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Factors Affecting Building Construction Projects' Cost Estimating

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بسم الله الرحمن الرحيم

قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا

إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ

البقرة – آية 34

Dedicated to My Father's soul and to my family

Who are the source of my inspiration, encouragement, guidance and happiness, and who share my goals and aspirations. May Almighty ALLAH bless and protect them.

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ABSTRACT

Cost estimating is an assessment of the expected cost of any construction project. The accuracy of such estimate has a serious effect on the expected profit of the construction contractor. Hence, a certain contingency premium should be added to the base estimate to increase the level of confidence. Such premium is materially affected by many factors. Through this research, the main factors that are expected to affect the accuracy of the building construction project's cost estimate were clearly identified. Twelve factors are identified as the most important factors. These factors were: economic instability, quality of firm's project planning and management, relevant experience of estimating team, availability of management and finance plans, ability of estimating team, labor and equipment required, estimating method, project location, periodical payments, accuracy of bidding documents provided by client, competent and leadership of project manager and impact of project schedule (expected delay).

Pertinent cost data of a selected sample of construction projects are investigated to show the effect of these factors on the construction project cost variance. Finally, a Neural Network model was developed that can greatly help to assess the expected cost variance of any future construction project. Cost variance is considered as an indicator for the accuracy of the cost estimating process. The validity of the proposed model is tested to confirm that the model could assess the expected cost variance at a satisfactory level of accuracy.

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CHAPTER ONE
INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 Overview

Many factors affect the accuracy of building construction projects' cost estimating which should be considered in the early stage of the estimating process. Some factors can incorrectly increase the estimated costs and the possibility of contractual disputes between the various parties involved. Other factors can help the estimator to decrease the unnecessary cost of an item and hence lead to successful tendering in a very competitive market.

Therefore, accurate estimating requires detailed study of the biding documents and the environmental situation. It also involves a careful analysis of all projects' data in order to arrive to the most accurate estimate of the probable cost consistent with the bidding time available and the accuracy and completeness of the information submitted.

1.2 Problem Statement

The impact of inaccurate cost estimating on construction business is significant. Overestimated cost result in submitting a high tender price by the contractor, which could lead to the tender being unacceptable to client. On the other hand, an underestimated cost may lead to a situation where a contractor incurs losses on the contracts awarded by clients. Contractor needs to identify these factors and assign cost variance related it.

This study is an attempt to identify the main factors affecting the accuracy of cost estimate in building construction. Such factors that the estimator should consider when preparing a cost estimating. Then, developing a model that assesses related cost variance so that it will lead to:

1- Minimize cost variance that is an indicator of accuracy of cost estimating.

2- Avoid the contractor's submission of an overestimated bid.

3- Enhance the effectiveness of the cost control process.

1.3 Scope and Objectives

Many factors affect accuracy of construction projects cost estimating. Through this study, factors affecting building construction projects cost estimating are discussed. Design-bid-build projects (DBB), either executed by governmental or private companies and selected in an open tendering are selected for the scope of this study.

The main objectives of this study are:

1- Identifying factors affecting the accuracy of the building construction projects cost estimating process.

2- Determining and testing the severity of factors that affect the accuracy of the building construction projects' cost estimating using analysis of data collected from questionnaire form.

3- Measuring the effects of the factors that severely affect the accuracy of the cost estimates and trying to link them.

4- Developing a model that can be used to assess the expected cost variance. Identifying such variance can help in accurately determining the risk premium that should be added to the estimated cost.

1.4 Research Methodology

This study is conducted in the following sequence:

1- A literature review carried out to investigate the previous works in this research area.

2- Identification of factors affecting the accuracy of cost estimating process based on the previous literature review.

3- A questionnaire survey carried out to identify the most important cost estimating factors in the Egyptian construction market.

4- Pertinent data of a selected sample of building construction projects collected. The analysis of such data will help to show how the previously identified cost estimating factors can affect the accuracy of the cost estimating process. Cost variance is an indicator for the accuracy of the cost estimating process.

