CHAPTER 1

INTRODUCTION

1.1 Overview

The construction industry in Egypt is dominated by a competitive business environment that being driven by a lowest cost mentality. Bids are generally awarded on the basis of the lowest bid that meets the stated specification. Despite its importance, the cost estimate processes very noisy due to many unpredictable factors affecting on cost estimate during tender stage.

The purpose of construction cost estimate is to give a reasonably accurate idea of the cost. The estimated cost of a work is a close approximation of its actual cost. The agreement of the estimated cost with the actual cost will depend on accurate use of estimating methods and correct visualization of the work, as it will be done. An important part of cost estimation is the analysis process of cost elements.

Many cost estimate forecasting techniques have been exploited in the construction industry. A major limitation of most of these models is that they only take account of significant factors that can be readily quantified. However most of the significant factors affecting cost estimate are qualitative such as; client priority on construction time, contractor's planning capability, procurement methods and market conditions including level of construction activity. Due to the qualitative nature of these factors, they are difficult to structure and quantify. Despite their importance, most of these factors are often ignored by current forecasting techniques. Only techniques which include a risk assessment element may consider some qualitative factors.

1.2 Problem Statement

Cost estimate during the tender stage is crucial in the construction industry and of great significance for any construction company. Little attention is given to the variables that might affect cost estimate in the Egyptian construction market. Consequently, it was found important to design the current study aiming to investigate and highlight those variables as assessed by a sample of cost estimators working in different categories of Egyptian construction companies.

1.3 The Objectives

The objectives of this study can be summarized as follows:

1. Investigate and identify the variables that affect the cost estimate during tender stage.
2. Evaluate and rank the identified factors.
3. Finding the most sensitive factors that affect the construction cost estimate.

1.4 Borders of the Study

The current study is applicable only during **tender stage** from point of view of **contractors** cost estimator for **residential and building** projects delivered through traditional method **DBD** (**D**esign **B**id and **B**uild) by **public** or **private** contractors in **Egypt**.

1.5 Thesis Methodology

To achieve the study objectives, the following steps are being proposed:

1. Review the literature to study previous researchers` related work and collect the variables that might affect the cost estimate during tender stage.
2. Conduct unstructured interviews with cost estimator's experts to discuss these variables, choose or mix, and determine the final factors that will be used in the questionnaire of the study, ensuring its suitability for the Egyptian construction market.
3. Conducting questionnaire survey among three different groups of contractor which are; Large, medium and small size contractors.
4. Analyze questionnaire results to identify and rank the significant factors for each contractors group.
5. Applying the Fuzzy Sets theory to identify the agreements between the three groups of contractors.
6. Using Pareto principal to identify the most important factors (Key factors).
7. Suggesting model for predicting cost estimate accuracy.

1.6 Reader's Guide

The thesis contains six chapters, each of which includes the following:

Chapter 1: Is an introductory chapter to present the problem, objectives, methodology and thesis arrangement.

Chapter 2: Literature review; review of the previous work.

Chapter 3: The statistical tests and other methods used in identifying, evaluating and ranking the factors that affect the construction cost estimate.

Chapter 4: General discussion and interpretations of the sensitive factors.

Chapter 5: Highlight the thesis conclusions and recommendations for future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Cost estimating is crucial aspect of construction management which needs the closest comparatively simple subject to understand. However, as it brings one up against practical work, methods and procedures, it cannot be acquired without close application. The cost estimate is a necessary piece of the alternatives analysis of the scoping. It is also used to evaluate the cost-effectiveness of alternatives. Ultimately, the cost estimate is the main item that most ask about when referring to a project. It is also used to provide an estimate of the future funding needs of a construction project. Under-estimating may result in the client getting an unpleasant shock when tenders are opened and drastically modifying or abandoning the work at that stage. Over-estimating may lose the engineer or estimator his client or his job, or in any case his confidence.

The person who manages or prepares cost estimate is called cost estimator who cannot be trained entirely in a classroom. The theory and science of estimating is important, but it takes experience with construction to complete the training of an estimator. A person possessing the “art of estimating” has a good feel for the effort required to produce work, good construction experience, and knowledge of the theory and science of estimating. The less information available about a project, the more experience is required to do a cost estimate. An estimator would typically have an engineering or architectural background and be qualified by experience.

Knowledge of building technology is essential to be able to break down a building into components in a structured way and then price the different components with applicable unit rates to derive the total cost, so experience from the construction site is essential. Moreover, Min-Yuan et al. (2009), stated that; construction cost estimates generally rely on experts' intuitive experience. Scientific methods should be developed and employed during project planning and design stages in order to raise cost estimate accuracy.

2.2 Cost Estimating Techniques

The primary function of cost estimation is to produce an accurate and reliable cost forecast of a construction project. However, what cost should be forecasted depends on the requirements of a client and also upon the information and data available. There are different techniques currently used for project cost estimation at different stages of project development and within the same stage. The attractiveness of each method includes its ease of application, familiarity, speed and level of accuracy and reliability as shown in table 2.1 (Ashworth 1995).

Table 2.1: AACE International Cost Estimation Classification

Estimate Class	Level of Project Definition	End Usage Typical Purpose of Estimate	Expected Accuracy Range
Class 5	0% to 2%	Concept screening	-50% to 100%
Class 4	1% to 5%	Study and feasibility	-30% to 50%
Class 3	10% to 40%	Budget authorization or control	-20% to 30%
Class 2	30% to 70%	Control bid tender	-15% to 20%
Class 1	50% to 100%	Check estimate or bid tender	-10% to 15%

In general a number of types of estimates have been prepared by researchers according to professionals, companies, associations and government agencies. Most of these estimates can be classified into three categories (Clark and Lorenzoni 1997), *Proposal (screening) estimate*, *budget estimate* and *definitive estimate*. The later provides an accurate estimate of project costs because it is based on solid data obtained from very detailed engineering information. The purpose of definitive estimate can be both cost control and purchasing decisions for which accurate estimates are required. The accuracy of this estimate vary from +10% to –5%. In Fig 2.1, definitive cost estimate is shown along the time line. Other cost estimates may be made depending on the purpose.

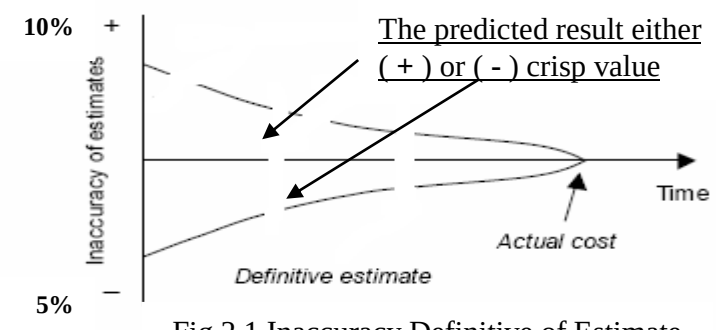


Fig 2.1 Inaccuracy Definitive of Estimate

2.3 Predicting Cost Estimate Accuracy

Several researchers e.g. Boussabaine (2002), have formulated cost estimate in construction using different techniques such as statistical analysis, regression techniques, neural networks and Neurofuzzy systems. The average accuracy of these models ranges between 40% and 70%. He also suggested that more information regarding construction projects is required such as date of tendering and regional project location. On the other hand, as the number of projects increase for neural network and fuzzy models development a substantial increase in the level of the prediction accuracy will be obtained. It was noted that all models rely to some extent on assumptions, whether explicit or implicit. To assess the viability of a model, the user needs to understand the assumptions which contribute to it. Unfortunately, where the assumptions are built in, it is difficult to assess and evaluate the model in question. A key issue to consider here also is that construction cost estimate will always be uncertain. Therefore, the user must distinguish between those that include a formal measure of uncertainty (stochastic methods) and those that do not deterministic.

The conclusions of the previous study lead to concentrate on predicting cost estimate accuracy, which we believes that it's more advisable to the cost estimators to help them in prediction of their estimate accuracy which is usually a function of the following factors (Dillon et al. 2002), time available, techniques employed, information available, cost estimation knowledge and experience and considering of the factors affecting cost estimate

2.4 Variability Identification and Analysis

Cost estimate also depends upon: (1) who was involved in preparing the estimate; (2) how the estimate was prepared; (3) what was known about the project; and (4) other significant factors considered while preparing the estimate which affecting on cost estimate. Thus, it is necessary that construction practitioners are being aware of uncertainty, incompleteness and unknown circumstances of factors affecting the reliable predictions of cost estimate.

Elhag et al. (2005), identified and evaluate cost-determinant variables where 67 variables affecting construction cost were identified through literature and pilot interviews. These factors were grouped into six broad categories; the first three categories represent the construction industry participants which include: (1) Client characteristics, (2) Consultant and Design parameters (3) Contractor attributes (Tables 2.2, 2.3& 2.4).

Table 2.2 Client Characteristics factors

Sl. No.	Cost Estimate Factors
1.01	Type Of Client (Public / Private / Developer)
1.02	Financial Ability / Payment Record
1.03	Project Finance Method /
1.04	Partnering Arrangements
1.05	Priority On Construction Time /
1.06	Experience Of Procuring Construction
1.07	Client Requirements On Quality
1.08	Certainty Of Project Brief

Table 2.3 Consultant and Design Characteristics Factors

Sl. No.	Cost Estimate Factors
2.01	Completeness & Timeliness of Project Information (Design,
2.02	Build Ability of Design
2.03	Working Relationships with Client / Contractors / Other Design
2.04	Variation Orders & Additional Works (Magnitude, Timing,
2.05	Quality of Design & Specifications
2.06	Inspection, Testing & Approval of Completed Works (Toughness /
2.07	Submission of Early Proposals for Costing / Cost Planning
2.08	Absence of Alterations and Late Changes to Design (No 'Design-As-

Table 2.4 Contractor Characteristics Factors

Sl. No.	Cost Estimate Factors
3.01	Management Team (Suitability, Experience, Performance)
3.02	Management / Labor Relationships & Confidence in Work Force
3.03	Financial Capability
3.04	Experience on Similar Projects
3.05	Current Work Load
3.06	Level of Communications within the Contractor Organization
3.07	Estimation Method & Cost Control Technique (Accuracy &
3.08	Planning Capability & Level of Resource Deployment / Utilization /
3.09	Productivity Effects:
3.10	% of Main Contractor Direct Work & % of Subcontracted Work
3.11	Number of Subcontractors
3.12	Mark Up Policies & % (General& Project Wise) (Special or Normal
3.13	Record of Payments to Sub-Contractors
3.14	Previous Claims Record I.E. Assessment of 'Low Tender' – 'High
3.15	Present Claims (Size & Quantity)
3.16	Accidents on Sites Record
3.17	Bond / Warranty Arrangements
3.18	CDM Regulations Awareness

The fourth category represents factors related to Project characteristics (Table 2.5). The fifth category involves the relation between the construction parties which is Contract procedures and Procurement methods (Table 2.6).

Table 2.5 Project Characteristics Factors:-

Sl. No.	Cost Estimate Factors
4.01	Type / Function (Residential, Commercial, Industrial, Offices)
4.02	Size / Gross Floor Area
4.03	Height and numbers of Stories
4.04	No. of Basement Levels
4.05	Level of Uncertainty of Soil Conditions
4.06	Complexity
4.07	Type of Structures (Steel, Concrete, Brick, Timber, Masonry)
4.08	Location (Regions / Rural; Urban) (Inner City / Outskirts)
4.09	Site Conditions / Site Topography
4.10	Construction Method / Technology
4.11	Type of Foundations (Pile / Raft / Pad / ... Etc.)
4.12	Off-Site Prefabrication
4.13	Type of Cladding & External Walls (Brick, Double Glazing, Etc.)
4.14	Access to Site
4.15	Intensity / Complexity of Building Services
4.16	Phasing Requirements (Areas to Be Handed Over First Or Initial Non-Availability)
4.17	Quality of Finishing

Table 2.6 Contract Procedure & Procurement Methods Factors:-

Sl. No.	Cost Estimate Factors
5.01	Type of Contract / Use of Standard Form of Contract
5.02	Tender Selection Method (Open, Selected, Negotiation, Single or Two Stage)
5.03	Payment Modalities (Fixed Price, Cost Plus, BOT, PFI-DBFO, Etc. ...)
5.04	Method of Procurement (Traditional, Design & Build, Project Management)
5.05	Spread of Risk between Construction Parties (Client / Consultant / Contractors)
5.06	Claims & Disputes Resolution Methods (Litigation / Arbitration / Others)
5.07	Interviewing Of Selected Prospective Contractors

The sixth category represents the factors related to the construction market environment which named as: External factors and market conditions (Table 2.7).

Table 2.7 External factors & market characteristics:-

Sl. No.	Cost Estimate Factors
6.1	Material Prices / Availability / Supply / Quality / Imports
6.2	Labor Costs / Availability / Supply / Performance / Productivity
6.3	Plant Costs / Availability / Supply / Condition / Performance
6.4	Weather Condition
6.5	Government Regulations/Policies (Health & Safety, Fire, CDM,Etc.)
6.6	Level of Competition & Level Of Construction Activity
6.7	Number of Bidders on Competitive Projects
6.8	Interest Rate /Inflation Rate
6.9	Stability of Market Conditions

A comparison of statistical analysis of their impact was conducted by. Priority ranking of cost-influencing factors is carried out using a questionnaire survey commissioned amongst quantity surveyors in the UK. Findings of this survey indicate that there is no significant variation in the ranking of each group. However, category of consultant and design parameters was ranked top followed by client characteristics with four out of the 10 top factors being related to this category. The third and fourth ranks were occupied by project characteristics and external market conditions, respectively. On the other hand, the fifth group of factors included contract procedures and procurement methods. The contractor attributes group scoring the least index occupied the bottom of the list. These findings indicated that construction project costs were more affected by architects and consultants than by contractors. This outcome is consistent with many literature reviews that the project costs are more determined by decisions at the briefing, feasibility and initial design stages rather than by later construction stages.

Chan and Park (2005), identified 52 determinants (Table 2.8) relating to the project, the construction team and the contractor that have impact on project cost, constructed a predictive project cost model using the principal component technique and to assess the relative importance of determining factors. The data are obtained from a random sample survey comprised of Singapore building projects completed after 1992 costing more than US$5 million. Three main groups of variables are identified, pertaining to characteristics of the project, contractors and owner/consultants. Special project requirements such as high technological level, contractor's specialized skills, and public administered contract have significant effects on cost. Other factors include contractor's technical expertise, owner's level of construction sophistication and contractor's financial management ability.

Table 2.8 Determinants of Project Cost (Chan and Park 2005)

No.	Factors	No.	Factors
1	Type of contract.	28	Design decisions made (by owner) when bids are invited
2	Singapore Institute of Architects Form of contract.	29	Design completion when budget is fixed.
3	Public sector standard conditions of contract.	30	Good bidding information.
4	Residential building.	31	Importance for project to be completed within budget.
5	Commercial building.	32	Importance for project to be delivered.
6	Industrial building.	33	Time given to owners/consultants to evaluate bids.
7	Public owned.	34	Extent to which the contract period is allowed to vary during bid evaluation stage.
8	Level of design complexity.	35	Importance for the project to be completed on time.
9	Level of technologically advancement.	36	Bidding environment.
10	Level of specialization required of contractors.	37	Consultant's level of construction sophistication
11	Percentage of repetitive elements.	38	Owner's level of construction sophistication.
12	Presence of special issues.	39	Consultant's experience with similar projects.
13	Type of specification 15performance; 35combination.	40	Owner's experience with similar projects.
14	Extent to which bid documents allow additions to scope	41	Consultant's staffing level to attend to contractor.
15	Flexibility of scope of works when contractor is hired.	42	Owner's staffing level to attend to contractor.
16	Project scope definition completion when bids are invited	43	No. of design-bid-build/design-build projects handled by consultant in the past.
17	Design completion (by owner) when bids are invited.	44	No. of design-bid-build/design-build projects handled by owner in the past.
18	Contractor's experience with similar types of projects.	45	Contractor's staffing level.
19	Contractor's experience with similar size of projects	46	Adequacy of contractor's plant and equipment.
20	Contractor's experience with projects in Singapore.	47	Magnitude of change orders in contractor's past projects.
21	Subcontractors' experience and capability.	48	Type of contract.
22	Communication among project team members.	49	Public sector standard conditions of contract. Dummy variable.
23	Contractor's prior working relationship with the owner.	50	Residential building.
24	Contractor's prior working relationship with consultants.	51	Commercial building.
25	Contractor's track record for completion on **time.**	52	Industrial building.
26	Contractor's track record for completion on **budget.**		
27	Contractor's track record for completion to acceptable **quality.**		

Akintoye (2003), examined factors that influence a contractor's estimate of a project cost. Of the 24 factors, seven main factors were identified using the factor analysis

approach: project complexity, technological requirements, information, team requirement, contract requirement duration and market requirement.

Trost and Oberlender (2003), developed an estimate scoring system to measure the impact of four determinants on estimate accuracy. The questions were divided in to four divisions (Tables 2.9 to 2.12).

Table 2.9 Division 1; Represents the first question in the scoring system Best ⟷ Worst

WHO WAS INVOLVED IN PREPARING THE ESTIMATE?	1	2	3	4	5
1.1 Owners experience level					
1.2 Engineer / Designers experience level					
1.3 Relevant experience of the estimating team					
1.4 level of involvement of the project manager					
1.5 Involvement of other resources in preparing estimate					
1.6 Review and acceptance of estimate by appropriate parties					
1.7 Level of team integration and alignment					
1.8 Purpose and intended use of estimate					
1.9 Attitude / culture toward changes					

Table 2.10 Division 2; Represents the second question in the scoring system

HOW WAS THE ESTIMATE PREPARED?	1	2	3	4	5
2.1 Completeness of cost information					
2.2 Applicability of cost information					
2.3 Accuracy and reliability of cost information					
2.4 Slandered procedure for updating cost information					
2.5 Time allowed for preparing the estimate					
2.6 Alignment of estimate methodology with available project information					
2.7 Is the estimating work process formally defined and followed?					
2.8 Formal structure to categorize and prepare the cost estimate					
2.9 Utilization of check lists to ensure completeness and technical basis					
2.10 Documentation of information used in preparing the estimate					
2.11 Method used to determine contingency					

Table 2.11 Division3; Represents the third question in the scoring system

WHAT WAS KNOWN ABOUT THE PROJECT?	1	2	3	4	5
3.1 Capacities					
3.2 Technology					
3.3 Processes					
3.4 Site location					
3.5 Plot plan					
3.6 Utility sources and supply condition					
3.7 Environment assessment					
3.8 Process flow sheet					
3.9 Mechanical equipment list					
3.10 Heat and material balance					
3.11 Project strategy					
3.12 Project design criteria					
3.13 Project schedule					

Table 2.12 Division 4; Represents the fourth question in the scoring system

FACTORS CONSIDERED WHILE PREPARING THE ESTIMATE?	1	2	3	4	5
4.1 Owners costs					
4.2 Impact of project classification					
4.3 Impact of contract type					
4.4 Impact of project schedule					
4.5 Impact of governmental requirements					
4.6 Work force					
4.7 Labour productivity					
4.8 Bidding climate					
4.9 Taxes and insurance					
4.10 Money Factors					
4.11 Logistics for engineering and construction					

The estimate scoring system consists of 45 elements and is organized into 4 divisions. Data were collected from 67 projects; representing $5.6 billion in total installed costs, and used to correlate the estimate scores with estimated versus actual costs. Statistical analyses determined the relative influence of the 45 elements, based on collected project data. The results showed a significant correlation between the estimate score and the accuracy of the estimate. Computer software, the Estimate Score Program (ESP), was developed to automate the scoring procedure, assess estimate accuracy, and predict contingency, based on historical cost data. The estimator can enter the base estimate into ESP and then rate the estimate, relative to each of the 45 elements. ESP automatically calculates the estimate score, as the user rates each element. The user can query the ESP historical database to view the estimate scores and estimate accuracy of similar projects. The user can also predict the cost range—upper and lower limits—of a desired confidence level. ESP can be used to "check" the amount of contingency determined by other methods, as well as a method of predicting its own contingency.

Chan et al. (2001), identified a set of project success factors for design and build projects and examine the relative importance of these factors. In their study, the success of the projects is measured by the ability to complete on time and within budget. Terms such as ‘behind schedule’, ‘on schedule’, ‘ahead of schedule’, ‘overrun budget’, on budget’ and ‘under run budget’ are used to categorize the projects. Some project success factors are highlighted such as: team commitment, contractor’s competences, risk and liability assessment, client’s competencies, end users’ needs and constraints imposed by end users. Some researchers reckon that success factors are different for different types of projects.

Akinci and Flscher (1998), described the factors that affecting cost estimate of project by: The factors that directly influence the estimated cost of a project which can lead to unrealistic cost estimates before construction actually starts. They classified the factors into two groups' estimator specific and design and project specific. Estimators, like many people have motivation and cognitive biases, and these biases can lead to distorted and inaccurate cost estimates. Design and project specific factors include vagueness in scope, design complexity, and project size.

Hegazy and Ayed (1998), developed a parametric cost-estimating model for projects where little information is known about the scope of the project. This type of parametric model consists of one or more functions, or cost-estimating relationships, between the cost as the dependent variable and the cost-determining factors. The neural networks approach adopted by this study is appropriate due to the presence of difficult tasks involving intuitive judgment and the need to detect data patterns that elude conventional analytical techniques.

McCaffer et al. (1998), presented factors required to improve construction quality in Egypt, together with their relative importance. 16 factors were generated and the relative importance of each factor was determined. The first factor was the improvement of the design and planning in the pre-construction stage, the second factor was the improvement of the financial level and standard of living of employees, the sixteenth and last factor was the encouragement of innovation for simpler and more accurate work methods.

Bennett et al. (1996), studied project selection and performance from the owners' perspective. They constructed three statistically viable models to predict unit cost, construction speed and delivery speed. In determining one of the performance metrics, the study included other performance metrics as predictor variables, which clearly showed the interdependence of the three factors.

Tiong (1997), believe that the success of BOT (build–operate–transfer) projects is affected by a limited number factors. As for design and build projects, the number of factors to be considered is much more. Chan et al. (2001), identified 31 factors, Ashley et al. (1987), stressed on 64 factors. Songer and Molenaar, (1997), as well as, Konchar and

Sanvido (1998), had nearly 100 factors that affect project cost, schedule and quality performance of a project.

