5	Flexibility in the noncritical activities		2				1				
Experience of the company	EC1	Reputation				4						5
	EC2	Being familiar with the area or being domestic			3							5
	EC3	Knowledge of construction regulations			3					3		
	EC4	Volume of work committed			3					3		
	EC5	Experience in local area			3					3		
	EC6	Scale of projects completed				4				3		
Tender	TD1	Tender quality			3					3		
	TD2	Willingness to tender			3						4	
Other	OC1	Site proximity		2								5
	OC2	Ongoing work commitments				4						5
	OC3	Physical resources				4						5
	OC4	Relationships with the client			3							5

Response 8

Criteria	Code	Factors	The score of each factor (Q15)					The score of each factor (Q16)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns					5	1				
	CC2	Flexibility in payment terms and conditions				4				3		
	CC3	Tender price					5				4	
	CC4	Sub-contractor's difficulty in reimbursement			3			1				
	CC5	Failure to complete contract					5	1				
	CC6	Financial stability				4		1				
	CC7	Financial references	1							3		
Quality	QC1	Quality					5				4	
	QC2	Sub-contractor's poor management ability					5	1				
	QC3	QA/QC programs					5				4	
Staff's behavior & there experiences	SC1	Energy saving materials and installations	1					1				
	SC2	Poor competency of laborers				4				3		
	SC3	Experience of technical personnel			3						4	
	SC4	Decorum, conduct and non-disruptiveness of the staff					5			3		
	SC5	Prevention of vandalism					5			3		
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity					5	1				
	SC7	Creativity and innovation					5				4	
	SC8	Labor force retention					5			3		
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites					5	1				
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities	1							3		
	SF3	Safety consciousness on the job site		2							4	
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs			3					3		
	IR2	Responsiveness to warranty issues	1					1				
	IR3	Not buying insurance for major equipment and employees	1							3		

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					5	1				
	DR2	Disputes and arbitration					5	1				
	DR3	Failure to comply with the quality specifications					5	1				
	DR4	Lack of readily available utilities on site			3				2			
	DR5	Risk avoidance					5			3		
Time	TC1	Flexibility and cooperation when resolving delays					5				4	
	TC2	Delay					5			3		
	TC3	Length of time in industry			3						4	
	TC4	Flexibility in critical activities					5				4	
	TC5	Flexibility in the noncritical activities					5				4	
Experience of the company	EC1	Reputation					5				4	
	EC2	Being familiar with the area or being domestic					5					5
	EC3	Knowledge of construction regulations					5				4	
	EC4	Volume of work committed			3						4	
	EC5	Experience in local area				4						5
	EC6	Scale of projects completed			3						4	
Tender	TD1	Tender quality					5				4	
	TD2	Willingness to tender					5					5
Other	OC1	Site proximity			3			1				
	OC2	Ongoing work commitments			3					3		
	OC3	Physical resources					5				4	
	OC4	Relationships with the client					5				4	

Response 9

Criteria	Code	Factors	The score of each factor (Q17)					The score of each factor (Q18)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns				4				3		
	CC2	Flexibility in payment terms and conditions				4				3		
	CC3	Tender price					5				4	
	CC4	Sub-contractor's difficulty in reimbursement			3						4	
	CC5	Failure to complete contract				4						5
	CC6	Financial stability			3						4	
	CC7	Financial references	1								4	
Quality	QC1	Quality				4					4	
	QC2	Sub-contractor's poor management ability			3					3		
	QC3	QA/QC programs			3					3		
Staff's behavior & there experiences	SC1	Energy saving materials and installations	1							3		
	SC2	Poor competency of laborers		2							4	
	SC3	Experience of technical personnel		2							4	
	SC4	Decorum, conduct and non-disruptiveness of the staff	1								4	
	SC5	Prevention of vandalism	1								4	
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity		2							4	
	SC7	Creativity and innovation		2							4	
	SC8	Labor force retention	1								4	
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites		2						3		
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities	1								4	
	SF3	Safety consciousness on the job site				4						5
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs			3						4	
	IR2	Responsiveness to warranty issues			3					3		
	IR3	Not buying insurance for major equipment and employees				4				3		