Other researchers obtained the factors affecting cost estimate from measuring the performance (Cost, Time, and Quality) of a construction project by different metrics, for example Dissanayaka and Kumaraswamy (1999), evaluated the relative influences of critical procurement and non-procurement related factors on cost performance in a sample of Hong Kong based building projects. Using multiple linear regression, they found that cost overruns are influenced by; levels of client confidence in the construction team, risk retained by client for quantity variations, levels of construction complexity related new technology and payment modality. These factors were then used to develop artificial neural network models for predicting cost indices.

Songer and Molenaar (1997), as well as, Konchar and Sanvido (1998), identified eleven performance metrics that are classified under the broad categories of cost, time, quality and other aspects of the construction project. They measured project cost in three ways: (i) unit cost expressed as a ratio of final project cost to area; (ii) cost growth determined by the percentage change in final project cost and contract project cost; and (iii) intensity, defined as the unit cost of design and construction work put in place in a facility per unit time.

Kaming et al. (1997), investigated factors influencing construction cost overruns on high-rise projects in Indonesia. Project managers were consulted, via a questionnaire survey, to assess the different variables. The identified variables were then ranked according to their perceived importance and frequencies of occurrence. Using factor analysis techniques, causes of delay and cost overrun were successfully grouped into factors (main categories). Inflationary increases in material cost, inaccurate material estimating and project complexity were found to be the main causes of cost overruns. This study relied on the judgments of project managers for the identification of factors associated with cost overruns. However, no attempt had been made to consult cost estimators or quantity surveyors who primarily deal with costs.

Naoum (1994), investigated whether the means of procurement influence project performance. The study conducted a comparison analysis of project performances for management and traditional contracting in the UK. Project performance was measured by ten factors including, unit cost of building, and cost overrun and client satisfaction with cost. A model was developed linking various project performances with different characteristics of construction projects. The study concluded that there was not enough evidence to suggest that management contracting can reduce the overall cost.. However, this study fell short of investigating the underlying critical determinants of unit costs of building or of factors affecting cost overruns under each procurement scheme.

Moselhi et al. (1993), developed an analogy-based model for bidding strategy which mainly estimates an optimum mark-up percentage and a win/lose probability. The decision support system also anticipates project profitability in Canada and USA. The model depends on 30 attributes, which significantly influence decision-making at the tendering process stage. A detailed comparison between these attributes and cost-influencing factors reveals that a number of attributes are highly relevant, albeit in a different way, in the estimation of construction costs.

Elinwa and Buba (1993), investigated construction cost factors in Nigeria. A questionnaire survey was conducted, which involved architects, engineers and quantity surveyors. Thirty-one variables were assessed, and analyses of results showed good agreement between the responses. The top ranked factors, which contributed to construction cost, included: cost of materials, fraudulent practices and fluctuation in prices of materials.

Okpala and Aniekwu (1988), investigated causes of high costs of construction in Nigeria. The study revealed 27 factors contributing to high costs and delays in completion time. A questionnaire survey was conducted which included engineers, architects and quantity surveyors. The rankings of the influencing variables by the three professions were found to be fairly similar, despite some differences in their views. The professionals generally agreed that shortage of materials, methods of financing and payments for completed works and poor contract management were the three major reasons for high construction costs and delays. The top ranked factor was identified as price fluctuations.

The factors identified in this study are largely influenced by the locality of the country in which the research was conducted.

In 1906, Italian economist and sociologist, Vilfredo Pareto created a mathematical formula to describe the uneven income distribution in Switzerland at that time, observing that 80% of the wealth was held by a mere 20% of the families. Later analysis of distributions in industry and nature has demonstrated that 80/20 Pareto distributions were very common in various fields and not exclusive to income distribution.

2.5 Artificial Intelligence based Estimating Technique

An estimate is a calculation of the quantities of various items of work, and the expenses likely to be incurred there on. The total of these probable expenses to be incurred on the work is a close approximation of its actual cost. New technologies especially in the field of Artificial Intelligence (AI) have been providing powerful decision support systems to tackle complex management processes such as construction environments.

Brandon and Raftery (1994) as well as Seeley (1996), elicited the following estimating methods

- Functional unit
- Cube method
- Superficial area
- Superficial-perimeter
- Approximate quantities
- Elemental analysis
- Interpolation
- Resource analysis
- Cost engineering

Most of The methods suffer from lack of precision and uncertainty. Their weaknesses also lie in the difficulty of making allowance of a whole range of factors such as:

1. Client characteristics
2. Consultant and design characteristics
3. Contractor characteristics
4. Project characteristics
5. Contract procedures and procurement methods
6. External factors and market characteristics

Other cost modelling techniques include Linear / Dynamic Programming, Regression Analysis, Simulation / Risk Analysis, and Expert Systems (ES). These models lack the ability to deal with problems such as:

- Imprecision and uncertainty of data and variables affecting costs of construction projects.
- Unknown combined effects and inter-relationships of cost-influencing factors.
- Complex and vagueness of input – output relationships which cannot fit nicely and successfully into a quantitative description.

2.5.1 Introduction for Fuzzy Set Theory

Fuzzy set theory was developed specifically to deal with uncertainties that are not statistical in nature (Zadeh 1965). The fuzzy set theory describes the set of elements in a way to permit a gradual transition from being a member of a set to a nonmember. Each element has a degree of member ranging from *zero* to *one*, where *zero* signifies non-membership and *one* indicates full membership. Fuzzy set theory is very useful in modeling complex and vague systems. The basic idea is that artificial logic systems can be developed to emulate the linguistic way human think and judge. In this context, the fuzzy logic approach is intended to streamline the decision analysis process and produce an evaluation according to the decision-makers value system and judgment, while maintaining simplicity and tractability. Fuzzy set theory is a tool that transforms linguistic control strategy into a mathematical control method.

A fuzzy linguistic variable is defined as a variable, the values of which are words, phrases, or sentences in a given language. For example Fig 2.2 shows type of client (public or private) effect on cost estimate can be considered as *linguistic variable* with values such as "low effect", "medium effect", or "high effect". Since words are usually less precise than numbers, linguistic variables provide a method to characterize complex systems that are will defined to be described in traditional quantitative terms (Zimmermann 1991). A linguistic variable is defined by the name of a variable X and a term set T(x) of the linguistic values of X with each value being a fuzzy number defined on universe of discourse U.

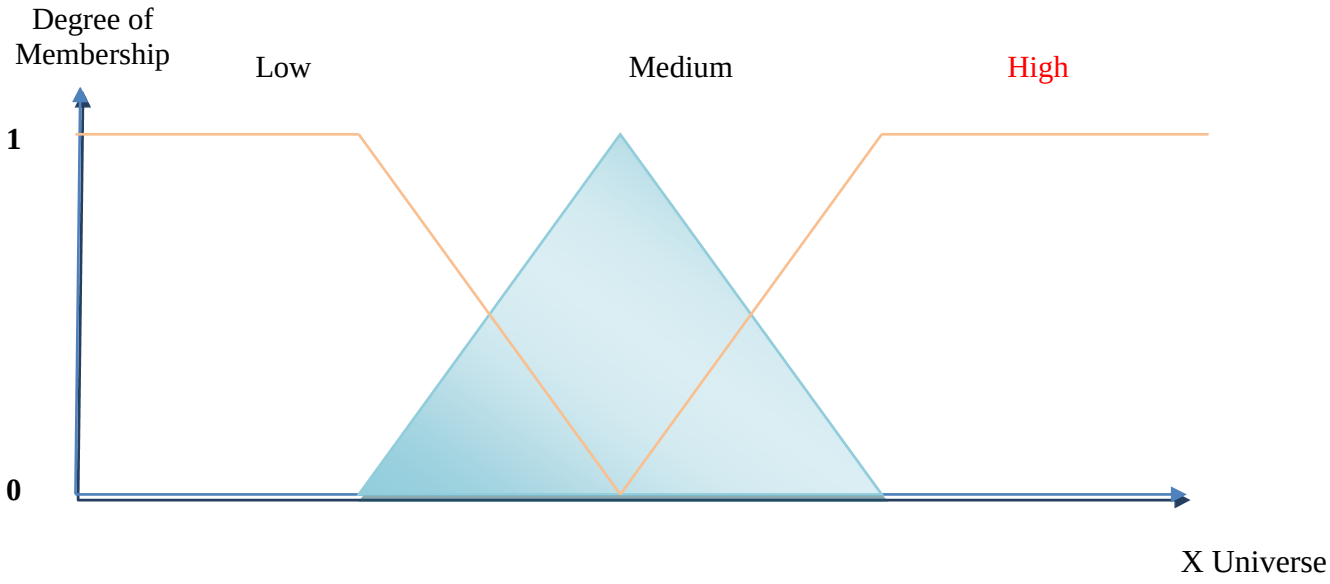


Fig 2.2 Linguistic Variable for the Type of Client Effect on Cost Estimate

2.5.2 Artificial Intelligence based Model

Kuo et al. (2002), proposed and examined Novel Neural Network architecture, the logarithm-neuron network (LNN), for its efficiency and accuracy in quantity estimating of steel and RC buildings. The architecture of the LNN is the same as that of the standard back-propagation neural network (BPN), but logarithm neurons are added to the input layer and output layer of the network. The results indicate that the logarithm neurons in the network provide enhanced network architecture to improve significantly the performance of these networks in quantity.

Attala and Hegazy (2003), developed a model using artificial neural network (ANN) to estimate cost deviation from the planned values in reconstruction projects. Two indicators of cost deviation are used in this study: cost overrun to the owner, and the cost of rework to the contractor. Based on the information obtained, 36 factors were identified as having direct impact on the cost performance of reconstruction projects (Table 2.13). They compared the ANN model with the regression model and concluded that both models produced relatively close results. The main difference was that ANN was more sensitive and used 18 variables in the estimation, while regression model used only five variables. However, the ANN technique is more suitable for problems involving high level of uncertainty and in cases where some decision support system is required

Table 2.13 Factors Having Direct Impact on Performance (Attala and Hegazy 2003)

Category	Factor
Cost	Budget baseline and budget allocations Work packages costing Cost breakdown structure (CBS) Cost variance (CV) Forecast analysis Unit prices Cash allowances Cash flow
Schedule	Work breakdown structure Bar charts Critical path method Incremental milestones Time variance Percent complete Coordination schedule Liquidated damages Change directive versus change notice
Quality	Quality standards and specifications with input from O&M! Responsibilities of individuals toward quality Inspection and testing Independent inspection firms Inspection by operator/maintenance Inspection by end user Prequalification of contractors
Scope	As-built drawings Constructability review Design committees
Communication	Site meetings ~biweekly with users' representatives Electronic communication Implementation team Direct communication sub team
Safety	Joint health and safety committee Awareness sessions Emergency plan and procedures
Site	Site layout plan Relocation schedule

Knight and Fayek (2002), described a model for use in predicting potential cost overruns on engineering design projects. The output of the model is useful in assessing the amount of possible risk on a project and the likelihood of making a profit on the job. The model is intended for use by engineering consultants, i.e., structural, mechanical, and electrical engineers, in the building design industry. This research uses fuzzy logic to model the relationships between the characteristics of a project and the potential risk events that may occur, and the associated cost overruns caused by combinations of the project characteristics and risk events.

Wilmot and Cheng (2003), developed an artificial neural network model which relates overall highway construction costs, described in terms of a highway construction cost index, to the cost of construction material, labor, and equipment, the characteristics of the contract and the contracting environment prevailing at the time the contract was let. Results demonstrate that the model is able to replicate past highway construction cost trends in Louisiana with reasonable accuracy. Future construction input costs are estimated from commercially available forecasts of indicator variables closely associated with the price of construction labor, construction equipment, and a representative set of highway construction materials. Future contract characteristics and the contracting environment that is likely to exist in the future are estimated from past trends or stipulated to be consistent with policy decisions in the future.

Love et al. (2004), developed a consultant's performance evaluation model for the evaluation of the performance of cost estimators in the construction industry of Hong Kong. Nominal group technique is adopted in identifying the decision criteria for the evaluation, and a reliability interval method (RIM) is developed to assess the importance weighting of each criterion. The RIM allows statistical analysis and fuzzy assessment of the weight. The results report the weights of each decision criterion and its sub-criterion in evaluating cost estimator's performance. Interestingly, the results show that traditional functions of cost estimator are the least treasured from the clients. Proactive and professional advice is considered to be much more important. The study is highly relevant to industry practitioners in assessing performance of costs estimators, as well as to researchers in further developing the consultant selection model.

Kumar and Reddy (2005), described a methodology to identify the project duration by incorporating qualitative as well as quantitative factors of the construction industry. The qualitative factors are converted into numerical measures by giving suitable membership values. This relies on advanced mathematical tools in addition to construction knowledge rules defined by planning experts to enhance and automate the planning process of complex projects, where conventional model-based approach is very difficult to implement. Furthermore, this methodology makes the experts' knowledge explicit and can be applied mechanically to other projects, mutatis and mutandis. A case study is worked out to demonstrate the applicability of the proposed methodology and this can be easily computerized.

Sanchez (2005), identified the most common risks in infrastructure projects in Germany, to quantify in terms of money the cost of the risks involved in construction projects, a list of Risk-Factors (RF) has been created in order to model the behaviour of the risks for the chosen construction project. Analyzed and evaluated Risk-Factors impact to the Contractor's profit; this is made with the help of the Neuronal-Risk Assessment System (NRAS). The core parts of the system are represented by Artificial Neural Networks (ANN) and risk management.

Kim et al. (2005), applied hybrid models of neural networks (NN) and genetic algorithms (GA) to cost estimation of residential buildings to predict preliminary cost estimates. Data used in the study are for residential buildings constructed from 1997 to 2000 in Seoul, Korea. These are used in training each model and evaluating its performance. The models applied were Model I, which determines each parameter of a back-propagation network by a trial-and-error process; Model II, which determines each parameter of a back-propagation network by GAs; and Model III, which trains weights of NNs using genetic algorithms. The research revealed that optimizing each parameter of back-propagation networks using GAs is most effective in estimating the preliminary costs of residential buildings. Therefore, GAs may help estimators overcome the problem of the lack of adequate rules for determining the parameters of NNs.

Lowe (2006), developed a neural network cost models by using data collected from nearly 300 building projects. Data were collected from predominantly primary sources using real-life data contained in project files, with some data obtained from the Building Cost Information Service, supplemented with further information, and some from a questionnaire distributed nationwide. The data collected included final account sums and, so that the model could evaluate the total cost to the client, clients' external and internal costs, in addition to construction costs. Models based on linear regression techniques have been used as a benchmark for evaluation of the neural network models. The results showed that the major benefit of the neural network approach was the ability of neural networks to model the nonlinearity in the data. The 'best' model obtained so far gives a mean absolute percentage error (MAPE) of 16.6%, which includes a percentage (unknown) for client changes. This compares favorably with traditional estimating where values of MAPE between 20.8% and 27.9% have been reported. However, it is anticipated that further analyses will result in the development of even more reliable models.

Orlando (2009), developed and test a model of cost estimating for the shell and tube heat exchangers in the early design phase via the application of artificial neural networks (ANN).

Min Yuan and Hsing-Chih (2010), used Evolutionary Fuzzy Neural Inference Model (EFNIM), to improve cost estimation accuracy. The advantages inherent in Genetic Algorithms, Fuzzy Logic and Neural Networks are incorporated into the EFNIM, making this model highly applicable to identifying optimal solutions for complex problems.

2.6 Conclusions:

Cost estimation is an experience-based process. Construction practitioners are aware of uncertainty, incompleteness and unknown circumstances of factors affecting construction costs. Realization and understanding of cost-determinants enrich the competence of cost estimators, and hence along with decent cost forecasting techniques, deliver more reliable and accurate cost estimates.

A wide range of cost forecasting techniques has been exploited in the construction industry. Major limitations of most of cost forecasting techniques are taken in account of significant factors that can be readily quantified.

It is deduced that most of the significant factors affecting project costs are qualitative such as client priority on construction time, contractors planning capability, procurement methods and market conditions including level of construction activity. Due to the qualitative nature of these factors, they are difficult to structure and quantify. Despite their importance, most of these factors are often ignored by current forecasting techniques. A great deal of research approaches factors affecting cost of construction projects from different angles.

CHAPTER 3

DATA COLLECTION AND ANALYSIS

3.1 Introduction

Literature survey and interviews with cost estimators working for construction companies categorized as group one, according to the "Egyptian Federation for Contractors and Building Construction" were conducted to sort out the factors that may affect the cost estimate in Egypt-Cairo and gather them in a questionnaire manuscript. Then semi-structured interviews were regarded as pilot study to adjust and modify the questionnaire manuscript before delivering (hand to *hand)* to cost estimators. Sixty-eight factors were selected (APPENDEX C) and grouped into six different categories by applying Cause and Effect Diagram (APPENDEX B). Factors are grouped under six broad categories describing client characteristics, consultant and design parameters, contractor attributes, project characteristics, contract procedures and procurement methods, external factors and market conditions as shown on (Fig. 3.1).

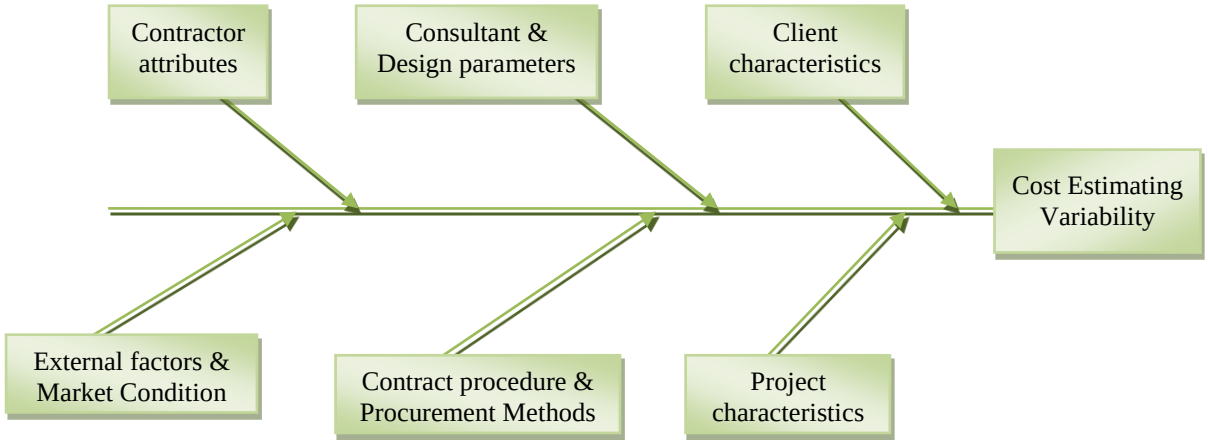


Fig. 3.1 Fishbone Diagram Showing the Different Category

3.2 Data Collection

Data was collected in two stages:

1. Stage one; from literature survey and interviews
2. Stage two; a questionnaire.

Stage One, literature survey and interviews with cost estimators working for Construction Company categorized as group one, according to the "Egyptian Federation for Contractors and Building Construction" were conducted to sort out the factors that may affect the cost

estimate in Egypt and gather them in a questionnaire manuscript. Then semi-structured interviews were regarded as pilot study to adjust and modify the questionnaire manuscript before delivering *(hand to hand)* to the cost estimators. Sixty-eight factors were selected APPENDEX D; and grouped into six different categories by applying Cause and Effect Diagram, APPENDEX C.

Stage Two, a questionnaire methodology targeting contractors cost estimators was adopted to evaluate and rank these factors according to their influence and significance regarding the cost estimates of the construction projects. The questionnaire (APPENDIX D) was developed in two parts. Part one is an introductory section and included questions regarding the profile of the cost estimators and their company. In part two, the respondents are asked to give a score for each of the 68 factors identified from the literature reviews APPENDIX A. Respondents are asked to indicate the extent to which their company (his opinion) would consider these factors to be important in their cost estimating.

The questionnaire was delivered to one hundred twenty cost estimators in Cairo-Egypt working along with different construction companies. The address of the construction companies was obtained from the "Egyptian Federation for Contractors and Building Construction". Personal contact was the major communication tool which is used to get the cost estimators participate in the study.

Sample profile: 120 Questionnaires were sent out, 30 targeting each of large and medium size contractors. 60 For small size contractors. The result of response was, 96 respondents replied, which represents an overall response rate of 80%. The response rate of the large contractors was 73%, medium contractors was 60% and for small contractors 93.3%.

Three different groups of construction companies were selected for the study. The first group represents the large size contractors (30 questionnaires), categories G1 and G2. The "Egyptian Federation for Contractors and Building Construction" system of registration involves seven groups, with G1 being the largest and G6 and G7 the smallest. G2 contractors are eligible to bid for projects up to a value of 37.5 million L.E (US$1 = 5.7 L.E.) and G1 contractors may bid for projects of any size. The second group selected for this study covered G4 and G5 contractors, representing the medium-size contractors (30 questionnaires). G4 contractors are allowed to bid for projects up to 15 million L.E (US$1 = 5.7 L.E.) and G5 may bid for projects to the value of 6 million L.E (US$1 = 5.7 L.E.). G3 contractors were left out of the survey so as to make a distinction between the large and

medium contractors, Mohammed and Shan (2002), The third group selected for this study covered G6 and G7 contractors, representing the small-size contractors (60 questionnaires). G6 contractors are allowed to bid for projects up to 3 million L.E (US$1 = 5.7 L.E.) and G7 may bid for projects to the value of 1.5 million L.E (US$1 = 5.7 L.E.)

3.3 Data Analysis

The attitude of contractor's size towards factors influencing cost estimate has been assessed by evaluating the sensitivity rating respondents placed on the identified factors. Respondents were asked in the questionnaire (APPENDIX D, part II) to indicate, on a scale from 1 (Insensitive) to 3 (sensitive) the sensitivity rating they attach to different factors. The data collected from the survey were compiled and processed using mathematical and statistical techniques. The analysis included simple mathematical calculations along with some sophisticated statistical measures. The agreement on category ranking was analyzed through several statistical tests using two main software programs, the first is StatPac virgin 3, 2005 for measuring the descriptive statistical, while the second was VisualSatat 5.1.0, 2005 for estimating Kendall's concordance which was used in ranking the categories. Kendall's concordance determines the "reliability" of the responses defined as agreement or concordance among cost estimators. These techniques made it possible to analyze and examine certain aspects of the cost estimate factors, (1) the 'sensitivity index' of the different factors that may have an impact on cost estimate, and (2) the likely variation between responses from large, medium and small contractors. Sensitivity index is used to assess the importance contractors assign to different factors. ANOVA Tests were carried on to enable the research to establishing whether the small, medium, and large contractors' evaluation of the various factors varied significantly.

3.3.1 Mean Weighted Rating

A mean weighted rating for each factor is computed to deliver an indication of the importance of the factor, (Equation 3.1). Since the ratings range between 1 and 3, point 2 is considered as the neutral point.

Mean weighted rating = $(\sum_i v_i * f_i) / n$ …….(3.1)

Where:

v_i = rating of each factor (1, 2, 3)

f_i = frequency of responses

n = total number of responses

3.3.2 Sensitivity Index (SI)

Sensitivity index is used to rank the factors according to their significance in affecting cost estimate. This index helps ranking the factors in accordance with their importance to the cost estimators and also determines any similarities or differences between the small, medium and the large contractors (Shash and Abdul Hadi, 1993), illustrated by Equation 3.2.

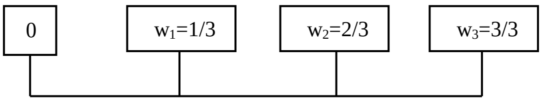
Where: $$S.I. = \left(\sum_{i=1}^{3} w_i * f_i\right) * \frac{100\%}{n} \quad \ldots\ldots (3.2)$$

i = represent the ratings 1, 2, 3

f_i = frequency of responses

n = total number of responses

w_i = weight for each rating



3.3.3 Coefficient of Variation:

Coefficient of variation (COV) expresses the standard deviation as percentage of the mean. (COV) is useful in comparing relative variability of different responses. Its value is computed by (Equation 3.3).

$$COV = \frac{S}{\overline{X}} * 100\%. \quad \ldots\ldots (3.3)$$

Where:

COV = coefficient of variation

S = standard deviation

$\overline{X}$ = weighted mean of sample

3.3.4 Kendall's Concordance Test

There are two issues to be investigated: testing the hypothesis that respondents (cost estimators) are independent; and finding a measure of the relationship between rankings of factors for each category. The measure of the relationship will describe the agreement or concordance between cost estimators in their judgements on each category of factors. The

coefficient (W) ranges from 0 to 1, with 1 indicating complete inter-cost estimators agreement and 0 indicating complete disagreement among cost estimators.

3.3.5 Friedman chi-square

For testing the reliability between cost estimators the significance of Friedman chi-square was measured.

3.4 Attitude of Contractors Large Size (G1&G2) Toward the Identified Factors

3.4.1 Factor ranking within each category:

The sensitivity index of each factor within each category was calculated according to mean weighted rating and coefficient of variation. Consequently, overall ranking of the different factors according to such sensitive index was assessed.

Within the Client Characteristics category, the highest coefficient of variations and sensitivity indices were recorded for four factors out of nine. These were: financial ability/payment records (93.9%), type of client (89.2%), client requirements on quality (86.2%) and project finance method /appropriate were Funding in place on time (84.6%). Consequently, all the previous factors were ranked one to four respectively. The lowest ranked factor was client certainty of project brief achieving sensitivity index (48%).

Within the consultant and Designer characteristics category, the highest coefficient of variation (1.03) and sensitivity index (86.1) was in the absence of alteration and late changes to design factor which was assigned the highest rank. On the other hand, the inspection, testing and approval of completed works factor recorded the least coefficient of variation (0.16) and sensitive index (57.2%) and assigned rank 8.

Within the Contractor characteristics category, the greatest sensitive indices out of 18 factors were assigned for the experience on similar projects (93.8%), Financial capability (92.3%). Management team (92.3%) being ranked 1, 2 and 3 respectively. Contrary the least sensitive indices were manifested for the CDM regulations awareness (48%) and accidents on sites record (45%).

Within the Contract procedure & Procurement method category, the payment modalities and tender selection method showed the highest sensitive indices; 90.8% & 83% respectively, with ranks 1 and 2 within the 7^{th} included factors. The lowest percentages were recorded for the Interviewing of selective prospective contractor's factor (55.5%).

Within the Project characteristics category, the top factors with the highest sensitivity indices were Complexity 98.5%, Level of uncertainty of soil condition 92.3%, Height/No.

of stories 90.8% and Type of structures 90.8%. On the other hand, the least sensitive indices were assigned for Type /function 64.7% and Off-site prefabrication 64.7%.

Finally, within the External factors and market characteristics category, the Plant costs, Material prices, Labor costs, Interest rate and stability of market conditions showed the highest sensitive indices 98.5, 96.9, 96.9, 95.4 and 95.4 % respectively. On the other hand, the lowest sensitive index was the weather condition factor 51.2%.

3.4.2 Overall Ranking of Factors among all Categories

It was found that the top ten factors were complexity 98.5% related to Projects category. Plant cost, Material prices, Labor cost, Interest rate and stability of market conditions related to External category and assigned 98.5, 96.9, 96.9, 95.4, and 95.4% respectively. The Financial ability factor exhibited a sensitive index of 93.9% related to the Client category. 93.8 % and 92.3% sensitive indices were assigned for experience on similar projects and financial capability factors which are included within the Contractor category. Finally, the level of uncertainty of soil condition related to the projects category was assigned the 10^{th} rank with a sensitive index of 92.3% (Table 3.3).

Meanwhile, sensitively indices less than 50% were recorded for the partnering arrangements and Certainty of project brief (Client category) which were assigned ranks 65&66, as well as CDM and Accidents on sites records (Contractor category) assigned ranks 67 & 68 (Table 3.3).

3.4.3 Agreement on Category Ranking:

The agreement on Category ranking was statistically analyzed through several statistical tests using two software. The first was StatPac virgin 3, 2005 for measuring the descriptive statistical, while the second was VisualSatat 5.1.0, 2005 for estimating Kendall's concordance which was used in ranking the category. Kendall's determines the "reliability" of the responses defined as agreement or concordance) among ratters (cost estimators. The coefficient *W* ranges from 0 to 1, with 1 indicating complete inter-estimators agreement, and 0 indicating complete disagreement among cost estimators. The data were arranged in rows and cost estimators in columns sensitivity rating is items being judged. For testing the reliability between cost estimators the significance of Friedman chi-square was measured as given in table 3.3. A very high significant agreement was recorded among cost estimators for the sensitivity of: External factors & Market characteristics (chi-

square=32.82), Project characteristics (chi-square=32.82), Contractor characteristics (chi-square=27.91 and P=0.0001) and Contract procedure & procurement method (chi-square=16.46 and P=0.001). A repeated measures analysis of data, (Kendall's test) was made to support this result better, those categories maintaining a coefficient of concordance (1) falling in the sensitive rating level. Furthermore, the other two categories; Consultant & Designer characteristics (chi-square=6.64) and Client characteristics (chi-square=6.91) which indicating low reliability between the cost estimators, showed a highly significant agreement at P=0.032, and 0.036 respectively, and achieving coefficient of concordance *W* 0.828 and 0.652 at the slightly sensitive level among cost estimators(Table 3.1).

Table 3.1 Category ranking according to Kendall's test (large size contractors)

Category Rank	Category	Degree of freedom	Chi-square	Kendall's analysis for rating			Significance
				Insensitive	Slightly Sensitive	Sensitive	
1	External Factors	8	32.82			1.000	0.000
2	Project Characteristics	16	32.82			1.000	0.000
3	Contractor Characteristics,	17	27.91			1.000	0.000
4	Contract Procedure	6	16.46			1.000	0.003
5	Consultant & Designer Characteristics	7	6.64	0.256	0.652	0.567	0.036
6	Client Characteristics	8	6.91	0.239	0.828	0.346	0.032

The descriptive statistical analysis shows 62% agreement among cost estimators regarding the effect of categories on cost estimate. (Fig. 3.2).

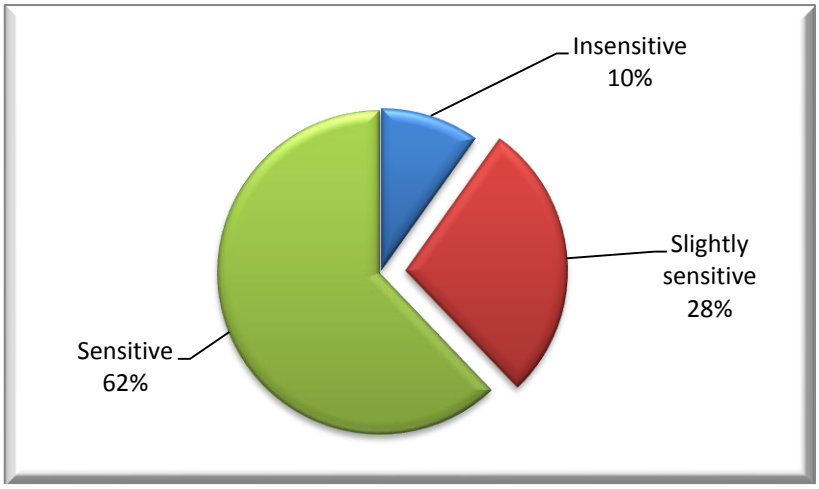


Fig 3.2 the agreement percent (62%) among cost estimators in large size contractors about the categories influence on cost estimate

The 62% can be broken down to the six categories as follows; External factor & Market condition **15.9%,** Project characteristics **15.2%,** Contractors **14.4%,** Contract **12.1%** and other **4.5%** divided among Consultant & designer attributes and client characteristics with **3%** and

1.5% respectively. The results showed that the Client group scored the least average sensitivity index of 1.50%. This indicates that the cost estimators perceive that the External factors have more influence on cost estimate rather than any other categories (Fig 3.3).

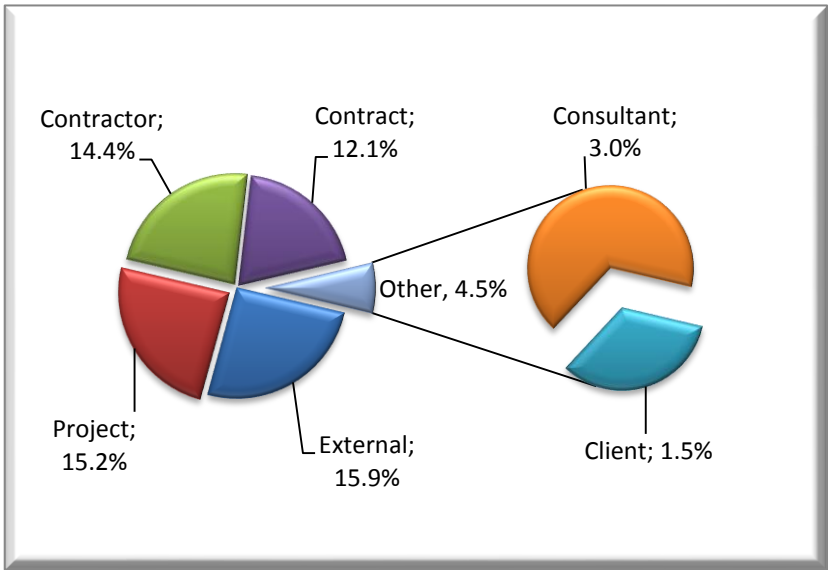


Fig 3.3 the categories breakdown for the 62%
Large size contractors which influence on cost estimate

These findings indicate that cost estimate for large size contractors are more affected by external factors & market conditions rather than by project and contractor characteristics. Also external factors & market conditions affect the decisions taken during cost estimate at any of the project stages rather than by feasibility, initial design stages and during construction stages.

Table 3.2 Factors Ranking per Category for Large Size Contractors

No.	Description of Factors	Mean	Standard Deviation	Coefficient Of Variation	Sensitive Index	Category Ranking
	Client Characteristics					
2.02	Financial Ability / Payment Record	0.94	1.432	1.52	93.9%	1
2.01a	Type Of Client (Private)	0.89	1.047	1.17	89.2%	2
2.07	Client Requirements On Quality	0.86	1.144	1.32	86.2%	3
2.03	Project Finance Method /Appropriate Funding In Place On Time	0.85	0.946	1.12	84.6%	4
2.01	Type Of Client (Public)	0.76	0.637	0.84	75.3%	5
2.05	Priority On Construction Time / Deadline Requirements	0.74	0.576	0.78	73.8%	6
2.06	Experience Of Procuring Construction	0.52	0.095	0.18	51.1%	7
2.04	Partnering Arrangements	0.50	0.120	0.24	49.6%	8
2.08	Certainty Of Project Brief	0.48	0.309	0.64	48.0%	9
	Consultant & Designer Characteristics					
2.16	Absence Of Alterations And Late Changes To Design	0.86	0.887	1.03	86.1%	1
2.09	Completeness & Timeliness Of Project Information (Design, Drawings, Specifications)	0.82	0.722	0.88	81.5%	2
2.1	Build Ability Of Design	0.79	0.688	0.87	78.4%	3
2.12	Variation Orders & Additional Works (Magnitude, Timing, Interference Level)	0.76	0.729	0.96	75.3%	4
2.13	Quality Of Design & Specifications	0.76	0.729	0.96	75.3%	5
2.15	Submission Of Early Proposals For Costing / Cost Planning	0.74	0.527	0.71	73.9%	6
2.11	Working Relationships With Client / Contractors / Other Design Team Consultants (Previous / Present)	0.70	0.568	0.82	69.2%	7
2.14	Inspection, Testing & Approval Of Completed Works (Toughness / Requirements)	0.58	0.095	0.16	57.2%	8
	Contractor Characteristics					
2.2	Experience On Similar Projects	0.94	1.325	1.41	93.8%	1
2.19	Financial Capability	0.92	1.330	1.44	92.3%	2
2.17	Management Team (Suitability, Experience, Performance)	0.92	1.228	1.33	92.3%	3
2.28	Mark Up Policies & % (General & Project Wise) (Special Or Normal Conditions Applied)	0.88	1.041	1.18	87.7%	4
2.25	Productivity Effects:(Managerial, Organizational, Labor, Technology	0.85	0.870	1.03	84.6%	5
2.23	Estimation Method & Cost Control Technique (Accuracy & Reliability)	0.80	0.681	0.85	80.0%	6
2.21	Current Work Load	0.77	0.631	0.82	76.9%	7
2.24	Planning Capability & Level Of Resource Deployment / Utilization / Optimization	0.74	0.775	1.04	73.7%	8
2.18	Management / Labor Relationships & Confidence In Work Force	0.73	0.596	0.82	72.3%	9
2.26	% Of Main Contractor Direct Work & % Of Subcontracted Work	0.70	0.694	1.00	69.2%	10
2.31	Present Claims (Size & Quantity)	0.67	0.432	0.65	66.2%	11
2.3	Previous Claims Record I.E. Assessment Of 'Low Tender' – 'High Claims' Performance	0.67	0.555	0.83	66.2%	12
2.22	Level Of Communications Within The Contractor Organization	0.62	0.643	1.04	61.6%	13
2.29	Record Of Payments To Sub-Contractors	0.59	0.208	0.35	58.7%	14
2.33	Bond / Warranty Arrangements	0.59	0.834	1.41	58.5%	15

No.	Description of Factors	Mean weight rating	Standard Deviation	Coefficient Of variation	Sensitive Index	Category Ranking
2.27	Number Of Subcontractors	0.58	0.773	1.34	57.0%	16
2.34	CDM Regulations Awareness	0.48	0.309	0.64	48.0%	17
2.32	Accidents On Sites Record	0.45	0.284	0.62	45.0%	18
	Contract Procedure & Procurement Method					
2.37	Payment Modalities (Fixed Price, Cost Plus … Etc)	0.91	1.231	1.35	90.8%	1
2.36	Tender Selection Method (Open, Selected, Negotiation, Single Or Two Stage, Etc. ...)	0.83	0.764	0.92	83.0%	2
2.35	Type Of Contract /Use Of Standard Form Of Contract	0.79	0.684	0.87	78.5%	3
2.38	Method Of Procurement (Traditional)	0.71	0.764	1.07	70.7%	4
2.4	Claims & Disputes Resolution Methods (Litigation / Arbitration / Others)	0.68	0.500	0.73	67.7%	5
2.39	Spread Of Risk Between Construction Parties (Client / Consultant / Contractors)	0.65	0.777	1.19	64.6%	6
2.41	Interviewing Of Selected Prospective Contractors	0.56	0.550	0.98	55.5%	7
	Project Characteristics					
2.47	Complexity	0.98	1.628	1.65	98.5%	1
2.46	Level Of Uncertainty Of Soil Conditions	0.92	1.330	1.44	92.3%	2
2.44	Height / No. Of Stories	0.91	1.231	1.35	90.8%	3
2.48	Type Of Structures (Steel, Concrete, Brick, Timber, Masonry)	0.91	1.231	1.35	90.8%	4
2.43	Size / Gross Floor Area	0.88	1.137	1.29	87.7%	5
2.45	No. Of Basement Levels	0.88	1.137	1.29	87.7%	6
2.58	Quality Of Finishing	0.88	0.964	1.10	87.6%	7
2.52	Type Of Foundations (Pile / Raft / Pad / ... Etc.)	0.83	1.051	1.26	83.2%	8
2.56	Intensity / Complexity Of Building Services	0.82	0.777	0.95	81.5%	9
2.49	Location (Regions / Rural ; Urban)&(Inner City / Outskirts)	0.77	0.631	0.82	76.9%	10
2.54	Type Of Cladding & External Walls (Brick, Double Glazing, Etc.)	0.76	0.577	0.76	75.4%	11
2.57	Phasing Requirements (Areas To Be Handed Over First Or Initial Non-Availability)	0.76	0.729	0.96	75.3%	12
2.55	Access To Site	0.74	0.576	0.78	73.8%	13
2.51	Construction Method / Technology	0.74	0.662	0.89	73.8%	14
2.5	Site Conditions / Site Topography	0.74	0.775	1.04	73.7%	15
2.42	Type / Function (Residential, Building)	0.65	0.486	0.75	64.7%	16
2.53	Off-Site Prefabrication	0.65	0.486	0.75	64.7%	17
	External Factors & Market Characteristics					
2.61	Plant Costs / Availability / Supply / Condition / Performance	0.98	1.628	1.65	98.5%	1
2.59	Material Prices / Availability / Supply / Quality / Imports	0.97	1.525	1.57	96.9%	2
2.6	Labor Costs / Availability / Supply / Performance /Productivity	0.97	1.525	1.57	96.9%	3
2.66	Interest Rate /Inflation Rate	0.95	1.424	1.49	95.4%	4
2.67	Stability Of Market Conditions	0.95	1.424	1.49	95.4%	5
2.64	Level Of Competition & Level Of Construction Activity	0.77	0.700	0.91	76.8%	6
2.65	Number Of Bidders On Competitive Projects	0.76	0.637	0.84	75.3%	7
2.63	Government Regulations/Policies (Health & Safety, Fire)	0.67	0.432	0.65	66.2%	8
2.62	Weather Condition	0.52	0.139	0.27	51.2%	9

Table 3.3 Overall Ranking of Factors (large size contractors)

No.	Description of Factors	Sensitive Index	Category Name	Overall Ranking
2.47	Complexity	98.5%	Projects	1
2.61	Plant Costs / Availability / Supply / Condition / Performance	98.5%	External	2
2.59	Material Prices / Availability / Supply / Quality / Imports	96.9%	External	3
2.6	Labor Costs / Availability / Supply / Performance /Productivity	96.9%	External	4
2.66	Interest Rate /Inflation Rate	95.4%	External	5
2.67	Stability Of Market Conditions	95.4%	External	6
2.02	Financial Ability / Payment Record	93.9%	Client	7
2.2	Experience On Similar Projects	93.8%	Contractor	8
2.19	Financial Capability	92.3%	Contractor	9
2.46	Level Of Uncertainty Of Soil Conditions	92.3%	Projects	10
2.17	Management Team (Suitability, Experience, Performance)	92.3%	Contractor	11
2.37	Payment Modalities (Fixed Price, Cost Plus, Etc)	90.8%	Contract	12
2.44	Height / No. Of Stories	90.8%	Projects	13
2.48	Type Of Structures (Steel, Concrete, Brick, Timber, Masonry)	90.8%	Projects	14
2.01a	Type Of Client (Private)	89.2%	Client	15
2.43	Size / Gross Floor Area	87.7%	Projects	16
2.45	No. Of Basement Levels	87.7%	Projects	17
2.28	Mark Up Policies & % (General & Project Wise) (Special Or Normal Conditions Applied)	87.7%	Contractor	18
2.58	Quality Of Finishing	87.6%	Projects	19
2.07	Client Requirements On Quality	86.2%	Client	20
2.16	Absence Of Alterations And Late Changes To Design	86.1%	Consultant	21
2.03	Project Finance Method /Appropriate Funding In Place On Time	84.6%	Client	22
2.25	Productivity Effects:(Managerial, Organizational, Labor, Technology	84.6%	Contractor	23
2.52	Type Of Foundations (Pile / Raft / Pad / ... Etc.)	83.2%	Projects	24
2.36	Tender Selection Method (Open, Selected, Negotiation, Single Or Two Stage, Etc. ...)	83.0%	Contract	25
2.56	Intensity / Complexity Of Building Services	81.5%	Projects	26
2.09	Completeness & Timeliness Of Project Information (Design, Drawings, Specifications)	81.5%	Consultant	27
2.23	Estimation Method & Cost Control Technique (Accuracy & Reliability)	80.0%	Contractor	28
2.35	Type Of Contract /Use Of Standard Form Of Contract	78.5%	Contract	29
2.1	Build Ability Of Design	78.4%	Consultant	30
2.21	Current Work Load	76.9%	Contractor	31
2.49	Location (Regions / Rural ; Urban)&(Inner City / Outskirts)	76.9%	Projects	32
2.64	Level Of Competition & Level Of Construction Activity	76.8%	External	33
2.54	Type Of Cladding & External Walls (Brick, Double Glazing)	75.4%	Projects	34
2.01	Type Of Client (Public)	75.3%	Client	35
2.65	Number Of Bidders On Competitive Projects	75.3%	External	36

No.	Description of Factors	Sensitive Index	Category Name	Overall Ranking
2.12	Variation Orders & Additional Works (Magnitude, Timing, Interference Level)	75.3%	Consultant	37
2.13	Quality Of Design & Specifications	75.3%	Consultant	38
2.57	Phasing Requirements (Areas To Be Handed Over First Or Initial Non-Availability)	75.3%	Projects	39
2.15	Submission Of Early Proposals For Costing / Cost Planning	73.9%	Consultant	40
2.05	Priority on Construction Time / Deadline Requirements	73.8%	Client	41
2.55	Access to Site	73.8%	Projects	42
2.51	Construction Method / Technology	73.8%	Projects	43
2.24	Planning Capability & Level Of Resource Deployment / Utilization / Optimization	73.7%	Contractor	44
2.5	Site Conditions / Site Topography	73.7%	Projects	45
2.18	Management / Labor Relationships & Confidence In Work Force	72.3%	Contractor	46
2.38	Method of Procurement (Traditional)	70.7%	Contract	47
2.11	Working Relationships With Client / Contractors / Other Design Team Consultants (Previous / Present)	69.2%	Consultant	48
2.26	% of Main Contractor Direct Work & % Of Subcontracted Work	69.2%	Contractor	49
2.4	Claims & Disputes Resolution Methods (Litigation / Arbitration / Others)	67.7%	Contract	50
2.31	Present Claims (Size & Quantity)	66.2%	Contractor	51
2.63	Government Regulations/Policies (Health & Safety, Fire)	66.2%	External	52
2.3	Previous Claims Record I.E. Assessment Of 'Low Tender' – 'High Claims' Performance	66.2%	Contractor	53
2.42	Type / Function (Residential, Building)	64.7%	Projects	54
2.53	Off-Site Prefabrication	64.7%	Projects	55
2.39	Spread of Risk Between Construction Parties (Client / Consultant / Contractors)	64.6%	Contract	56
2.22	Level of Communications Within The Contractor Organization	61.6%	Contractor	57
2.29	Record of Payments To Sub-Contractors	58.7%	Contractor	58
2.33	Bond / Warranty Arrangements	58.5%	Contractor	59
2.14	Inspection, Testing & Approval Of Completed Works (Toughness / Requirements)	57.2%	Consultant	60
2.27	Number Of Subcontractors	57.0%	Contractor	61
2.41	Interviewing Of Selected Prospective Contractors	55.5%	Contract	62
2.62	Weather Condition	51.2%	External	63
2.06	Experience Of Procuring Construction	51.1%	Client	64
2.04	Partnering Arrangements	49.6%	Client	65
2.08	Certainty Of Project Brief	48.0%	Client	66
2.34	CDM Regulations Awareness	48.0%	Contractor	67
2.32	Accidents On Sites Record	45.0%	Contractor	68

3.5 Attitude of Medium Size Contractors (G4&G5) Toward the Identified Factors

3.5.1 Factor ranking within each category:

Similar to large size contractors the sensitivity index was calculated for each factors and used on ranking the factors in each category and also the overall ranking (Tables 3.5 & 3.6).