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time				4					4	
	DR2	Disputes and arbitration			3						4	
	DR3	Failure to comply with the quality specifications				4						5
	DR4	Lack of readily available utilities on site		2						3		
	DR5	Risk avoidance	1							3		
Time	TC1	Flexibility and cooperation when resolving delays			3						4	
	TC2	Delay			3						4	
	TC3	Length of time in industry		2							4	
	TC4	Flexibility in critical activities		2							4	
	TC5	Flexibility in the noncritical activities	1						2			
Experience of the company	EC1	Reputation			3							5
	EC2	Being familiar with the area or being domestic		2								5
	EC3	Knowledge of construction regulations		2							4	
	EC4	Volume of work committed				4					4	
	EC5	Experience in local area			3						4	
	EC6	Scale of projects completed			3						4	
Tender	TD1	Tender quality	1							3		
	TD2	Willingness to tender	1							3		
Other	OC1	Site proximity	1								4	
	OC2	Ongoing work commitments		2							4	
	OC3	Physical resources				4					4	
	OC4	Relationships with the client	1							3		

Response 10

Criteria	Code	Factors	The score of each factor (Q19)					The score of each factor (Q20)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns			3							5
	CC2	Flexibility in payment terms and conditions					5					5
	CC3	Tender price					5				4	
	CC4	Sub-contractor's difficulty in reimbursement					5					5
	CC5	Failure to complete contract					5					5
	CC6	Financial stability					5					5
	CC7	Financial references				4						5
Quality	QC1	Quality					5					5
	QC2	Sub-contractor's poor management ability				4					4	
	QC3	QA/QC programs			3							5
Staff's behavior & there experiences	SC1	Energy saving materials and installations			3					3		
	SC2	Poor competency of laborers				4					4	
	SC3	Experience of technical personnel				4						5
	SC4	Decorum, conduct and non-disruptiveness of the staff			3							5
	SC5	Prevention of vandalism				4						5
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity			3						4	
	SC7	Creativity and innovation			3							5
	SC8	Labor force retention			3							5
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites				4					4	
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities				4						5
	SF3	Safety consciousness on the job site				4						5
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs			3							5
	IR2	Responsiveness to warranty issues				4					4	
	IR3	Not buying insurance for major equipment and employees			3							5

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					5					5
	DR2	Disputes and arbitration				4					4	
	DR3	Failure to comply with the quality specifications					5					5
	DR4	Lack of readily available utilities on site				4						5
	DR5	Risk avoidance				4						5
Time	TC1	Flexibility and cooperation when resolving delays					5					5
	TC2	Delay					5					5
	TC3	Length of time in industry				4						5
	TC4	Flexibility in critical activities				4						5
	TC5	Flexibility in the noncritical activities			3							5
Experience of the company	EC1	Reputation				4						5
	EC2	Being familiar with the area or being domestic				4					4	
	EC3	Knowledge of construction regulations				4						5
	EC4	Volume of work committed				4					4	
	EC5	Experience in local area			3						4	
	EC6	Scale of projects completed				4						5
Tender	TD1	Tender quality			3							5
	TD2	Willingness to tender			3							5
Other	OC1	Site proximity		2							4	
	OC2	Ongoing work commitments			3						4	
	OC3	Physical resources			3							5
	OC4	Relationships with the client			3							5