Within the Client Characteristics category the sensitivity index ranged from (100% to 33%), the highest coefficient of variations and sensitivity indices were recorded for 5 factors out of 9. These were: financial ability/payment records (100%), client requirements on quality (90.6%), project finance method /appropriate were Funding in place on time (88.8%), type of client / privet (88.7%), and type of client / public (84.9%). Consequently, all the previous factors were ranked 1-5 respectively. The lowest ranked factor was partnering arrangements achieving sensitivity index (33%).

Within the consultant and Designer characteristics category the sensitivity index ranged from (81.1% to 60.6%), the highest coefficient of variation and sensitivity index was apparent in the Variation Orders & Additional Works (Magnitude, Timing, and Interference Level factor which was assigned rank first (81.1%) at top of other 8 factors, Build ability of design came second with sensitivity index (79.2%). On the other hand, the Quality of design & Specifications factor recorded the least sensitive index (60.6%) and assigned rank 8.

Within the Contractor characteristics category the sensitivity index ranged from (96.2% to 34.8%), the greatest sensitive indices for 4 factors out of 18 were assigned for the experience on similar projects (96.2%), Financial capability (92.4%), Productivity Effects (Managerial, Organizational, Labor Technology) (90.6%), Mark Up Policies (88.7%), being ranked 1,2,3 &4 respectively. On the contrary, the least sensitive indices were manifested for the Accidents on sites record (34.8%) and CDM regulations awareness (34.8%) factors which exhibited ranks 17&18.

Within the Contract procedure & Procurement method category the sensitivity index ranged from (98.1% to 60.6%), the payment modalities and claims & disputes resolution methods showed the highest sensitive indices; (98.1% & 83.0%) respectively, being ranked 1&2 within seven included factors. The lowest sensitivity percentages were recorded for the Method of Procurement factor (60.6%) which was given a rank of seventh.

Within the Project characteristics category the sensitivity index ranged from (100% to 58.7%), five factors achieved sensitivity indices (100%) out of 17 factors were size / gross floor area 100% (rank 1), no. of basement levels 100% (rank 2), type of structures 100% (rank 3) and intensity / complexity of building services 100% (rank 4) and quality of finishing100% (rank 5). On the other hand, the least sensitive indices were assigned for off-site prefabrication (64.2%) (Rank 16) and type / function (residential, building) (58.7%) (Rank 17).

Finally, Within the External factor and market characteristics category the sensitivity index ranged from (100% to 47.7%), two factors achieved sensitivity indices (100%) out of 9 factors, the Material prices (rank 1), stability of market conditions (rank 2), other factors like labor costs, Interest rate and plant costs showed high sensitive indices 94.3%, 94.3% and 84.9% respectively. These were assigned ranks from 3-5. On the other hand, the lowest sensitive index was apparent in the government regulations/policies (health & safety, fire) factor 47.7%.

3.5.2 Overall ranking of factors among all Categories:

It was found that the top ten factors out of 68 included ones were Financial Ability / Payment Record 100% related to Client category (rank 1). Size / gross floor area, no. of basement levels, type of structures, intensity / complexity of building services and quality of finishing related to Project category and assigned 100% for all (ranks 2-6). Material prices factor and stability of market conditions exhibited a sensitive index of 100% for both, related to the External category (rank 7 & 8). 98.1 % sensitive indices were assigned for payment modalities factor which is included within the Contract category (ranks 9). Finally, complexity related to the projects category was assigned the 10^{th} rank with a sensitive index of 98.1% (Table 3.6).
Meanwhile, sensitive indices less than 50% were recorded in 10 factors, six factors were related to Contractor category; (record of payments to sub-contractors, present claims (size & quantity), previous claims record, level of communications within the contractor organization, accidents on sites record and CDM regulations awareness) ranked (59,62,64-67) respectively. Weather condition and government regulations/policies (health & safety, fire) related to External category were (ranked 60 and 63), experience of procuring construction and partnering arrangements (Client category) assigned ranks 61 and 68.

3.5.3 Agreement on Category ranking:

The agreement on Category ranking was statistically analyzed through several statistical tests using two main software programs, the first was StatPac virgin 3, 2005 for measuring the descriptive statistical, while the second was VisualSatat 5.1.0, 2005 for estimating Kendall's concordance which was used in ranking the category. Kendall's W (determining the "reliability" of the responses defined as agreement or concordance) among ratters (cost estimators). The coefficient *W* ranges from 0 to 1, with 1 indicating complete inter-cost estimators agreement, and 0 indicating complete disagreement among cost estimators. The data were arranged in: (rows) are cost estimators; (columns) sensitivity rating is items being judged (Table 3.6).

For testing the reliability between cost estimators the significance of Friedman chi-square was measured. A very highly significant agreement was recorded among cost estimators for the sensitivity of: External factors & Market characteristics (chi-square=25.0), Project characteristics (chi-square=25.0), Contractor characteristics (chi-square=7 and P=0.000) and Contract procedure & procurement method (chi-square=7 and P=0.001). A repeated measures analysis of data, (Kendall's test) was made to supports this result better, those categories maintaining a coefficient of concordance (1.0) falling in the sensitive rating level . Furthermore, the other two categories; Client characteristics (chi-square=6.33) and Consultant & Designer characteristics (chi-square=4.00) which indicating low reliability between the cost estimators, also showed low significant agreement at P=0.421, and 0.135 respectively, and achieving coefficient of concordance *W* 0.894 and 0.598 at the slightly sensitive level among cost estimators (Table 3.4).

Table 3.4 Category Ranking according to Kendall's test (medium size contractors)

Category Rank	Category	Degree of freedom	Chi-square	Kendall's analysis for rating			Significance
				Insensitive	Slightly Sensitive	Sensitive	
1	External Factors & Market Characteristics	8	25.00			1.0	0.000
2	Project Characteristics	16	25.00			1.0	0.000
3	Contractor Characteristics,	17	7.00			1.0	0.000
4	Contract Procedure & Procurement Method	6	7.00			1.0	0.001
5	Client Characteristics	8	6.33	0.217	0.894	0.243	0.421
6	Consultant & Designer Characteristics	7	4.00	0.598	0.598	0.286	0.135

An agreement among cost estimators regarding the sensitivity level effect of categories factor on cost estimate was found as; 63%, 32% and 5% for sensitive, slightly, insensitive respectively (Fig.3.4).

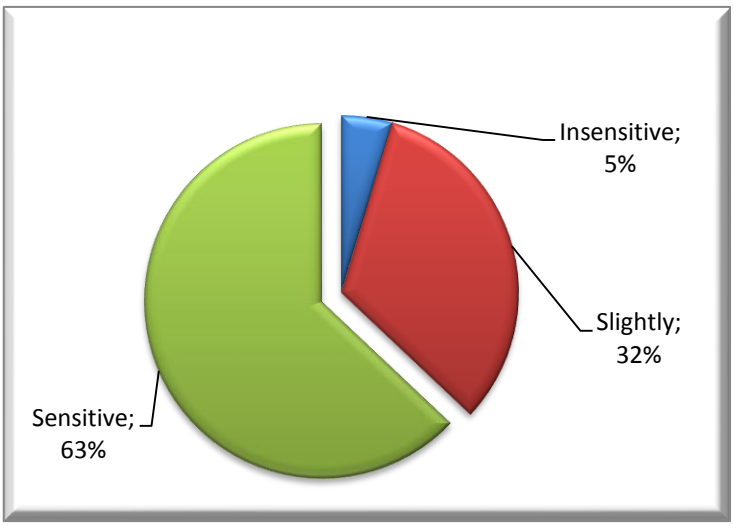


Fig 3.4 the agreement percent (63%) among cost estimators in medium size contractors about the categories influence on cost

The sixty three agreement percent; is divided among the six categories according to cost estimators agreement as follow; External factor & Market condition 16.7%, Project characteristics 15.7%, Contractors 9.3%, Contract 9.3% and other 12% divided among client group with 8.3% and consultant & designer attributes scored the least average sensitivity index of 3.7%. This indicates that the cost estimators (medium size contractors) perceive that the external factors have more influence on cost estimate than any other categories (Fig 3.5)

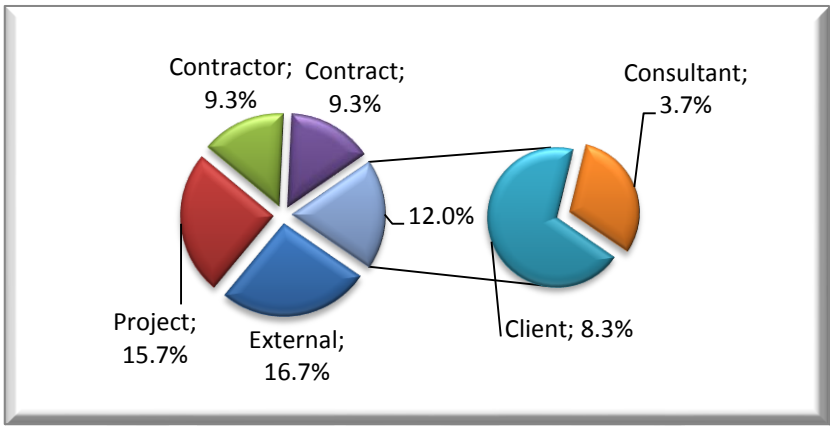


Fig 3.5 the categories breakdown for the 63%
Medium size contractors which influence on cost estimate

These findings indicate that cost estimate for medium size contractors are more affected by external factors & market condition than by project and contractor. These results are coincident with that obtained for the large-size contractors.

Table 3.5 Category Ranking of Factors (medium size contractors)

No.	Description of Factors	Mean weight rating	Standard Deviation	Coefficient of variation	Sensitive Index	Category Ranking
	Client Characteristics					
2.02	Financial Ability / Payment Record	1.00	1.732	1.73	100.0%	1
2.07	Client Requirements On Quality	0.91	1.125	1.24	90.6%	2
2.03	Project Finance Method /Appropriate Funding In Place On Time	0.89	1.252	1.41	88.8%	3
2.01a	Type Of Client (Private)	0.89	1.018	1.15	88.7%	4
2.01	Type Of Client (Public)	0.85	0.834	0.98	84.9%	5
2.05	Priority On Construction Time / Deadline Requirements	0.74	0.780	1.05	73.6%	6
2.08	Certainty Of Project Brief	0.54	0.032	0.06	53.3%	7
2.06	Experience Of Procuring Construction	0.48	0.170	0.35	47.8%	8
2.04	Partnering Arrangements	0.33	0.577	1.73	33.0%	9
	Consultant & Designer Characteristics					
2.12	Variation Orders & Additional Works (Magnitude, Timing, Interference Level)	0.81	0.714	0.88	81.1%	1
2.1	Build Ability Of Design	0.80	0.690	0.87	79.2%	2
2.16	Absence Of Alterations And Late Changes To Design	0.78	0.694	0.89	77.3%	3
2.09	Completeness & Timeliness Of Project Information (Design, Drawings, Specifications)	0.72	0.855	1.18	71.7%	4
2.15	Submission Of Early Proposals For Costing / Cost Planning	0.69	0.686	1.00	68.0%	5
2.11	Working Relationships With Client / Contractors / Other Design Team Consultants (Previous / Present)	0.67	0.338	0.51	66.3%	6
2.14	Inspection, Testing & Approval Of Completed Works (Toughness / Requirements)	0.65	0.516	0.80	64.3%	7
2.13	Quality Of Design & Specifications	0.61	0.722	1.18	60.6%	8
	Contractor Characteristics					
2.2	Experience On Similar Projects	0.96	1.480	1.54	96.2%	1
2.19	Financial Capability	0.93	1.239	1.34	92.4%	2
2.25	Productivity Effects:(Managerial, Organizational, Labor, Technology)	0.91	1.125	1.24	90.6%	3
2.28	Mark Up Policies & % (General & Project Wise) (Special Or Normal Conditions Applied)	0.89	1.018	1.15	88.7%	4
2.17	Management Team (Suitability, Experience, Performance)	0.85	0.834	0.98	84.9%	5
2.21	Current Work Load	0.76	0.725	0.95	75.4%	6
2.23	Estimation Method & Cost Control Technique (Accuracy & Reliability)	0.72	0.855	1.18	71.7%	7
2.24	Planning Capability & Level Of Resource Deployment / Utilization / Optimization	0.69	0.686	1.00	68.0%	8
2.26	% Of Main Contractor Direct Work & % Of Subcontracted Work	0.65	0.516	0.80	64.3%	9
2.18	Management / Labor Relationships & Confidence In Work Force	0.63	0.432	0.69	62.5%	10
2.33	Bond / Warranty Arrangements	0.63	0.996	1.58	62.3%	11
2.27	Number Of Subcontractors	0.59	0.263	0.44	58.8%	12
2.29	Record Of Payments To Sub-Contractors	0.50	0.147	0.29	49.6%	13
2.31	Present Claims (Size & Quantity)	0.48	0.274	0.57	47.7%	14

No.	Description of Factors	Mean weight rating	Standard Deviation	Coefficient of variation	Sensitive Index	Category Ranking
2.3	Previous Claims Record I.E. Assessment Of 'Low Tender' – 'High Claims' Performance	0.46	0.263	0.57	45.9%	15
2.22	Level Of Communications Within The Contractor Organization	0.44	0.385	0.87	44.0%	16
2.32	Accidents On Sites Record	0.35	0.516	1.47	34.8%	17
2.34	CDM Regulations Awareness	0.35	0.516	1.47	34.8%	18
	Contract Procedure & Procurement Method					
2.37	Payment Modalities (Fixed Price, Cost Plus)	0.98	1.605	1.63	98.1%	1
2.4	Claims & Disputes Resolution Methods (Litigation / Arbitration / Others)	0.83	0.764	0.92	83.0%	2
2.39	Spread Of Risk Between Construction Parties (Client / Consultant / Contractors)	0.80	0.663	0.83	79.3%	3
2.41	Interviewing Of Selected Prospective Contractors	0.76	0.567	0.75	75.6%	4
2.36	Tender Selection Method (Open, Selected, Negotiation, Single Or Two Stage)	0.74	0.548	0.74	73.7%	5
2.35	Type Of Contract /Use Of Standard Form Of Contract	0.70	0.446	0.63	70.1%	6
2.38	Method Of Procurement (Traditional)	0.61	0.722	1.18	60.6%	7
	Project Characteristics					
2.43	Size / Gross Floor Area	1.00	1.732	1.73	100.0%	1
2.45	No. Of Basement Levels	1.00	1.732	1.73	100.0%	2
2.48	Type Of Structures (Steel, Concrete, Brick, Timber, Masonry)	1.00	1.732	1.73	100.0%	3
2.56	Intensity / Complexity Of Building Services	1.00	1.732	1.73	100.0%	4
2.58	Quality Of Finishing	1.00	1.732	1.73	100.0%	5
2.47	Complexity	0.98	1.605	1.63	98.1%	6
2.52	Type Of Foundations (Pile / Raft / Pad)	0.98	1.605	1.63	98.1%	7
2.44	Height / No. Of Stories	0.96	1.480	1.54	96.2%	8
2.46	Level Of Uncertainty Of Soil Conditions	0.87	0.920	1.06	86.8%	9
2.51	Construction Method / Technology	0.83	0.764	0.92	83.0%	10
2.57	Phasing Requirements (Areas To Be Handed Over First Or Initial Non-Availability)	0.83	0.764	0.92	83.0%	11
2.54	Type Of Cladding & External Walls (Brick, Double Glazing, Etc.)	0.81	0.714	0.88	81.1%	12
2.49	Location (Regions / Rural ; Urban)&(Inner City / Outskirts)	0.80	0.690	0.87	79.2%	13
2.5	Site Conditions / Site Topography	0.78	0.626	0.80	77.4%	14
2.55	Access To Site	0.74	0.644	0.87	73.6%	15
2.53	Off-Site Prefabrication	0.65	0.883	1.36	64.2%	16
2.42	Type / Function (Residential, Building)	0.59	0.644	1.09	58.7%	17
	External Factors & Market Characteristics					
2.59	Material Prices / Availability / Supply / Quality / Imports	1.00	1.732	1.73	100.0%	1
2.67	Stability Of Market Conditions	1.00	1.732	1.73	100.0%	2
2.6	Labor Costs / Availability / Supply / Performance /Productivity	0.94	1.357	1.44	94.3%	3
2.66	Interest Rate /Inflation Rate	0.94	1.357	1.44	94.3%	4
2.61	Plant Costs / Availability / Supply / Condition / Performance	0.85	0.834	0.98	84.9%	5
2.65	Number Of Bidders On Competitive Projects	0.80	0.663	0.83	79.3%	6
2.64	Level Of Competition & Level Of Construction Activity	0.78	0.694	0.89	77.3%	7
2.62	Weather Condition	0.50	0.500	1.00	49.5%	8
2.63	Government Regulations/Policies (Health & Safety, Fire)	0.48	0.274	0.57	47.7%	9

Table 3.6 Overall Ranking of Factors (medium size contractors)

No.	Description of Factors	Sensitive Index	Category Name	Overall Ranking
2.02	Financial Ability / Payment Record	100.0%	Client	1
2.43	Size / Gross Floor Area	100.0%	Project	2
2.45	No. Of Basement Levels	100.0%	Project	3
2.48	Type Of Structures (Steel, Concrete, Brick, Timber, Masonry)	100.0%	Project	4
2.56	Intensity / Complexity Of Building Services	100.0%	Project	5
2.58	Quality Of Finishing	100.0%	Project	6
2.59	Material Prices / Availability / Supply / Quality / Imports	100.0%	External	7
2.67	Stability Of Market Conditions	100.0%	External	8
2.37	Payment Modalities (Fixed Price, Cost Plus, Etc)	98.1%	Contract	9
2.47	Complexity	98.1%	Project	10
2.52	Type Of Foundations (Pile / Raft / Pad / ... Etc.)	98.1%	Project	11
2.2	Experience On Similar Projects	96.2%	Contractor	12
2.44	Height / No. Of Stories	96.2%	Project	13
2.6	Labor Costs / Availability / Supply / Performance /Productivity	94.3%	External	14
2.66	Interest Rate /Inflation Rate	94.3%	External	15
2.19	Financial Capability	92.4%	Contractor	16
2.07	Client Requirements On Quality	90.6%	Client	17
2.25	Productivity Effects:(Managerial, Organizational, Labor, Technology)	90.6%	Contractor	18
2.03	Project Finance Method /Appropriate Funding In Place On Time	88.8%	Client	19
2.01a	Type Of Client (Private)	88.7%	Client	20
2.28	Mark Up Policies & % (General & Project Wise) (Special Or Normal Conditions Applied)	88.7%	Contractor	21
2.46	Level Of Uncertainty Of Soil Conditions	86.8%	Project	22
2.01	Type Of Client (Public)	84.9%	Client	23
2.17	Management Team (Suitability, Experience, Performance)	84.9%	Contractor	24
2.61	Plant Costs / Availability / Supply / Condition / Performance	84.9%	External	25
2.4	Claims & Disputes Resolution Methods (Litigation / Arbitration / Others)	83.0%	Contract	26
2.51	Construction Method / Technology	83.0%	Project	27
2.57	Phasing Requirements (Areas To Be Handed Over First Or Initial Non-Availability)	83.0%	Project	28
2.12	Variation Orders & Additional Works (Magnitude, Timing, Interference Level)	81.1%	Consultant	29
2.54	Type Of Cladding & External Walls (Brick, Double Glazing, Etc.)	81.1%	Project	30
2.39	Spread Of Risk Between Construction Parties (Client / Consultant / Contractors)	79.3%	Contract	31
2.65	Number Of Bidders On Competitive Projects	79.3%	External	32
2.1	Build Ability Of Design	79.2%	Consultant	33

No.	Description of Factors	Sensitive Index	Category Name	Overall Ranking
2.49	Location (Regions / Rural ; Urban)&(Inner City / Outskirts)	79.2%	Project	34
2.5	Site Conditions / Site Topography	77.4%	Project	35
2.16	Absence Of Alterations And Late Changes To Design	77.3%	Consultant	36
2.64	Level Of Competition & Level Of Construction Activity	77.3%	External	37
2.41	Interviewing Of Selected Prospective Contractors	75.6%	Contract	38
2.21	Current Work Load	75.4%	Contractor	39
2.36	Tender Selection Method (Open, Selected, Negotiation, Single Or Two Stage, Etc. ...)	73.7%	Contract	40
2.55	Access To Site	73.6%	Project	41
2.05	Priority On Construction Time / Deadline Requirements	73.6%	Client	42
2.09	Completeness & Timeliness Of Project Information (Design, Drawings, Specifications)	71.7%	Consultant	43
2.23	Estimation Method & Cost Control Technique (Accuracy & Reliability)	71.7%	Contractor	44
2.35	Type Of Contract /Use Of Standard Form Of Contract	70.1%	Contract	45
2.15	Submission Of Early Proposals For Costing / Cost Planning	68.0%	Consultant	46
2.24	Planning Capability & Level Of Resource Deployment / Utilization / Optimization	68.0%	Contractor	47
2.11	Working Relationships With Client / Contractors / Other Design Team Consultants (Previous / Present)	66.3%	Consultant	48
2.14	Inspection, Testing & Approval Of Completed Works (Toughness / Requirements)	64.3%	Consultant	49
2.26	% Of Main Contractor Direct Work & % Of Subcontracted Work	64.3%	Contractor	50
2.53	Off-Site Prefabrication	64.2%	Project	51
2.18	Management / Labor Relationships & Confidence In Work Force	62.5%	Contractor	52
2.33	Bond / Warranty Arrangements	62.3%	Contractor	53
2.13	Quality Of Design & Specifications	60.6%	Consultant	54
2.38	Method Of Procurement (Traditional)	60.6%	Contract	55
2.27	Number Of Subcontractors	58.8%	Contractor	56
2.42	Type / Function (Residential, Building)	58.7%	Project	57
2.08	Certainty Of Project Brief	53.3%	Client	58
2.29	Record Of Payments To Sub-Contractors	49.6%	Contractor	59
2.62	Weather Condition	49.5%	External	60
2.06	Experience Of Procuring Construction	47.8%	Client	61
2.31	Present Claims (Size & Quantity)	47.7%	Contractor	62
2.63	Government Regulations/Policies (Health & Safety, Fire)	47.7%	External	63
2.3	Previous Claims Record I.E. Assessment Of 'Low Tender' – 'High Claims' Performance	45.9%	Contractor	64
2.22	Level Of Communications Within The Contractor Organization	44.0%	Contractor	65
2.32	Accidents On Sites Record	34.8%	Contractor	66
2.34	CDM Regulations Awareness	34.8%	Contractor	67
2.04	Partnering Arrangements	33.0%	Client	68

3.6 Attitude of Small size the contractors (G6&G7) Toward the Identified Factors

3.6.1 Factor ranking within each category:

The sensitivity index of each factor within each category was calculated according to mean weighted rating and coefficient of variation (Table 3.8). Consequently, Ranking of the different factors according to such sensitive index was assessed as shown in (Table 3.9).

Within the External factor and market characteristics category the sensitivity index ranged from (98.8% to 40.7%), two factors achieved sensitivity indices (98.8%) out of 9 factors, the Material prices (rank 1), labor costs(rank 2), other factors like stability of market conditions, plant costs and interest rate /inflation rate showed high sensitive indices 93.3%, 81.3% and 68.6% respectively. These were assigned ranks from 3-5. On the other hand, the lowest sensitive index was apparent in the government regulations/policies (health & safety, fire) factor 40.7% (rank 9)

Within the Project characteristics category the sensitivity index ranged from (98.8% to 47.2%), the greatest sensitive indices for 5 factors out of 17 were assigned for the size / gross floor area 98.8% (rank 1), type of foundations 98.2% (rank 2), level of uncertainty of soil conditions97.2% (rank 3), type of structures 96.4% (rank 4) and no. of basement levels 93.9% (rank 5). on the other hand, the least sensitive indices were assigned for phasing requirements (65%); (rank sixteen) and type / function (residential, building) (47.2%); Ranked Seventeen.

Within the Contractor characteristics category the sensitivity index ranged from (89.7% to 35.4%), the greatest sensitive indices for 4 factors out of 18 were assigned for the Mark Up Policies (89.7%), Management Team (Suitability, Experience, Performance) (83.6%), Financial capability (81.2%), Current Work Load (75.8%), being ranked 1,2,3 &4 respectively. On the contrary, the least sensitive indices were manifested for the Level of Communications within the Contractor Organization (43.6%) and CDM regulations awareness (35.4%) factors which exhibited ranks seventeen and eighteen.

Within the Contract procedure & Procurement method category the sensitivity index ranged from (83.7% to 44.8%), the payment modalities and claims & disputes resolution methods showed the highest sensitive indices; (83.7% & 65.5%) respectively, being ranked 1&2 within seven included factors. The lowest sensitivity percentages were recorded for the type of contract /use of standard form of contract (44.8%) which was given a rank of seventh.

Within the Client Characteristics category the sensitivity index ranged from (98.8% to 40.1%), the highest coefficient of variations and sensitivity indices were recorded for 5 factors out of 9. These were: financial ability/payment records (98.8%), client requirements on quality (97.6%), project finance method /appropriate were Funding in place on time (93.3%), type of client / privet (93.3%), and type of client / public (89.1%). Consequently, all the previous factors were ranked 1-5 respectively. The lowest ranked factor was partnering arrangements achieving sensitivity index (40.1%).

Finally, Within the Consultant and Designer characteristics category the sensitivity index ranged from (78.8% to 59%) which is low, the highest coefficient of variation and sensitivity index was apparent in the Variation Orders & Additional Works (Magnitude, Timing, and Interference Level factor which was assigned rank 1 (78.8%) at top of other 8 factors, build ability of design came second with sensitivity index (73.3%). On the other hand, the Quality of design and Specifications and submission of early proposals for costing / cost planning factors recorded the least sensitive index (59%) and assigned rank 7&8.

3.6.2 Overall ranking of factors among all Categories:

It was found that the top ten factors out of 68 included ones were financial ability / payment record 98.8%(rank 1), client requirements on quality 97.6%(rank 6), related to client category. Size / gross floor area 98.8% (rank 2), type of foundations 98.2% (rank 4), level of uncertainty of soil conditions 97.2% (rank 7), type of structures 96.4% (rank 8) and no. of basement levels 93.9% (rank 9) related to project category. Material prices factor and labor costs / availability / supply / performance /productivity exhibited a sensitive index of 98.8% and both are related to External category (rank 3 & 4). Finally, project finance method /appropriate funding in place on time related to the Cline category was assigned the 10^{th} rank with a sensitive index of 93.3%.Meanwhile, sensitive indices less than 50% were recorded in 10 factors; six factors were related to Contractor category; (present claims (size & quantity), interviewing of selected prospective contractors, method of procurement (traditional), type of contract /use of standard form of contract, level of communications within the contractor organization and CDM regulations awareness) ranked (59,61-64,68) respectively. Type / function (residential, building) related to Project category were (ranked 60). Finally certainty of project brief and partnering arrangements (Client category) assigned ranks 65 & 67 (Table 3.9).

3.6.3 Agreement on Category ranking:

For testing the reliability between cost estimators the significance of Friedman chi-square was measured. A very highly significant agreement was recorded among cost estimators for the sensitivity of: Client characteristics (chi-square=65.82), Project characteristics (chi-square=61.75), External factors & Market characteristics (chi-square=41.82) and Contractor characteristics (chi-square=32.32 and P=0.000). A repeated measures analysis of data, (Kendall's test) was made to supports this result better, those categories maintaining a coefficient of concordance (1.0) falling in the sensitive rating level . Furthermore, the other two categories; Contract procedure & procurement method (chi-square=37.75) and Consultant & Designer characteristics (chi-square=30.25) which indicating low reliability between the cost estimators, also showed low significant agreement at P=0.421, and 0.135 respectively, and achieving coefficient of concordance *W* 0.917 and 0.846 at the slightly sensitive level among cost estimators (Table 3.7).

Table 3.7 Category Ranking According to Kendall's test (small size contractors)

Category Rank	Category	Degree of freedom	Chi-square	Kendall's analysis for rating			Significance
				Insensitive	Slightly Sensitive	Sensitive	
1	Client Characteristics	8	65.82			1.0	0.000
2	Project Characteristics	16	61.75			1.0	0.000
3	External Factors & Market Characteristics	8	41.82			1.0	0.000
4	Contractor Characteristics,	17	32.32			1.0	0.000
5	Consultant & Designer Characteristics	7	37.75	0.293	0.917	0.112	0.421
6	Contract Procedure & Procurement Method	6	30.25	0.39	0.846	0.161	0.135

The descriptive statistical analysis shows agreement among cost estimators regarding the sensitivity level effect of categories factor on cost estimate 53%, 38% and 9% for sensitive, slightly and insensitive respectively (Fig.3.6).

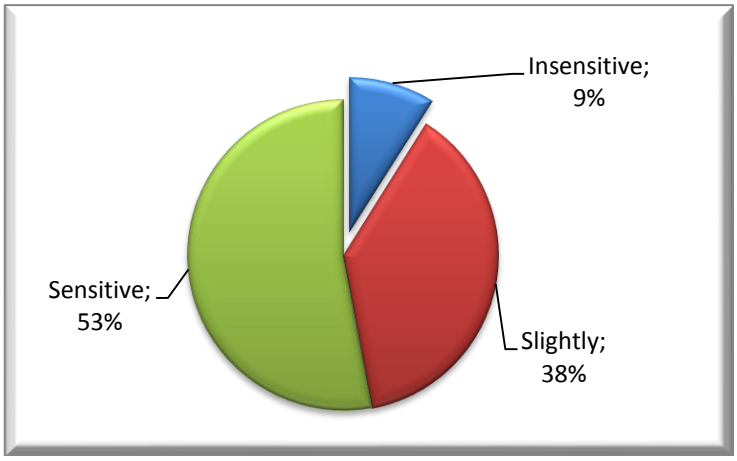


Fig 3.6 the agreement percent (53%) among cost estimators in small size contractors about the categories influence on cost estimate

The value of the sensitive level percentage (53%); divided among the six categories according to cost estimators agreement as follow; Client 14.3%, Project characteristics 14%, External factor & Market condition 12.2%, Contractors 10.7%, and other percent 1.8% divided among contract 1.2% on the other hand, the consultant and designer attributes group scored the least average sensitivity index of 0.60%. This indicates that the cost estimators (small size contractors) perceive that the client characteristics have more influence on construction project costs than any other categories. This outcome is may be acceptable; due to the direct relation between the contractors and the Client which makes the project costs are more determined by Client decisions which make the project final cost increase or decreased according to the client point of view (Fig 3.7).

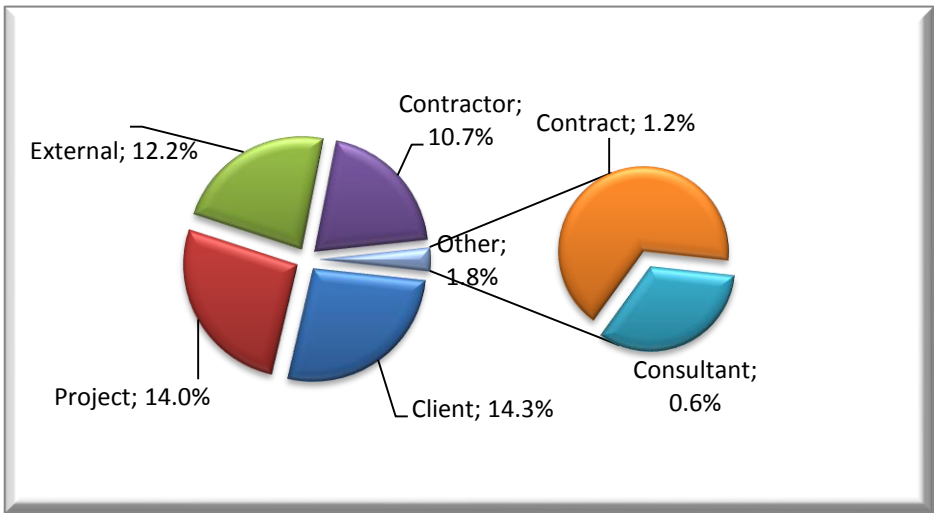


Fig 3.7 the categories breakdown for the 53%
Small size contractors which influence on cost estimate

These findings indicate that construction project costs estimate for small size contractors are more affected by client characteristics than by project and contractor.

Table 3.8 Category Ranking of Factors (small size contractors)

No.	Description of Factors	Mean weight rating	Standard Deviation	Coefficient variation	Sensitive Index	Category Ranking
	Client Characteristics					
2.02	Financial Ability / Payment Record	0.99	1.650	1.67	98.8%	1
2.07	Client Requirements On Quality	0.98	1.569	1.61	97.6%	2
2.03	Project Finance Method /Appropriate Funding In Place On Time	0.93	1.333	1.43	93.3%	3
2.01a	Type Of Client (Private)	0.93	1.293	1.38	93.3%	4
2.01	Type Of Client (Public)	0.89	1.041	1.17	89.1%	5
2.05	Priority On Construction Time / Deadline Requirements	0.74	0.723	0.97	73.9%	6
2.06	Experience Of Procuring Construction	0.54	0.427	0.80	53.1%	7
2.08	Certainty Of Project Brief	0.42	0.325	0.77	41.9%	8
2.04	Partnering Arrangements	0.40	0.377	0.93	40.1%	9
	Consultant & Designer Characteristics					
2.12	Variation Orders & Additional Works (Magnitude, Timing, Interference Level)	0.79	0.547	69%	78.8%	1
2.1	Build Ability Of Design	0.74	0.569	77%	73.3%	2
2.16	Absence Of Alterations And Late Changes To Design	0.70	0.573	82%	69.1%	3
2.14	Inspection, Testing & Approval Of Completed Works (Toughness / Requirements)	0.64	0.586	92%	63.1%	4
2.09	Completeness & Timeliness Of Project Information (Design, Drawings, Specifications)	0.61	0.531	87%	60.2%	5
2.11	Working Relationships With Client / Contractors / Other Design Team Consultants (Previous / Present)	0.60	0.288	48%	59.1%	6
2.13	Quality Of Design & Specifications	0.60	0.541	91%	59.0%	7
2.15	Submission Of Early Proposals For Costing / Cost Planning	0.60	0.592	99%	59.0%	8
	Contractor Characteristics,					
2.28	Mark Up Policies & % (General & Project Wise) (Special Or Normal Conditions Applied)	0.90	1.182	1.32	89.7%	1
2.17	Management Team (Suitability, Experience, Performance)	0.84	0.784	0.93	83.6%	2
2.19	Financial Capability	0.82	0.717	0.88	81.2%	3
2.21	Current Work Load	0.76	0.599	0.79	75.8%	4
2.2	Experience On Similar Projects	0.76	0.578	0.76	75.2%	5
2.25	Productivity Effects:	0.75	0.632	0.84	74.6%	6
2.18	Management / Labor Relationships & Confidence In Work Force	0.73	0.715	0.98	72.7%	7
2.26	% Of Main Contractor Direct Work & % Of Subcontracted Work	0.70	0.554	0.79	69.2%	8
2.33	Bond / Warranty Arrangements	0.68	0.620	0.91	67.4%	9
2.27	Number Of Subcontractors	0.65	0.483	0.74	64.4%	10
2.29	Record Of Payments To Sub-Contractors	0.57	0.247	0.43	56.7%	11
2.23	Estimation Method & Cost Control Technique (Accuracy & Reliability)	0.55	0.429	0.77	54.9%	12
2.3	Previous Claims Record I.E. Assessment Of 'Low Tender' – 'High Claims' Performance	0.55	0.342	0.62	54.3%	13
2.24	Planning Capability & Level Of Resource Deployment / Utilization / Optimization	0.55	0.471	0.86	54.3%	14
2.32	Accidents On Sites Record	0.53	0.063	0.12	52.6%	15

No.	Description of Factors	Mean weight rating	Standard Deviation	Coefficient variation	Sensitive Index	Category Ranking
2.31	Present Claims (Size & Quantity)	0.49	0.196	0.40	49.0%	16
2.22	Level Of Communications Within The Contractor Organization	0.44	0.341	0.77	43.6%	17
2.34	CDM Regulations Awareness	0.36	0.510	1.43	35.4%	18
	Contract Procedure & Procurement Method					
2.37	Payment Modalities (Fixed Price, Cost Plus, Etc)	0.84	0.860	1.02	83.7%	1
2.4	Claims & Disputes Resolution Methods (Litigation / Arbitration / Others)	0.66	0.438	0.66	65.6%	2
2.36	Tender Selection Method (Open, Selected, Negotiation, Single Or Two Stage, Etc. ...)	0.65	0.432	0.66	64.9%	3
2.39	Spread Of Risk Between Construction Parties (Client / Consultant / Contractors)	0.52	0.322	0.61	51.9%	4
2.41	Interviewing Of Selected Prospective Contractors	0.46	0.358	0.77	46.0%	5
2.38	Method Of Procurement (Traditional)	0.46	0.351	0.77	45.4%	6
2.35	Type Of Contract /Use Of Standard Form Of Contract	0.45	0.271	0.60	44.8%	7
	Project Characteristics					
2.43	Size / Gross Floor Area	0.99	1.650	1.67	98.8%	1
2.52	Type Of Foundations (Pile / Raft / Pad / ... Etc.)	0.98	1.609	1.64	98.2%	2
2.46	Level Of Uncertainty Of Soil Conditions	0.98	0.887	0.91	97.2%	3
2.48	Type Of Structures (Steel, Concrete, Brick, Timber, Masonry)	0.96	1.488	1.54	96.4%	4
2.45	No. Of Basement Levels	0.94	1.373	1.46	93.9%	5
2.56	Intensity / Complexity Of Building Services	0.92	1.218	1.32	92.1%	6
2.44	Height / No. Of Stories	0.89	1.195	1.35	88.6%	7
2.47	Complexity	0.89	1.007	1.14	88.5%	8
2.54	Type Of Cladding & External Walls (Brick, Double Glazing, Etc.)	0.85	0.821	0.97	84.2%	9
2.49	Location (Regions / Rural ; Urban)&(Inner City / Outskirts)	0.79	0.689	0.88	78.1%	10
2.53	Off-Site Prefabrication	0.77	0.522	0.68	76.3%	11
2.51	Construction Method / Technology	0.71	0.865	1.22	70.3%	12
2.58	Quality Of Finishing	0.70	0.983	1.41	69.0%	13
2.55	Access To Site	0.68	0.930	1.36	67.9%	14
2.5	Site Conditions / Site Topography	0.68	0.729	1.07	67.3%	15
2.57	Phasing Requirements (Areas To Be Handed Over First Or Initial Non-Availability)	0.65	0.511	0.78	65.0%	16
2.42	Type / Function (Residential, Building)	0.48	0.230	0.48	47.2%	17
	External Factors & Market Characteristics					
2.59	Material Prices / Availability / Supply / Quality / Imports	0.99	1.650	1.67	98.8%	1
2.6	Labor Costs / Availability / Supply / Performance /Productivity	0.99	1.347	1.36	98.8%	2
2.67	Stability Of Market Conditions	0.93	1.056	1.13	93.3%	3
2.61	Plant Costs / Availability / Supply / Condition / Performance	0.82	0.692	0.85	81.3%	4
2.66	Interest Rate /Inflation Rate	0.69	0.396	0.57	68.6%	5
2.65	Number Of Bidders On Competitive Projects	0.61	0.582	0.96	60.2%	6
2.62	Weather Condition	0.57	0.408	0.71	56.6%	7
2.64	Level Of Competition & Level Of Construction Activity	0.53	0.384	0.72	52.5%	8
2.63	Government Regulations/Policies (Health & Safety, Fire)	0.41	0.291	0.71	40.7%	9

Table 3.9 Overall Ranking of Factors (Small size Contractors)

No.	Description of Factors	Sensitive Index	Category Name	Overall Ranking
2.02	Financial Ability / Payment Record	98.8%	Client	1
2.43	Size / Gross Floor Area	98.8%	Project	2
2.59	Material Prices / Availability / Supply / Quality / Imports	98.8%	External	3
2.6	Labor Costs / Availability / Supply / Performance /Productivity	98.8%	External	4
2.52	Type Of Foundations (Pile / Raft / Pad / ... Etc.)	98.2%	Project	5
2.07	Client Requirements On Quality	97.6%	Client	6
2.46	Level Of Uncertainty Of Soil Conditions	97.2%	Project	7
2.48	Type Of Structures (Steel, Concrete, Brick, Timber, Masonry)	96.4%	Project	8
2.45	No. Of Basement Levels	93.9%	Project	9
2.03	Project Finance Method /Appropriate Funding In Place On Time	93.3%	Client	10
2.01a	Type Of Client (Private)	93.3%	Client	11
2.67	Stability Of Market Conditions	93.3%	External	12
2.56	Intensity / Complexity Of Building Services	92.1%	Project	13
2.28	Mark Up Policies & % (General & Project Wise) (Special Or Normal Conditions Applied)	89.7%	Contractor	14
2.01	Type Of Client (Public)	89.1%	Client	15
2.44	Height / No. Of Stories	88.6%	Project	16
2.47	Complexity	88.5%	Project	17
2.54	Type Of Cladding & External Walls (Brick, Double Glazing, Etc.)	84.2%	Project	18
2.37	Payment Modalities (Fixed Price, Cost Plus, Etc)	83.7%	Contract	19
2.17	Management Team (Suitability, Experience, Performance)	83.6%	Contractor	20
2.61	Plant Costs / Availability / Supply / Condition / Performance	81.3%	External	21
2.19	Financial Capability	81.2%	Contractor	22
2.12	Variation Orders & Additional Works (Magnitude, Timing, Interference Level)	78.8%	Consultant	23
2.49	Location (Regions / Rural ; Urban)&(Inner City / Outskirts)	78.1%	Project	24
2.53	Off-Site Prefabrication	76.3%	Project	25
2.21	Current Work Load	75.8%	Contractor	26
2.2	Experience On Similar Projects	75.2%	Contractor	27
2.25	Productivity Effects:	74.6%	Contractor	28
2.05	Priority On Construction Time / Deadline Requirements	73.9%	Client	29
2.1	Build Ability Of Design	73.3%	Consultant	30
2.18	Management / Labor Relationships & Confidence In Work Force	72.7%	Contractor	31
2.51	Construction Method / Technology	70.3%	Project	32
2.26	% Of Main Contractor Direct Work & % Of Subcontracted Work	69.2%	Contractor	33
2.16	Absence Of Alterations And Late Changes To Design	69.1%	Consultant	34
2.58	Quality Of Finishing	69.0%	Project	35