Response 11

Criteria	Code	Factors	The score of each factor (Q21)					The score of each factor (Q22)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns				4						5
	CC2	Flexibility in payment terms and conditions			3						4	
	CC3	Tender price					5					5
	CC4	Sub-contractor's difficulty in reimbursement					5					5
	CC5	Failure to complete contract					5					5
	CC6	Financial stability					5				4	
	CC7	Financial references			3							5
Quality	QC1	Quality				4						5
	QC2	Sub-contractor's poor management ability			3				2			
	QC3	QA/QC programs					5					5
Staff's behavior & there experiences	SC1	Energy saving materials and installations				4					4	
	SC2	Poor competency of laborers				4						5
	SC3	Experience of technical personnel					5					5
	SC4	Decorum, conduct and non-disruptiveness of the staff					5				4	
	SC5	Prevention of vandalism				4						5
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity					5				4	
	SC7	Creativity and innovation					5					5
	SC8	Labor force retention				4			2			
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites				4						5
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities			3						4	
	SF3	Safety consciousness on the job site			3					3		
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs			3						4	
	IR2	Responsiveness to warranty issues					5					5
	IR3	Not buying insurance for major equipment and employees					5	1				

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					5				4	
	DR2	Disputes and arbitration				4						5
	DR3	Failure to comply with the quality specifications					5					5
	DR4	Lack of readily available utilities on site			3					3		
	DR5	Risk avoidance					5					5
Time	TC1	Flexibility and cooperation when resolving delays				4						5
	TC2	Delay					5					5
	TC3	Length of time in industry				4						5
	TC4	Flexibility in critical activities					5					5
	TC5	Flexibility in the noncritical activities					5		2			
Experience of the company	EC1	Reputation					5					5
	EC2	Being familiar with the area or being domestic					5					5
	EC3	Knowledge of construction regulations				4						5
	EC4	Volume of work committed			3							5
	EC5	Experience in local area					5					5
	EC6	Scale of projects completed					5					5
Tender	TD1	Tender quality					5					5
	TD2	Willingness to tender					5					5
Other	OC1	Site proximity				4						5
	OC2	Ongoing work commitments				4						5
	OC3	Physical resources					5					5
	OC4	Relationships with the client				4						5

Response 12

Criteria	Code	Factors	The score of each factor (Q23)					The score of each factor (Q24)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns				4						5
	CC2	Flexibility in payment terms and conditions					5					5
	CC3	Tender price			3						4	
	CC4	Sub-contractor's difficulty in reimbursement					5				4	
	CC5	Failure to complete contract				4						5
	CC6	Financial stability			3							5
	CC7	Financial references			3						4	
Quality	QC1	Quality				4						5
	QC2	Sub-contractor's poor management ability				4						5
	QC3	QA/QC programs			3						4	
Staff's behavior & there experiences	SC1	Energy saving materials and installations			3						4	
	SC2	Poor competency of laborers			3						4	
	SC3	Experience of technical personnel				4						5
	SC4	Decorum, conduct and non-disruptiveness of the staff				4				3		
	SC5	Prevention of vandalism			3							5
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity			3						4	
	SC7	Creativity and innovation				4				3		
	SC8	Labor force retention			3						4	
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites			3							5
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities			3						4	
	SF3	Safety consciousness on the job site				4					4	
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs				4					4	
	IR2	Responsiveness to warranty issues				4					4	
	IR3	Not buying insurance for major equipment and employees				4				3		

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					5			3		
	DR2	Disputes and arbitration					5					5
	DR3	Failure to comply with the quality specifications					5					5
	DR4	Lack of readily available utilities on site				4					4	
	DR5	Risk avoidance				4					4	
Time	TC1	Flexibility and cooperation when resolving delays				4					4	
	TC2	Delay					5					5
	TC3	Length of time in industry					5				4	
	TC4	Flexibility in critical activities				4					4	
	TC5	Flexibility in the noncritical activities			3						4	
Experience of the company	EC1	Reputation			3						4	
	EC2	Being familiar with the area or being domestic				4					4	
	EC3	Knowledge of construction regulations					5				4	
	EC4	Volume of work committed				4						5
	EC5	Experience in local area					5				4	
	EC6	Scale of projects completed				4					4	
Tender	TD1	Tender quality			3						4	
	TD2	Willingness to tender				4					4	
Other	OC1	Site proximity			3					3		
	OC2	Ongoing work commitments			3					3		
	OC3	Physical resources			3							5
	OC4	Relationships with the client				4			2			