No.	Description of Factors	Sensitive Index	Category Name	Overall Ranking
2.66	Interest Rate /Inflation Rate	68.6%	External	36
2.55	Access To Site	67.9%	Project	37
2.33	Bond / Warranty Arrangements	67.4%	Contractor	38
2.5	Site Conditions / Site Topography	67.3%	Project	39
2.4	Claims & Disputes Resolution Methods (Litigation / Arbitration / Others)	65.6%	Contract	40
2.57	Phasing Requirements (Areas To Be Handed Over First Or Initial Non-Availability)	65.0%	Project	41
2.36	Tender Selection Method (Open, Selected, Negotiation, Single Or Two Stage, Etc. ...)	64.9%	Contract	42
2.27	Number Of Subcontractors	64.4%	Contractor	43
2.14	Inspection, Testing & Approval Of Completed Works (Toughness / Requirements)	63.1%	Consultant	44
2.09	Completeness & Timeliness Of Project Information (Design, Drawings, Specifications)	60.2%	Consultant	45
2.65	Number Of Bidders On Competitive Projects	60.2%	External	46
2.11	Working Relationships With Client / Contractors / Other Design Team Consultants (Previous / Present)	59.1%	Consultant	47
2.13	Quality Of Design & Specifications	59.0%	Consultant	48
2.15	Submission Of Early Proposals For Costing / Cost Planning	59.0%	Consultant	49
2.29	Record Of Payments To Sub-Contractors	56.7%	Contractor	50
2.62	Weather Condition	56.6%	External	51
2.23	Estimation Method & Cost Control Technique (Accuracy & Reliability)	54.9%	Contractor	52
2.3	Previous Claims Record I.E. Assessment Of 'Low Tender' – 'High Claims' Performance	54.3%	Contractor	53
2.24	Planning Capability & Level Of Resource Deployment / Utilization / Optimization	54.3%	Contractor	54
2.06	Experience Of Procuring Construction	53.1%	Client	55
2.32	Accidents On Sites Record	52.6%	Contractor	56
2.64	Level Of Competition & Level Of Construction Activity	52.5%	External	57
2.39	Spread Of Risk Between Construction Parties (Client / Consultant / Contractors)	51.9%	Contract	58
2.31	Present Claims (Size & Quantity)	49.0%	Contractor	59
2.42	Type / Function (Residential, Building)	47.2%	Project	60
2.41	Interviewing Of Selected Prospective Contractors	46.0%	Contract	61
2.38	Method Of Procurement (Traditional)	45.4%	Contract	62
2.35	Type Of Contract /Use Of Standard Form Of Contract	44.8%	Contract	63
2.22	Level Of Communications Within The Contractor Organization	43.6%	Contractor	64
2.08	Certainty Of Project Brief	41.9%	Client	65
2.63	Government Regulations/Policies (Health & Safety, Fire)	40.7%	External	66
2.04	Partnering Arrangements	40.1%	Client	67
2.34	CDM Regulations Awareness	35.4%	Contractor	68

3.7 Choosing the Sensitive Factors among all the Contractors

The Sets approach was applied in this study by choosing the sensitivity index values as the universe of discourse, X, which ranging from 0% to 100%, and divide it into three SETs describing the situations of the factors; insensitive SET, slightly sensitive SET and sensitive SET. The range for each SET is equal and obtained from the rating scale was taken from questionnaire, (Ques. 2) APENDEX (E), which was given before to the cost estimators for rating the factors, which are 1, 2 and 3. To make the fuzzy sets narrow and more closely spaced, a desired operation points is calculated as 16.67%, 50% and 83.33%. To calculate the operation points; the sum of the rating scale gives a total weight of 6 (1 + 2 + 3 = 6), while maximum value of the sensitivity index is (100%) so, the operated points will be equal to (the sensitivity index **100%** divided by the weight of the rating scale **6**) the result is 16.67% which represent the rang for each SET, so the first SET will start from 0% to 16.67%, the second SET will be (16.67%+16.67%=33.33%), the third SET will be (33.33+16.67=50%) the last SET will be (83.33+16.67=100) Fig 3.8

SETs rang		16.67% +	16.67% +	16.67% +	16.67% +	16.67% +
Operation points	16.67%	33.3%	**50%**	66.67%	**83.33%**	**100%**
SETs Number	1	2	3	4	**5**	6

Fig 3.8 Calculation process for the SETs rang

To develop the SETs, a significant overlap between them was created by making the base of one SET coincide the peak of the adjacent SET as shown on Fig 3.9

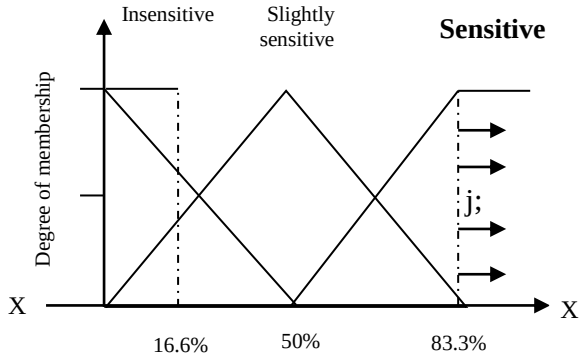


Fig. 3.9 Development of SETs

3.7.1 Creating the SETs for the Different Types of Contractors:

Three different groups of SETs were created for the study (SET; large, medium, and small size contractors). The universe of discourse X, will be the sensitivity index values for all the identified factors, $_yA(x)$ is the degree of membership which is equal to one, associated with element *x*.

The containment for any sensitive factor to be belonging to a SET is to comply with the following condition; membership = 1 this condition is applicable only for all the factors scored $\geq$ 83.33% sensitivity index (Fig 3.10).

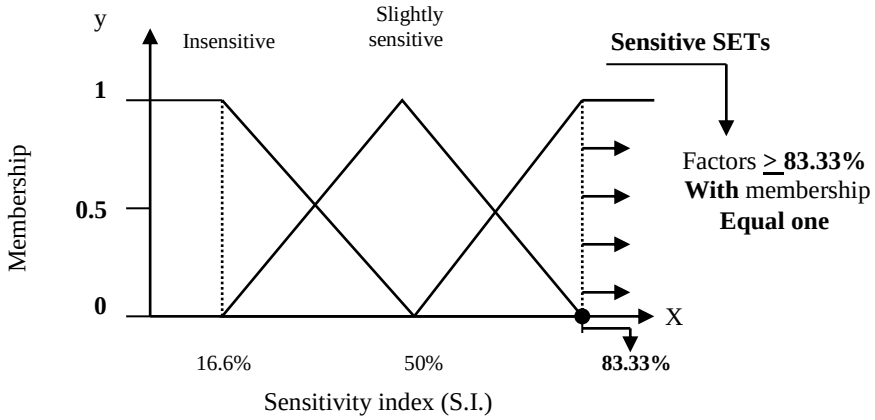


Fig 3.10 the two conditions for the sensitive SET membership

Example for large size contractors: The factor (project finance method /appropriate funding in place on time), which belong to client category, having a sensitivity index 84.6%, this value is greater than 83.33% which mean that this factor is fully contained in the sensitive set because it have a membership value of one.

Example for medium size contractors: The factor (build ability of design), which belong to consultant category, having a sensitivity index 79.2%, this value is less than 83.33%; which mean that this factor is not fully contained in the sensitive SET, because it have two values of membership, both is less than one, Fig 3.11, the lower value designated for the slightly sensitive SET, the higher for the sensitive one.

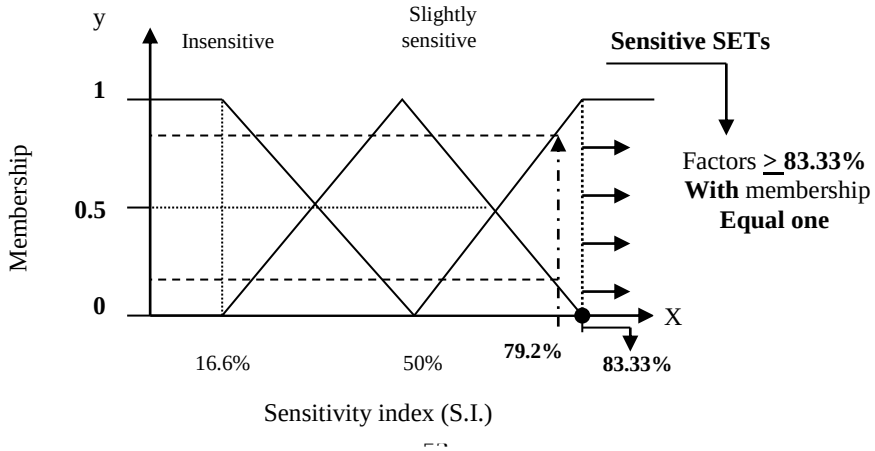


Fig 3.11 the build ability of design factor membership

From Table 3.3, the previous condition was applied to form a SET for the large size contractors; the selection for the sensitive factors based on the sensitivity index value, which resulting twenty three factors, from factor ranked one to factor ranked twenty three. Those factors comply with the previous conditions; this result formed in a SET which was designated as SET A shown in Fig 3.12, according to each factor serial numbers and also as it is listed in the next Table 3.10

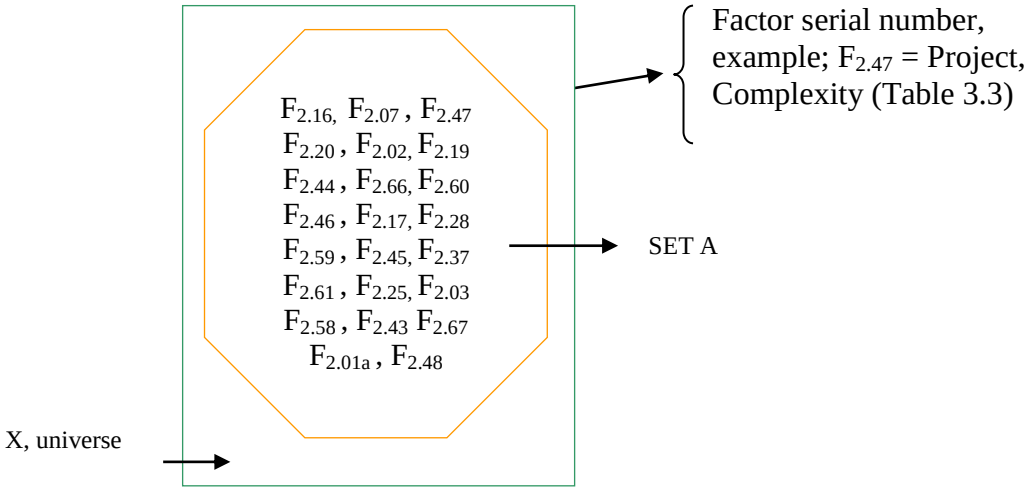


Fig 3.12 SET **A** for large size contractors

Description of SET A:

X ={x:x the sensitivity index for all the identified factors}

X={$F_{2.01}$, $F_{2.01a}$, $F_{2.02}$,……$F_{2.67}$, $F_{2.68}$}

A ={x:x the factors having sensitivity index $\geq$ 83.3%}

A is sub SET of X, A contained in X

SET A; contain 23 factors

3.7.2 Sensitive Factors Selection for Large Size Contractors

Table 3.10 SET A represent the ***sensitive*** factors $\geq$ 83.3% (Large size Contractors)

No.	Description of factors	Sensitive index	Category name
2.16	Absence Of Alterations And Late Changes To Design	86.1%	Consultant
2.07	Client Requirements On Quality	86.2%	Client
2.47	Complexity	98.5%	Projects
2.20	Experience On Similar Projects	93.8%	Contractor
2.02	Financial Ability / Payment Record	93.9%	Client
2.19	Financial Capability	92.3%	Contractor
2.44	Height / No. Of Stories	90.8%	Projects
2.66	Interest Rate /Inflation Rate	95.4%	External
2.60	Labor Costs / Availability / Supply / Performance /Productivity	96.9%	External
2.46	Level Of Uncertainty Of Soil Conditions	92.3%	Projects
2.17	Management Team (Suitability, Experience, Performance)	92.3%	Contractor
2.28	Mark up policies & % (general & project wise) (special or normal conditions applied)	87.7%	Contractor
2.59	Material Prices / Availability / Supply / Quality / Imports	96.9%	External
2.45	No. Of Basement Levels	87.7%	Projects
2.37	Payment Modalities (Fixed Price, Cost Plus, Etc)	90.8%	Contract
2.61	Plant Costs / Availability / Supply / Condition / Performance	98.5%	External
2.25	Productivity Effects:(Managerial, Organizational, Labor, Technology	84.6%	Contractor
2.03	Project Finance Method /Appropriate Funding In Place On Time	84.6%	Client
2.58	Quality Of Finishing	87.6%	Projects
2.43	Size / Gross Floor Area	87.7%	Projects
2.67	Stability Of Market Conditions	95.4%	External
2.01a	Type Of Client (Private)	89.2%	Client
2.48	Type Of Structures (Steel, Concrete, Brick, Timber, Masonry)	90.8%	Projects

Similarly SET B is formed for medium and small size contractors, according to Tables 3.6 chapter 3, the factors ranked from one to twenty five were selected to form SET B (Fig 3.13) and listed in (Table 3.11).

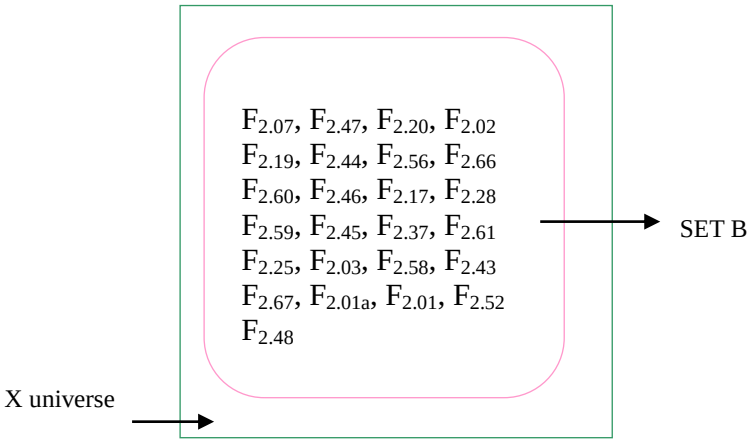


Fig 3.13 SET **B** for medium size contractors

Description of SET B:

X = {x:x the sensitivity index for all the identified factors }

X= {$F_{2.01}$, $F_{2.01a}$, $F_{2.02}$,……$F_{2.67}$, $F_{2.68}$}

B ={x:x the factors having sensitivity index $\geq$ 83.3%}

B is sub SET of X , B contained in X

SET B; contain **25 factors**

3.7.3 Sensitive Factors Selected for Medium Size Contractors

Table 3.11 Crisp SET B represents the ***sensitive*** factors (Medium size Contractors)

No.	Description of Factors	Sensitive Index	Category Name
2.07	Client Requirements On Quality	90.6%	Client
2.47	Complexity	98.1%	Project
2.20	Experience On Similar Projects	96.2%	Contractor
2.02	Financial Ability / Payment Record	100.0%	Client
2.19	Financial Capability	92.4%	Contractor
2.44	Height / No. Of Stories	96.2%	Project
2.56	Intensity / Complexity Of Building Services	100.0%	Project
2.66	Interest Rate /Inflation Rate	94.3%	External
2.60	Labor Costs / Availability / Supply / Performance /Productivity	94.3%	External
2.46	Level Of Uncertainty Of Soil Conditions	86.8%	Project
2.17	Management Team (Suitability, Experience, Performance)	84.9%	Contractor
2.28	Mark Up Policies & % (General & Project Wise) (Special Or Normal Conditions Applied)	88.7%	Contractor
2.59	Material Prices / Availability / Supply / Quality / Imports	100.0%	External
2.45	No. Of Basement Levels	100.0%	Project
2.37	Payment Modalities (Fixed Price, Cost Plus, Etc)	98.1%	Contract
2.61	Plant Costs / Availability / Supply / Condition / Performance	84.9%	External
2.25	Productivity Effects:(Managerial, Organizational, Labor, Technology)	90.6%	Contractor
2.03	Project Finance Method /Appropriate Funding In Place On Time	88.8%	Client
2.58	Quality Of Finishing	100.0%	Project
2.43	Size / Gross Floor Area	100.0%	Project
2.67	Stability Of Market Conditions	100.0%	External
2.01a	Type Of Client (Private)	88.7%	Client
2.01	Type Of Client (Public)	84.9%	Client
2.52	Type Of Foundations (Pile / Raft / Pad / ... Etc.)	98.1%	Project
2.48	Type Of Structures (Steel, Concrete, Brick, Timber, Masonry)	100.0%	Project

In the same way, SET C for the small size contractors the top twenty factors were selected (Fig 3.14) and listed on (Table 3.9).

Note: Tables 3.10, 3.11 and 3.12 were arranged alphabetically to facilitate the comparisons between SETs.

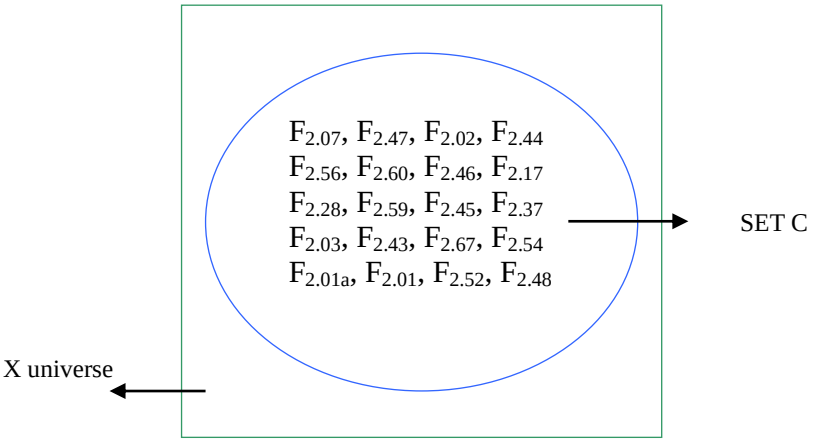


Fig 3.14 SET C for small size contractors

Description of SET C:

X = {x:x the sensitivity index for all the identified factors }

X= {$F_{2.01}$, $F_{2.01a}$, $F_{2.02}$,……$F_{2.67}$, $F_{2.68}$}

C ={x:x the factors having sensitivity index $\geq$ 83.3%}

(Table 3.12}, (Fig 3.14)

C is sub SET of X; C contained in X

SET C; contain **20 factors**

3.7.4 Sensitive Factors selected for Small Size Contractors

Table 3.12 crisp SET C represents the ***sensitive*** factors $\geq$ 83.3% (Small Size Contractors)

No.	Description of Factors	Sensitive Index	Category Name
2.07	Client Requirements On Quality	97.6%	Client
2.47	Complexity	88.5%	Project
2.02	Financial Ability / Payment Record	98.8%	Client
2.44	Height / No. Of Stories	88.6%	Project
2.56	Intensity / Complexity Of Building Services	92.1%	Project
2.60	Labor Costs / Availability / Supply / Performance /Productivity	98.8%	External
2.46	Level Of Uncertainty Of Soil Conditions	97.2%	Project
2.17	Management Team (Suitability, Experience, Performance)	83.6%	Contractor
2.28	Mark Up Policies & % (General & Project Wise) (Special Or Normal Conditions Applied)	89.7%	Contractor
2.59	Material Prices / Availability / Supply / Quality / Imports	98.8%	External
2.45	No. Of Basement Levels	93.9%	Project
2.37	Payment Modalities (Fixed Price, Cost Plus, Etc)	83.7%	Contractor
2.03	Project Finance Method /Appropriate Funding In Place On Time	93.3%	Client
2.43	Size / Gross Floor Area	98.8%	Project
2.67	Stability Of Market Conditions	93.3%	External
2.54	Type Of Cladding & External Walls (Brick, Double Glazing, Etc.)	84.2%	Project
2.01a	Type Of Client (Private)	93.3%	Client
2.01	Type Of Client (Public)	89.1%	Client
2.52	Type Of Foundations (Pile / Raft / Pad / ... Etc.)	98.2%	Project
2.48	Type Of Structures (Steel, Concrete, Brick, Timber, Masonry)	96.4%	Project

3.8 Selecting the Sensitive Factors by using SET theory

The sensitive factors; is the factors that cost estimators on the three groups of contractors, agreed upon their influence on cost estimate. One of the SET operations called INTERSECTION used to judge on the agreements between cost estimators. The intersection means: all elements that simultaneously reside in two or more SETs. The outcome will be three cases. The first case; complete disagreements between cost estimators; the intersection between SETs equals zero factors. The second case complete agreements between cost estimators, taken into consideration the different size of SETs, so the result in this case was equal to the smallest set contain factors (SET $A_{23factors}$ ∩ SET $B_{25factors}$ ∩ SET $C_{20factors}$ = the factors for SET $C_{20factors}$) this means that the intersection between the three SETs equals 20 factors. The third case will be partial agreement among cost estimators; where the intersection between SETs less than 20 factors Fig 3.15.