Response 13

Criteria	Code	Factors	The score of each factor (Q25)					The score of each factor (Q26)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns				4				3		
	CC2	Flexibility in payment terms and conditions		2					2			
	CC3	Tender price				4		1				
	CC4	Sub-contractor's difficulty in reimbursement		2						3		
	CC5	Failure to complete contract				4					4	
	CC6	Financial stability			3						4	
	CC7	Financial references	1							3		
Quality	QC1	Quality				4						5
	QC2	Sub-contractor's poor management ability					5				4	
	QC3	QA/QC programs			3				2			
Staff's behavior & there experiences	SC1	Energy saving materials and installations			3						4	
	SC2	Poor competency of laborers					5			3		
	SC3	Experience of technical personnel				4					4	
	SC4	Decorum, conduct and non-disruptiveness of the staff				4					4	
	SC5	Prevention of vandalism				4					4	
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity			3						4	
	SC7	Creativity and innovation			3					3		
	SC8	Labor force retention				4				3		
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites			3					3		
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities				4			2			
	SF3	Safety consciousness on the job site			3				2			
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs				4				3		
	IR2	Responsiveness to warranty issues		2					2			
	IR3	Not buying insurance for major equipment and employees		2					2			

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					5			3		
	DR2	Disputes and arbitration				4				3		
	DR3	Failure to comply with the quality specifications				4					4	
	DR4	Lack of readily available utilities on site		2					2			
	DR5	Risk avoidance				4				3		
Time	TC1	Flexibility and cooperation when resolving delays					5			3		
	TC2	Delay				4					4	
	TC3	Length of time in industry			3						4	
	TC4	Flexibility in critical activities					5			3		
	TC5	Flexibility in the noncritical activities			3				2			
Experience of the company	EC1	Reputation				4					4	
	EC2	Being familiar with the area or being domestic			3						4	
	EC3	Knowledge of construction regulations				4			2			
	EC4	Volume of work committed			3						4	
	EC5	Experience in local area				4					4	
	EC6	Scale of projects completed				4					4	
Tender	TD1	Tender quality			3					3		
	TD2	Willingness to tender				4			2			
Other	OC1	Site proximity			3				2			
	OC2	Ongoing work commitments				4			2			
	OC3	Physical resources				4					4	
	OC4	Relationships with the client				4				3		

Response 14

Criteria	Code	Factors	The score of each factor (Q27)					The score of each factor (Q28)				
			Low..Medium...High					Low..Medium...High				
			1	2	3	4	5	1	2	3	4	5
Cost	CC1	Cost overruns	1						2			
	CC2	Flexibility in payment terms and conditions				4				3		
	CC3	Tender price		2							4	
	CC4	Sub-contractor's difficulty in reimbursement			3					3		
	CC5	Failure to complete contract				4		1				
	CC6	Financial stability			3				2			
	CC7	Financial references		2						3		
Quality	QC1	Quality					5				4	
	QC2	Sub-contractor's poor management ability					5			3		
	QC3	QA/QC programs				4		1				
Staff's behavior & there experiences	SC1	Energy saving materials and installations				4		1				
	SC2	Poor competency of laborers					5			3		
	SC3	Experience of technical personnel					5				4	
	SC4	Decorum, conduct and non-disruptiveness of the staff					5			3		
	SC5	Prevention of vandalism					5	1				
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity				4				3		
	SC7	Creativity and innovation				4					4	
	SC8	Labor force retention					5			3		
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites					5			3		
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities					5			3		
	SF3	Safety consciousness on the job site					5			3		
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs			3					3		
	IR2	Responsiveness to warranty issues			3					3		
	IR3	Not buying insurance for major equipment and employees	1							3		