3.8.1 SETs Relation:

Partial agreement between cost estimators was represented through the following INTERSECTION equations:

$C \cap A \cap B = \{x: x \in C \text{ and } x \in A \text{ and } x \in B\}$

$C \cap A \cap B = \{F_{2.07}, F_{2.47}, F_{2.02}, F_{2.44}, F_{2.60}, F_{2.46}, F_{2.17}, F_{2.28}, F_{2.59}, F_{2.45}, F_{2.37}, F_{2.03}, F_{2.43}, F_{2.67}, F_{2.01a}, F_{2.48}\}$

Numbers of Factors = **16**, (shown in Table 3.15 and with designated column, marked blue)

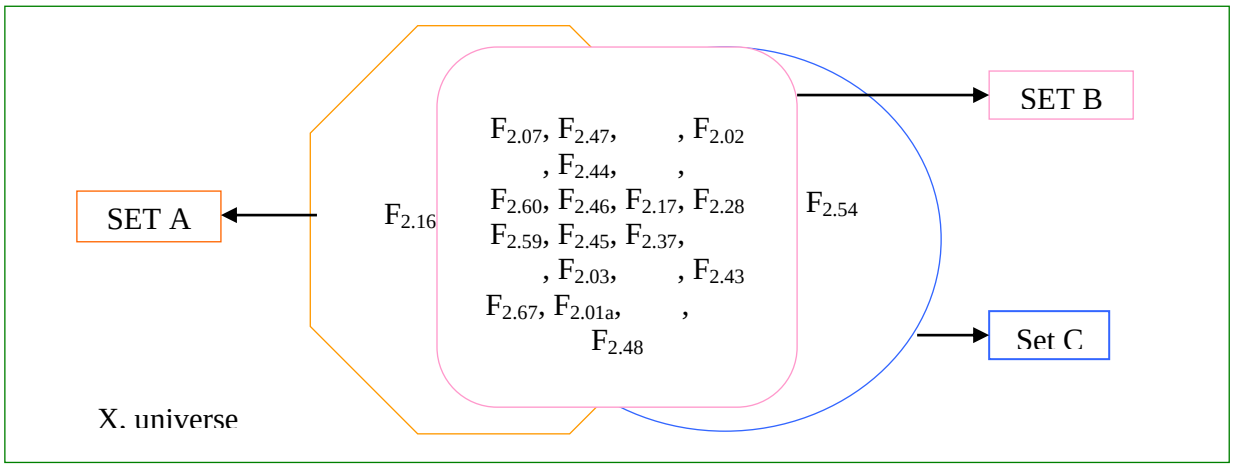


Fig 3.15 the Crisp SETs in partial agreement

3.8.2 Difference between SETs:

The collection of all factors on one SET and DOESN'T reside in other two sets

Large size contractors

The set of factors on A and NOT on B or C

$\{F_{2.16}\}$= {Absence of alterations and late changes to design} Numbers of Factors = 1

Medium size contractors

The factors on of SET $B_{25\ factors}$ and NOT on SET $A_{23\ factors}$ or SET $C_{20\ factors}$

{Ɵ, zero factors}

Which mean that: {x: x Є B and x Є A and x Є C}

Numbers of Factors = 0

Small size contractors

The factors on of SET $C_{20\ factors}$ and NOT on SET $A_{23\ factors}$ or SET $B_{25\ factors}$

$\{F_{2.54}\}$= {Type of cladding (brick, double glazing, etc.)} Assign under project category

Numbers of Factors = 1

3.8.3 Agreements Brief:

1. The cost estimators in the three contractors group agreed on 16 factors out of 25 factors; give a percent of 64%. Assign to five Categories; Client, Project, Contractors, Contract and External factors Table 3.15.
2. Agreement between Large and Medium size contractors was 22 out of 25 factors; give a percent of 88%. Assign to five Categories; Client, Project, Contractors, Contract and External factors Table 3.13.
3. Agreement between Large and Small size contractors was 16 out of 23 factors; give a percent of 69.5%. Assign to five Categories; Client, Project, Contractors, Contract and External factors Table 3.13.
4. Agreement between Medium and Small size contractors was 19 out of 25 factors; give a percent of 76%. Assign to five Categories; Client, Project, Contractors, Contract and External factors Table 3.13.
5. The sensitive factors; is the factors that cost estimators on the three groups of contractors, agreed upon their influence on cost estimate.

Table 3.13 Contractors group SETs relations

Factors no.	Description of Factors	SETs sensitivity index ≥ 83.33%			Agreement between cost Estimators in contractor groups			
		A large	B medium	C small	large medium Small	large medium	large small	 medium small
2.16	absence of alterations and late changes to design	86.1%						
2.07	client requirements on quality	86.2%	90.6%	97.6%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.47	Complexity	98.5%	98.1%	88.5%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.2	experience on similar projects	93.8%	96.2%			A ∩ B		
2.02	financial ability / payment record	93.9%	100.0%	98.8%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.19	financial capability	92.3%	92.4%			A ∩ B		
2.44	height / no. of stories	90.8%	96.2%	88.6%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.56	intensity / complexity of building services		100.0%	92.1%				B ∩ C
2.66	interest rate /inflation rate	95.4%	94.3%			A ∩ B		
2.6	labor costs / availability / supply / performance /productivity	96.9%	94.3%	98.8%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.46	level of uncertainty of soil conditions	92.3%	86.8%	97.2%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.17	management team (suitability, experience, performance)	92.3%	84.9%	83.6%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.28	mark up policies & % (general & project wise) (special or normal conditions applied)	87.7%	88.7%	89.7%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.59	material prices / availability / supply / quality / imports	96.9%	100.0%	98.8%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.45	no. of basement levels	87.7%	100.0%	93.9%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.37	payment modalities (fixed price, cost plus, etc)	90.8%	98.1%	83.7%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.61	plant costs / availability / supply / condition / performance	98.5%	84.9%			A∩ B		
2.25	productivity effects:(managerial, organizational, labor, technology)	84.6%	90.6%			A ∩ B		
2.03	project finance method /appropriate funding in place on time	84.6%	88.8%	93.3%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.58	quality of finishing	87.6%	100.0%			A ∩ B		
2.43	size / gross floor area	87.7%	100.0%	98.8%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.67	stability of market conditions	95.4%	100.0%	93.3%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.54	Type of cladding & external walls (brick, double glazing, etc.)			84.2%				
2.01a	type of client (private)	89.2%	88.7%	93.3%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
2.01	type of client (public)		84.9%	89.1%				B ∩ C
2.52	Type of foundations (pile / raft / pad / ... etc.)		98.1%	98.2%				B ∩ C
2.48	type of structures (steel, concrete, brick, timber, masonry)	90.8%	100.0%	96.4%	**A ∩ B ∩ C**	A ∩ B	A ∩ C	B ∩ C
	Total factors	23	25	20	**16**	22	16	19

Table 3.14 Factors Representing Strong Agreement Among the Three Contractors Groups

No.	Description of factors	Sensitive index			category name
		large size	medium size	small size	
2.07	Client Requirements On Quality	86.2%	90.6%	97.6%	Client
2.47	Complexity	98.5%	98.1%	88.5%	Projects
2.02	Financial Ability / Payment Record	93.9%	100.0%	98.8%	Client
2.44	Height / No. Of Stories	90.8%	96.2%	88.6%	Projects
2.60	Labor Costs / Availability / Supply / Performance /Productivity	96.9%	94.3%	98.9%	External
2.46	Level Of Uncertainty Of Soil Conditions	92.3%	86.8%	97.2%	Projects
2.17	Management Team (Suitability, Experience, Performance)	92.3%	84.9%	83.6%	Contractor
2.28	Mark Up Policies & % (General & Project Wise)	87.7%	88.7%	89.7%	Contractor
2.59	Material Prices / Availability / Supply / Quality / Imports	96.9%	100.0%	98.8%	External
2.45	No. Of Basement Levels	87.7%	100.0%	93.9%	Projects
2.37	Payment Modalities (Fixed Price, Cost Plus, Etc)	90.8%	98.1%	83.7%	Contract
2.03	Project Finance Method /Appropriate Funding In Place On Time	84.6%	88.8%	93.3%	Client
2.43	Size / Gross Floor Area	87.7%	100.0%	98.8%	Projects
2.67	Stability Of Market Conditions	95.4%	100.0%	93.3%	External
2.01a	Type Of Client (Private)	89.2%	88.7%	93.3%	Client
2.48	Type Of Structures (Steel, Concrete, Brick, Timber, Masonry)	90.8%	100.0%	96.4%	Projects

3.8.4 Ranking of the Sensitive Factors

The purpose of ranking the sensitive factors is to select the **key factors**, which were defined as; (the most factors having effect on the cost estimate) those factors to be used as input data for model attributes. In Table 3.14, the values of the sensitivity index is shown for the three contractors group and to rank the sensitive factors we should have only one index value, a sensitive mean weight for the three values was calculated by the Equation:

Mean weighted = $(\sum_i v_i * f_i) / n$ …….(3.1)

Where:

v_i = sensitivity index of each factor

f_i = frequency of responses for each contractor group (large $_{22}$, medium $_{18}$ and small $_{56}$)

n = total number of responses for all contractor group (96)

Then; all the factors were arranged in descending orders according to the sensitivity index value Table 3.15.

Example: Mean weight rating for *the materials characteristics factor:*

= ((96.9*22/96) + (100*18/96) + (98.8*56/96))/3 = 98.59%

Table 3.15 the Factors Represent the Full Agreements between the Three Contractors Group After Ranking

Rank	Description of factors	Mean weight	Category name
1	Material Prices / Availability / Supply / Quality / Imports	98.59%	External
2	Financial Ability / Payment Record	97.90%	Client
3	Labor Costs / Availability / Supply / Performance /Productivity	97.58%	External
4	Size / Gross Floor Area	96.48%	Projects
5	Type Of Structures (Steel, Concrete, Brick, Timber, Masonry)	95.79%	Projects
6	Stability Of Market Conditions	95.04%	External
7	Level Of Uncertainty Of Soil Conditions	94.13%	Projects
8	Client Requirements On Quality	93.68%	Client
9	No. Of Basement Levels	93.62%	Projects
10	Complexity	92.59%	Projects
11	Type Of Client (Private)	91.50%	Client
12	Height / No. Of Stories	90.53%	Projects
13	Project Finance Method /Appropriate Funding In Place On Time	90.46%	Client
14	Mark up policies & % (general & project wise) (special or normal conditions applied)	89.05%	Contractor
15	Payment Modalities (Fixed Price, Cost Plus)	88.03%	Contract
16	Management Team (Suitability, Experience, Performance)	85.84%	Contractor

3.9 Summary

The identified factors were statistically analyzed for each group of contractors also ranking of factors were made according to the opinion of each cost estimator in different contractor groups. For large size contractors Project Complexity factor was the most important one, while Accident on Site was not important and scored last in the overall ranking. But for medium and small size contractor's factor like Client Financial Ability and Payment Record was the most important one and scored 100% and 98.8% sensitivity index respectively. Sets theory was applied to identify the full agreement between the three groups of contractors which reviled sixteen factors and five categories out of six. The consultant group was not having significant effect on the cost estimate during tender stage. The factor Materials characteristics was the most important factor also the effect of Client financial ability and payment records was important Table 3.15.

CHAPTER 4

DISCUSSION AND FUZZY LOGIC MODEL FOR PREDECTING COST ESTIMATE VARIABILITY

4.1 Introduction

The previous chapter highlighted the level of importance the three groups of contractors have attached to the different factors in considering their effect on cost estimate. The factors that contributed significantly to the differences between the three groups of contractors in evaluating their influence were discussed under five categories out of six which was the consultant & design parameters and also conclude 16 factors out of 68.

4.2 Discussion of the Sensitive Factors

4.2.1 Client Category Factor; Financial Ability / Payment Record

Private and public clients have different effects on the cost estimate. The effect of client came from several factors such as: payment record, change orders, change of specification, ability to pay on time etc. The survey amongst cost estimators showed that the type of client has achieved an importance index of 92.51%, which indicates a high effect on cost estimate of construction projects. This might be attributed to the fact that private clients are more financially aware and try to get best value from their investment, whereas public sector is not commercially minded and also there is a problem of bureaucracy.

In the literature, it is reported that one of the major causes of business failure is related to client (Chan et al. 2004), client category factor; financial ability / payment record **scored second** on the top ranking factors. Agreements among cost estimators in the three contractors groups reflect the importance of this factor. This factor may put a strain on the contractors cost estimators to predict the cash flow needed. Cost estimators will increase the tender price if the client payment record is bad, and otherwise unpredictable estimate will occur and lead to claims. Semple et al. (1994), reported that claims occurred on private and public projects resulted in a 46.8% and 43% increase in cost respectively. Accordingly, cost estimators will estimate there projects higher to avoid claims or bid/no-bid decision.

4.2.2 External Category; Materials Characteristics

Stability of market condition **scored the top ranking** factors, sensitivity index which portray the agreements among cost estimators of the three contractor groups (large 95.4%,

medium 100% and small 93.3) reflect the importance of this factor. In countries where there is instability (often manifested by high inflation rate) of market condition, the effect of this factor is great and should not be disregarded. Cost estimators pay particular attention to this factor, change in contract clauses to hedge the effect of high inflation, so that both an owner and a contractor share the effect of price escalation. If these types of contract clauses do not exist, then the contractor bears all inflation effect. In those cases, a contractor should pay particular attention to the effect of inflation on its cost and consider it in its cost estimate (Akinci 1998). Also as the project duration increases, the market instability increases.

4.2.3 Project Characteristics

4.2.3.1 Size / Gross Floor Area

Project size and gross floor area of construction projects play a significant role in cost estimate process. Previous studies have shown that project size influence cost estimate. Thomas Randolph et al. (1990), conclude that as the project size increase the effect on cost estimate increase. This factor has an average sensitivity index of 99.4% and **ranked fourth** which indicates the importance of this factor.

4.2.3.2 Project Complexity

Project complexity is presented by the complexity of the design and the build ability, use of advanced technology, specialized methods of construction and the integration of multiple disciplines (Rusteika and Boomer 1992). The contractor who has prior experience with the use of specialized method or advanced technology faces less risk, so the contractor cost estimator estimate less.

In the study, full agreement among cost estimators in large and medium size contractors about the effect of this factor on cost estimate with an average sensitivity index of 98%.

In general, in complex design, estimators will have a harder time visualizing the construction process and hence will not be able to estimate the quantities, production rates, and unit cost related to project accurately. According to the cost estimators experience they will start to obtain figures resulted from guesswork rather than a systematic estimating approach.

4.2.3.3 Building Services Complexity

Building services cost contributes significantly to the total cost of projects. It is well documented in literature that the cost of buildings increases with the complexity of the

building services. The survey analysis showed that building services complexity has gained an importance index among all contractors size (81.5%, 100% and 92.1% for large, medium and small contractors respectively) which indicates a high effect on cost estimate of construction projects. These results reinforce the view that building services complexity has direct effect on the cost of projects.

4.2.3.4 Building Location

Regional variation as well as location within the same region is perceived to have a considerable impact on the cost estimate. Here, location refers to rural, inner city and city outskirts within the same region. The data analysis for the survey shows that the location has achieved an importance sensitivity index of 83% for large size, 79.2% for medium size and 78.1% for small size contractors, with an average index of 80% which indicates an effect on cost and duration of construction projects.

Projects that are located within inner cities are more expensive than other sites. This can be attributed to the fact that inner city projects may require demolition and also problems related to storage and access. Other possibly factors include transport, restriction on working conditions.

4.2.3.5 Number of Basement Levels

Literature review shows that number of basement levels influence directly the final project cost. From the survey analysis we can see that basement level has gained an importance sensitivity index with 87%, 100% and 94% for large, medium and small size contractors respectively. The cost estimators for large size contractors rate this factor less, this might be attributed as the large size contractor have more experience and adopting good construction methods that would which reduce the effect of this factor on cost estimate.

4.2.3.6 Type of Structures

Project manager's practical experience shows that type of structure has different effects on the final cost of projects. This might be attributed to several variables like different type of materials, formwork and plants required, and also the time required for the erection of different types of frames. The analysis for this factor shows a strong agreement between medium and small size contractor's (index of 100% and 96%), which indicates a high effect on cost estimate of construction projects.

4.2.3.7 Foundation Type

It is obvious that different type of foundations have different effects on the final costs of projects. This study is trying to establish the degree of influence of this factor in cost estimate. The cost estimators rating for this factor indicate that the type of foundation has achieved an importance average index of 93%, which indicates a high effect on cost estimate of construction projects. Literature survey shows that, the most expensive type of foundation is found to be the piles followed by strip footings and at the bottom of the list comes the pad footings. Nevertheless, the contribution of the foundation is proved to be significant to cost estimate.

4.2.3.8 Level of Uncertainty of Soil Condition

This factor is taking account of the load bearing capacity of different types of soils. The questionnaire classifies this factor as good, moderate and poor according to their load bearing capacity. It is perceived that as the soil capacity decreases the cost estimate would decrease.

The data analysis support that uncertainty of soil condition achieved an average importance sensitivity index of 94.5% between large and small size contractors, which indicates a high degree of influence on cost estimate of construction projects.

4.2.3.9 Height / Number of Story

The study amongst the cost estimators shows that the number of story has achieved an importance average index of 93%, which indicates a high degree of influence on cost estimate of construction projects. These results unveil that as the number of story increases, the average tender price per unit area decreased, this outcome supported by practical experience.

4.2.4 Contract Procedures & Procurement Methods

4.2.4.1 Payment Modality

Contract types may be grouped into two major categories: **Cost-reimbursable** contracts include all contract types that allow price adjustments relative to project costs. Cost plus contract are an example of this type contract. In cost plus contract, owners agree that they will reimburse the contractors for all construction costs that they have incurred and pay a fee for their services.

Fixed- price contracts include all contract type that requires the contractor to establish a stipulated sum for the completion defined scope of work. Examples of this type of contract are lump-sum and unit-price. In the lump- sum contracts, contractors agree on completing a defined package of work for a fixed sum of money. In the unit-price contracts, contractors agree on performing the quantities of work required in the field at the quoted unit prices. In the fixed-price contracts risk is allocated primarily toward the contractor, where contractors bear all the financial burdens of cost overruns if scope or site conditions do not change. In cost-reimbursable contracts, the owner has a greater degree of risk sharing with the contractors. As a result, contractor cost estimators who engage in fixed price contract should be particularly concerned about defining, analyzing, and determining the cost impact of all the risk and uncertainties to be involved in the project to achieve realistic cost estimate (Akinci 1998).

4.3 Determining the Model Factors

After ranking the factors which are; the most factors affecting the cost estimate including the sensitive one, the model factors were defined in order to reduce the number of equations to be used for the module attribute by applying **Pareto principal** on the selected factors given in Table 3.15.

Pareto principals; 80-20 rule has demonstrated that 80/20 Pareto distributions were very common in various fields and not exclusive to income distribution.

To find the contribution of Pareto principle in this study we simply divide the total number of the sensitive factors (16) over the total number of the identified factors (68) that gives value of 0.23, which mean that the contribution of Pareto principal in this study was 77/23 instead of 20/80. The interpretation of this result is: *Twenty three percent of the identified factors having seventy seven percent effects on cost estimate*

This contribution of Pareto principle (23/77) was applied to select the model factors; by multiplying the Pareto percent (0.23) by the number of the sensitive factors (16 factors) Table 3.15, the result is the first four factors which are:

1. **Material Prices / Availability / Supply / Quality / Imports.**
2. **Client Financial Ability / Payment Record.**
3. **Labor Costs / Availability / Supply / Performance /Productivity.**
4. **Project Size / Gross Floor Area.**

Those four factors used as input for the fuzzy model after combining together two of them which are; Materials Prices and Labor cost, because they are related to on category also both of them can be affected the construction market characteristics. This model we will map the input variables (three factors) to produce an output crisp value for the cost estimate inaccuracy.

4.4 The Fuzzy Logic Model

4.4.1 Introduction for Model Concept and Borders

Cost estimates are prepared for a variety of purposes, the end result establishing not only the degree of detail and accuracy of the estimate but also the effort involved and time allowed (or required) for its preparation. Depending on the amount of information available, estimates are grouped into three types, rough or order of magnitude estimates, budget estimates and definitive estimates, each of them having different accuracy. In this study a Fuzzy logic concept was applied to predict the cost estimate accuracy. The result is a crisp value with sign either positive or negative. Positive sign indicate: the predicted value maybe higher than the project actual cost on the opposite, negative sign means the predicted value maybe less than the project actual cost.

Borders: Cost estimate type; definitive (where accuracy ranging between -5% to +10%), level of information is high and design is completed.

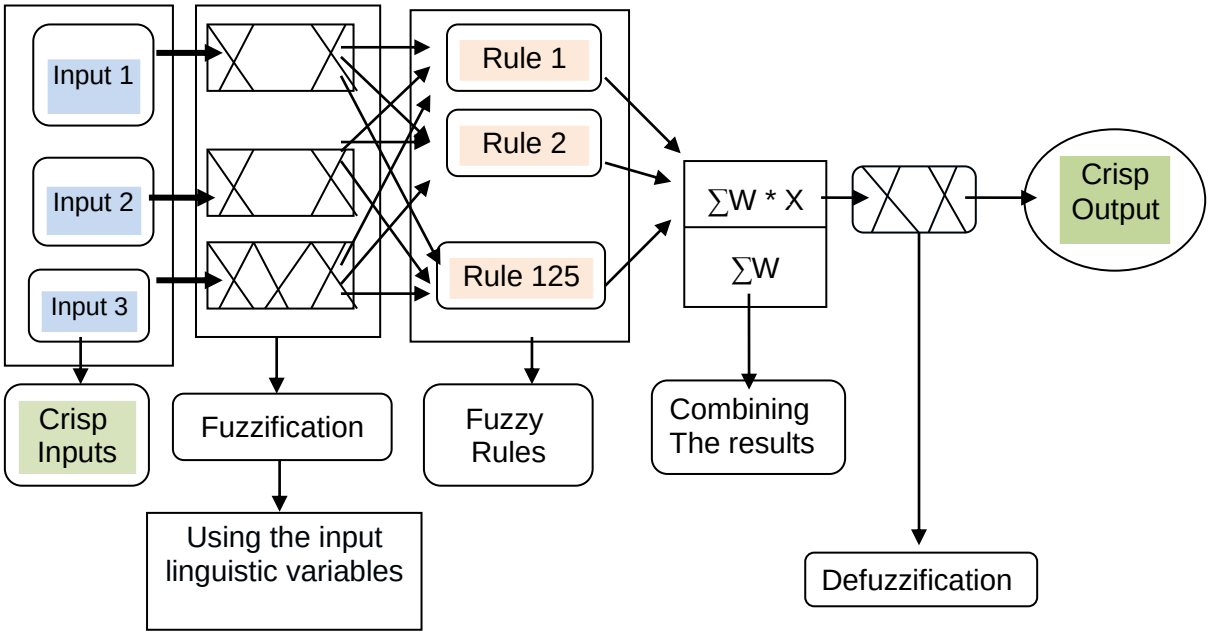


Figure 4.1Fuzzy Logic Model Structures

4.4.2 Input Variables Membership Function

The most important step in the design of fuzzy systems is the determination of the membership functions of the sets. There are many guidelines on developing the membership functions for fuzzy Sets. The method, which have been used in the study is (trimf) **Triangular-shaped built-in membership function**

Syntax y = trimf(x, params)

y = trimf(x,[a b c])

Description

The triangular curve is a function of a vector, x, and depends on three scalar parameters a, b, and c, as given by

$$f(x;a,b,c)=\begin{cases}0, & x\le a\\ \dfrac{x-a}{b-a}, & a\le x\le b\\ \dfrac{c-x}{c-b}, & b\le x\le c\\ 0, & c\le x\end{cases} \quad \text{----------} \quad (4.1)$$

Or, more compactly, by

$$f(x;a,b,c)=\max\left(\min\left(\frac{x-a}{b-a},\frac{c-x}{c-b}\right),o\right) \quad \text{----------} \quad (4.2)$$

The parameters A and C locate the "base" of the triangle and the parameter B locates the peak (Fig. 4.2).

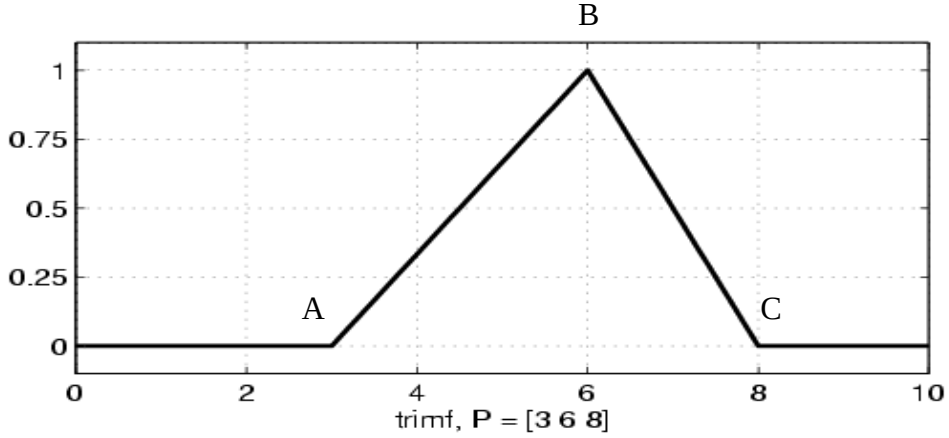


Figure 4.2 Member Ship Calculations

4.4.3 Fuzzification

Means using the membership functions of linguistic variables to compute each term's degree of validity at a specific operation point of the inference process. Fuzzification is the first step in the computation of a fuzzy system and must be performed for each input variable.

4.4.4 Fuzzy Rules

The computation of fuzzy rules is called fuzzy rule inference; the inference is a calculus consisting of two main steps: (1) Aggregation, (2) Composition. The majority of fuzzy based systems use production rules to represent the relation among the system variables and derive actions and predictions from the inputs. A rule consists of "if" part and "then" part. The rules **"IF"** part describe the situation, for which the rules are designed. The "**THEN"** part describes the response of the **fuzzy** system in this situation.

The following fuzzy rules are used to represent the relationship between: predicted cost estimate accuracy and its attributes of three key factors just to reduce the number of rules (125 Rules); Client Financial Ability, Labors Cost and Materials Prices finally Project size so;

R1: **IF** Client financial ability is **V. Low** and Project Size is **V. Low** and Labors and Materials Prices is **V. Low THEN** predicted cost estimate accuracy **is V. Low.**

In the previous fuzzy rule R1, the condition consists of **Three pre-conditions** linked together by an **AND** operator.

First pre-condition → (Client Financial Ability = V. Low.),

Second pre-condition → (Labors and Materials Prices =V. Low)

Third pre-condition → (Project size = V. Low)

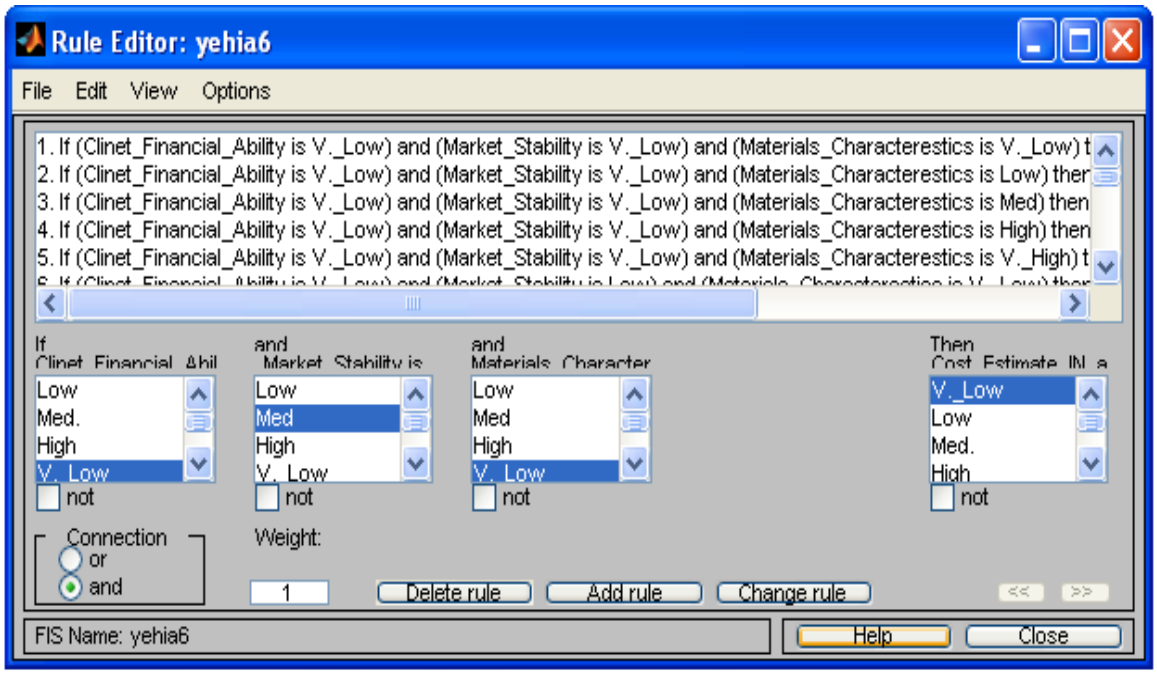


Figure 4.3 the Fuzzy Rule in the MatlaB Screen

IF Client Financial Ability is **V. Low and** Labors and Materials Prices is **Medium and** Project Size is **V. High THEN** Cost estimate accuracy is **Medium**

Table 4.1 Rules Used for the Model

Rule no.	**IF**	Client financial ability	**and**	Project Size	**and**	Labors and Materials Prices	**THEN**	Cost estimate accuracy
1	IF	V. Low	and	V. Low	and	V. Low	THEN	V. Low
2	IF	V. Low	and	V. Low	and	Low	THEN	V. Low
3	IF	V. Low	and	V. Low	and	Medium	THEN	V. Low
4	IF	V. Low	and	V. Low	and	High	THEN	Low
5	IF	V. Low	and	V. Low	and	V. High	THEN	Low
6	IF	V. Low	and	Low	and	V. Low	THEN	V. Low
7	IF	V. Low	and	Low	and	Low	THEN	V. Low
8	IF	V. Low	and	Low	and	Medium	THEN	Low
9	IF	V. Low	and	Low	and	High	THEN	Low
10	IF	V. Low	and	Low	and	V. High	THEN	Low
11	IF	V. Low	and	Medium	and	V. Low	THEN	V. Low
12	IF	V. Low	and	Medium	and	Low	THEN	Low
13	IF	V. Low	and	Medium	and	Medium	THEN	Low
14	IF	V. Low	and	Medium	and	High	THEN	Low
15	IF	V. Low	and	Medium	and	V. High	THEN	Medium
16	IF	V. Low	and	High	and	V. Low	THEN	Low
17	IF	V. Low	and	High	and	Low	THEN	Low
18	IF	V. Low	and	High	and	Medium	THEN	Low
19	IF	V. Low	and	High	and	High	THEN	Medium
20	IF	V. Low	and	High	and	V. High	THEN	Medium
21	IF	V. Low	and	V. High	and	V. Low	THEN	Low
22	IF	V. Low	and	V. High	and	Low	THEN	Low
23	IF	V. Low	and	V. High	and	Medium	THEN	Medium
24	IF	V. Low	and	V. High	and	High	THEN	Medium
25	IF	V. Low	and	V. High	and	V. High	THEN	Medium
26	IF	Low	and	V. Low	and	V. Low	THEN	V. Low
27	IF	Low	and	V. Low	and	Low	THEN	V. Low
28	IF	Low	and	V. Low	and	Medium	THEN	Low
29	IF	Low	and	V. Low	and	High	THEN	Low
30	IF	Low	and	V. Low	and	V. High	THEN	Low
31	IF	Low	and	Low	and	V. Low	THEN	V. Low
32	IF	Low	and	Low	and	Low	THEN	Low
33	IF	Low	and	Low	and	Medium	THEN	Low
34	IF	Low	and	Low	and	High	THEN	Low
35	IF	Low	and	Low	and	V. High	THEN	Medium
36	IF	Low	and	Medium	and	V. Low	THEN	Low
37	IF	Low	and	Medium	and	Low	THEN	Low
38	IF	Low	and	Medium	and	Medium	THEN	Low
39	IF	Low	and	Medium	and	High	THEN	Medium
40	IF	Low	and	Medium	and	V. High	THEN	Medium
41	IF	Low	and	High	and	V. Low	THEN	Low
42	IF	Low	and	High	and	Low	THEN	Low
43	IF	Low	and	High	and	Medium	THEN	Medium
44	IF	Low	and	High	and	High	THEN	Medium
45	IF	Low	and	High	and	V. High	THEN	Medium
46	IF	Low	and	V. High	and	V. Low	THEN	Low
47	IF	Low	and	V. High	and	Low	THEN	Medium
48	IF	Low	and	V. High	and	Medium	THEN	Medium
49	IF	Low	and	V. High	and	High	THEN	Medium

Rule no.	IF	Client financial ability	and	Project Size	and	Labors and Materials Prices	THEN	Cost estimate accuracy
50	IF	Low	and	V. High	and	V. High	THEN	High
51	IF	Medium	and	V. Low	and	V. Low	THEN	V. Low
52	IF	Medium	and	V. Low	and	Low	THEN	Low
53	IF	Medium	and	V. Low	and	Medium	THEN	Low
54	IF	Medium	and	V. Low	and	High	THEN	Low
55	IF	Medium	and	V. Low	and	V. High	THEN	Medium
56	IF	Medium	and	Low	and	V. Low	THEN	Low
57	IF	Medium	and	Low	and	Low	THEN	Low
58	IF	Medium	and	Low	and	Medium	THEN	Low
59	IF	Medium	and	Low	and	High	THEN	Medium
60	IF	Medium	and	Low	and	V. High	THEN	Medium
61	IF	Medium	and	Medium	and	V. Low	THEN	Low
62	IF	Medium	and	Medium	and	Low	THEN	Low
63	IF	Medium	and	Medium	and	Medium	THEN	Medium
64	IF	Medium	and	Medium	and	High	THEN	Medium
65	IF	Medium	and	Medium	and	V. High	THEN	Medium
66	IF	Medium	and	High	and	V. Low	THEN	Low
67	IF	Medium	and	High	and	Low	THEN	Medium
68	IF	Medium	and	High	and	Medium	THEN	Medium
69	IF	Medium	and	High	and	High	THEN	Medium
70	IF	Medium	and	High	and	V. High	THEN	High
71	IF	Medium	and	V. High	and	V. Low	THEN	Medium
72	IF	Medium	and	V. High	and	Low	THEN	Medium
73	IF	Medium	and	V. High	and	Medium	THEN	Medium
74	IF	Medium	and	V. High	and	High	THEN	High
75	IF	Medium	and	V. High	and	V. High	THEN	High
76	IF	High	and	V. Low	and	V. Low	THEN	Low
77	IF	High	and	V. Low	and	Low	THEN	Low
78	IF	High	and	V. Low	and	Medium	THEN	Low
79	IF	High	and	V. Low	and	High	THEN	Medium
80	IF	High	and	V. Low	and	V. High	THEN	Medium
81	IF	High	and	Low	and	V. Low	THEN	Low
82	IF	High	and	Low	and	Low	THEN	Low
83	IF	High	and	Low	and	Medium	THEN	Medium
84	IF	High	and	Low	and	High	THEN	Medium
85	IF	High	and	Low	and	V. High	THEN	Medium
86	IF	High	and	Medium	and	V. Low	THEN	Low
87	IF	High	and	Medium	and	Low	THEN	Medium
88	IF	High	and	Medium	and	Medium	THEN	Medium
89	IF	High	and	Medium	and	High	THEN	Medium
90	IF	High	and	Medium	and	V. High	THEN	High
91	IF	High	and	High	and	V. Low	THEN	Medium
92	IF	High	and	High	and	Low	THEN	Medium
93	IF	High	and	High	and	Medium	THEN	Medium
94	IF	High	and	High	and	High	THEN	High
95	IF	High	and	High	and	V. High	THEN	High
96	IF	High	and	V. High	and	V. Low	THEN	Medium
97	IF	High	and	V. High	and	Low	THEN	Medium
98	IF	High	and	V. High	and	Medium	THEN	High
99	IF	High	and	V. High	and	High	THEN	High
100	IF	High	and	V. High	and	V. High	THEN	High
101	IF	V. High	and	V. Low	and	V. Low	THEN	Low

Rule no.	IF	Client financial ability	and	Project Size	and	Labors and Materials Prices	THEN	Cost estimate accuracy
102	IF	V. High	and	V. Low	and	Low	THEN	high
103	IF	V. High	and	V. Low	and	Medium	THEN	Medium
104	IF	V. High	and	V. Low	and	High	THEN	Medium
105	IF	V. High	and	V. Low	and	V. High	THEN	Medium
106	IF	V. High	and	Low	and	V. Low	THEN	high
107	IF	V. High	and	Low	and	Low	THEN	Medium
108	IF	V. High	and	Low	and	Medium	THEN	Medium
109	IF	V. High	and	Low	and	High	THEN	Medium
110	IF	V. High	and	Low	and	V. High	THEN	Low
111	IF	V. High	and	Medium	and	V. Low	THEN	Medium
112	IF	V. High	and	Medium	and	Low	THEN	Medium
113	IF	V. High	and	Medium	and	Medium	THEN	Medium
114	IF	V. High	and	Medium	and	High	THEN	Low
115	IF	V. High	and	Medium	and	V. High	THEN	Low
116	IF	V. High	and	High	and	V. Low	THEN	Medium
117	IF	V. High	and	High	and	Low	THEN	Medium
118	IF	V. High	and	High	and	Medium	THEN	Low
119	IF	V. High	and	High	and	High	THEN	Low
120	IF	V. High	and	High	and	V. High	THEN	Low
121	IF	V. High	and	V. High	and	V. Low	THEN	Medium
122	IF	V. High	and	V. High	and	Low	THEN	Low
123	IF	V. High	and	V. High	and	Medium	THEN	Low
124	IF	V. High	and	V. High	and	High	THEN	Low
125	IF	V. High	and	V. High	and	V. High	THEN	V. Low

4.4.5 Defuzzification,

The objective of the Defuzzification process is to translate the linguistic outputs of the inference process into numerical values, centroid method used in the study

$$F(X) = Wj\mu ij(X) / \sum Wj \qquad (4.3)$$

Where f (x) is the crisp value (defuzzified numerical value)

Wj is the degree of validity (weight), μij (x) is the ith corresponding numerical value

4.4.6 Example

IF Client financial ability is **V. low** and Labors and Materials Prices is **Medium** and Projects Size is **High THEN** predicted cost estimate accuracy **is medium.**

Client Financial Ability is **V**. **low = 2**

Project Size is **Medium** = **4.5**

Labors and Materials Prices is **High = 6**

Predicted cost estimate accuracy **is medium = + 1.48%**

*Explanation of result: The cost estimation value obtained by the estimators in the early stage of the project maybe more than the actual cost by **1.48%.***

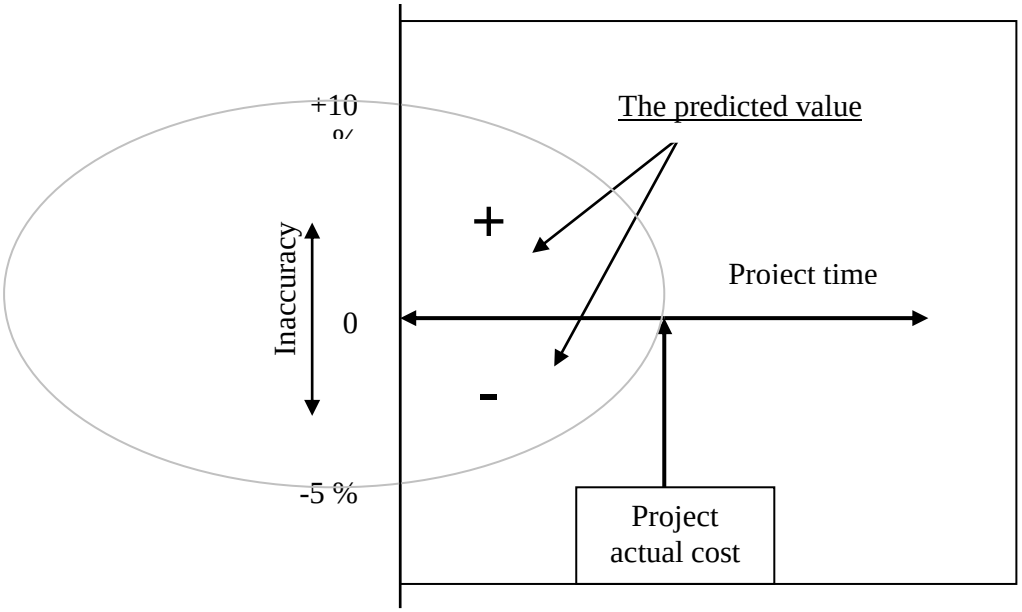


Figure 4.4 the *key factors* effect; either increasing or decreasing the gap between actual cost and cost estimate of the project

The scoring procedure, help in defining the estimate inaccuracy. The estimator (large, medium and small contractors) can enter the base **estimate** into an Excel sheet and then score the **key factors** Table 3.14 **representing the full agreement among raters**. The **estimate Score** can automatically calculated thorough Excel sheet, as the user rates each factor components, then the score results to be transferred to the MatlaB software – Fuzzy logic for Defuzzification procedure, the user can check the role generation to be confidant with the result. The output crisp value is an indication to cost estimate inaccuracy which mean that the **gap** between cost estimate and actual cost either increased or decreased according to the sign **(+** or **-)** .

CHAPTER 5

CONCLUSIONS AND FUTURE WORK

5.1 Summary

This study investigated the attitude of cost estimators towards some factors affecting the cost estimation of the construction projects and the likely effect of contractor size on such attitudes. Moreover, the cost estimators in three groups of contractors; small, medium and large-size were examined. However, the cost estimators indented several factors as important and influential. Some factors are strongly emphasized by the three groups of contractors, small, medium and large, while others by each two of groups. Sixty-eight variables affecting construction cost estimate were identified through literature and pilot interviews, then grouped into six broad categories: client characteristics, consultant and design parameters, contractor attributes, project characteristics, contract procedures and procurement methods and external factors and market conditions. Cost estimators attitudes towards the importance of these category factors varied with contractor size.

Data Collected from the Questionnaire

It was found that:

- 15% only of those involved in the tender stage are cost estimators.
- 62% of project managers are responsible for the estimating process and 23% for technical office managers.
- 65% of the cost estimators in this study relied on their experience to get an accurate estimate rather than any other methods.
- The less information available in tendering stage, the more experience is required to do a cost estimate.

Regarding the educational level

- 47% having architectural back ground,
- 42% civil and 11% for others.
- 1% of the estimators are females. Performing cost estimation requires knowledge and experience from construction sites. However, females are less exposed to such type of work and thus why they do not work as estimators.

5.2 Conclusions

From the results of the present study, the following conclusions could be drawn to highlight the important factors affecting cost estimation during pretender in a sample of different Egyptian construction companies:

1. Cost estimators attitudes towards the importance of these factors varied with contractor size.
2. The factors were related to internal and external backgrounds.
3. A strong agreement between cost estimators existed in the ranking of the cost factors.
4. The cost estimators in large and medium size contractors gave significant emphasis to project characteristic which ranked first, followed by external factors and market conditions.
5. Cost estimators in small size contractors ranked client factors first followed by project characteristics.
6. There was a strong agreement between cost estimators on the slight sensitivity effect of the consultant and designer characteristics category.
7. There was a strong agreement between cost estimators (large, medium and small size contractors) on the category constituting factors for project characteristics e.g. size / gross floor area, type of structure, no. of basement level, complexity and uncertainty of soil condition.
8. Four factors were strongly emphasized by the cost estimators in three groups of contractors, small, medium and large named as key factors; Materials characteristics, client financial ability / payment record, labors cost and size/gross area of the project.
9. Fuzzy logics were introduced in the study, to give a significant meaning for the key factors.
10. The key factors were used as input for the model, while the output was cost estimate inaccuracy.
11. Large and medium size contractors tended to be more concerned with the project characteristics.
12. Small size contractors were more concerned about their own financial abilities, and likely to have relatively limited resources and capabilities which made them more sensitive to marginal changes in the expected profits from a particular project. Consequently, they gave more attention to client characteristics (e.g.; client financial ability and payment records) which enable the company to maintain a viable business.

13. Small size contractors are more likely to be involved in construction projects as subcontractors.
14. The cost estimators in the small size contractors seemed to be under maintained pressure to take for the internal and the external factors that affect the cost estimate.
15. Sixteen factors concluded from this study showed great importance and should be taken in consideration before submitting the bid.
16. There were strong agreements between cost estimators on the financial ability of the client especially on private sector.
17. The most important factors that should be taken into consideration are materials characteristics, client financial ability, and Labors characteristics also size and gross area of the project.
18. None of the sixteen sensitive factors was related to the consultant and contract factors.

5.3 Future Work

The cost estimate variables are considered more subjective in nature and therefore harder, costly and time consuming to be extracted as bid data. Thus, it would be of great benefit to cost estimators in the construction industry in Egypt to design a computer program for estimate score. The estimator can enter the base estimate into the suggested program and then rate the estimate, relative to each of the sensitive factors. The program automatically calculates the estimate score, as the user rates each factor. The user can query the program historical database to view the estimate scores and enhance the bid value of similar projects.

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