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time					5		2			
	DR2	Disputes and arbitration					5		2			
	DR3	Failure to comply with the quality specifications					5		2			
	DR4	Lack of readily available utilities on site		2				1				
	DR5	Risk avoidance					5	1				
Time	TC1	Flexibility and cooperation when resolving delays					5			3		
	TC2	Delay					5				4	
	TC3	Length of time in industry			3						4	
	TC4	Flexibility in critical activities					5			3		
	TC5	Flexibility in the noncritical activities					5				4	
Experience of the company	EC1	Reputation					5				4	
	EC2	Being familiar with the area or being domestic			3					3		
	EC3	Knowledge of construction regulations					5			3		
	EC4	Volume of work committed				4		1				
	EC5	Experience in local area				4					4	
	EC6	Scale of projects completed			3					3		
Tender	TD1	Tender quality					5		2			
	TD2	Willingness to tender					5			3		
Other	OC1	Site proximity			3			1				
	OC2	Ongoing work commitments	1						2			
	OC3	Physical resources					5				4	
	OC4	Relationships with the client					5			3		

Response 15

Criteria	Code	Factors	The score of each factor (Q29)				
			Low..Medium...High				
			1	2	3	4	5
Cost	CC1	Cost overruns					5
	CC2	Flexibility in payment terms and conditions					5
	CC3	Tender price					5
	CC4	Sub-contractor's difficulty in reimbursement				4	
	CC5	Failure to complete contract					5
	CC6	Financial stability					5
	CC7	Financial references					5
Quality	QC1	Quality				4	
	QC2	Sub-contractor's poor management ability				4	
	QC3	QA/QC programs			3		
Staff's behavior & there experiences	SC1	Energy saving materials and installations			3		
	SC2	Poor competency of laborers			3		
	SC3	Experience of technical personnel			3		
	SC4	Decorum, conduct and non-disruptiveness of the staff			3		
	SC5	Prevention of vandalism			3		
	SC6	Cooperation with the other sub-contractors on the project and in the vicinity			3		
	SC7	Creativity and innovation			3		
	SC8	Labor force retention			3		
Safety	SF1	Jobsite cleanliness during projects and upon leaving jobsites				4	
	SF2	Prosecution due to unlawful disposal of construction waste, serious air and water pollution due to construction activities				4	
	SF3	Safety consciousness on the job site				4	
Insurance, repair & warranty for the employees & equipments	IR1	Onsite plant maintenance and repair programs			3		
	IR2	Responsiveness to warranty issues			3		
	IR3	Not buying insurance for major equipment and employees			3		

Disputes & risks	DR1	Suppliers incompetency to deliver materials on time		2			
	DR2	Disputes and arbitration		2			
	DR3	Failure to comply with the quality specifications		2			
	DR4	Lack of readily available utilities on site		2			
	DR5	Risk avoidance		2			
Time	TC1	Flexibility and cooperation when resolving delays					5
	TC2	Delay					5
	TC3	Length of time in industry					5
	TC4	Flexibility in critical activities					5
	TC5	Flexibility in the noncritical activities					5
Experience of the company	EC1	Reputation				4	
	EC2	Being familiar with the area or being domestic				4	
	EC3	Knowledge of construction regulations				4	
	EC4	Volume of work committed				4	
	EC5	Experience in local area				4	
	EC6	Scale of projects completed				4	
Tender	TD1	Tender quality				4	
	TD2	Willingness to tender				4	
Other	OC1	Site proximity			3		
	OC2	Ongoing work commitments					5
	OC3	Physical resources			3		
	OC4	Relationships with the client					5

APPENDIX C
Second Questionnaire Survey

1) Sample of the second questionnaire form

Cost Criteria	Tender price	Contractor's difficulty in reimbursement	Failure to complete contract
Tender price	1.00		
Contractor's difficulty in reimbursement		1.00	
Failure to complete contract			1.00