5- Developing a neural network model using BrainMaker professional for windows version 3.7. The model is used as a tool to assess the expected cost variance of any future building project. The model training steps are shown in detail along with the required inputs and outputs.

   Eventually, the validity of the proposed model is evaluated to find out the ability of the proposed model to predict the expected cost contingency.

6- Finally, based on this analysis, some recommendations are provided to improve the accuracy of the cost estimating process.

1.5 Thesis Organization

This section describes the phases of this research classified by chapter as follows. Chapter one presents thesis introduction. Chapter two is a literature review for the main factors affecting accuracy of building construction projects' cost estimating based on the previous studies. Chapter three presents the data collection process. Chapter four provides analysis of the collected projects' data along with their effect on cost estimating accuracy. Chapter five clarifies methodology of the proposed neural networks model development. Such model can be used for assessing the average variance between the estimated cost and actual cost. Finally, Chapter six presents summary, conclusions and recommendations of this research.

CHAPTER TWO
LITERATURE REVIEW

Chapter Two

LITERATURE REVIEW

2.1 Introduction

It is expected that the accuracy of cost estimating has a significant effect on construction industry. For instance, it may have a serious effect on contractor ability to compete successfully with other contractors. It also has an important effect on contractor's profit. Therefore, this research is an attempt to identify the most important factors affecting the accuracy of cost estimating in building construction projects in Egypt. Such factors should be taken into consideration when preparing cost estimating for any future project. This chapter represents some cost estimating definitions. It also gives some details about cost estimating types, and finally it mentions previous work in order to get a predetermined list of factors that may affect building construction projects cost estimating.

2.2 Definitions

Cost Estimating

Researchers and experts have different definitions for cost estimating. Chartered Institute of Building **(CIOB 2009)** defines cost estimating as a technical process of predicting costs of construction. The **A**ssociation for **A**dvancement of **C**ost **E**ngineering **(AACE 2013)** describes cost estimating as the basis for project management, business planning, budget preparation, and cost and schedule control.

The Project Management Institute **(PMBOK 2013)** describes cost estimating as the development of an approximation (estimate) of costs of the resources needed to complete project activities**. Uppal (1997)** considers that cost estimation is the determination of quantity and the predicting or forecasting "within a defined scope" of the costs required to construct and equip a facility, to manufacture goods, or to furnish a service.

In conclusion, cost estimating is the means of forecasting and foreseeing the future costs of a construction project before it actually exists. However, the final project cost will not be known until the construction is finished and facility is operated.

Cost Variance

Cost Variance (CV) = budgeted cost of work performed (BCWP) – actual cost of work performed (ACWP). A negative cost variance indicates that the activity is running over budget **(AACE 2013)**. Cost variance in this research is calculated by subtracting the estimated cost/value of project from the actual cost/value of the same project.

2.3 Elements of Cost Estimating:

Elements of cost estimating consist of:

1- Direct Cost
2- Indirect Cost
3- Markup

1-Direct Cost

Costs of completing work that are directly attributable to its performance and are necessary for its completion. In construction, the cost of installed equipment, material, labor and supervision directly or immediately involved in the physical construction of the permanent facility **(AACE 2013)**.

2- Indirect Cost

Costs not directly attributable to the completion of an activity which are typically allocated or spread across all activities on a predetermined basis. In construction it is costs which do not become a final part of the installation, but which are required for the orderly completion of the installation and may include, but are not limited to, field administration, direct supervision, capital tools, startup costs, contractor's fees, insurance, taxes, etc. **(AACE 2013).**

3-Markup

As variously used in construction estimating, includes such percentage applications as general overhead, profit, and other indirect costs. **(AACE2013).**

a) Profit

Represents the minimum acceptable return on investments, which is a function of risk.

“The amount of profit to be added to the estimated cost of the work is a question which a contractor must answer individually for each bid. There is no set amount that can be added. It all depends on local conditions, competition, and how badly the job is wanted **(Al-Khaldi 1990)**.

a) Contingency

An amount added to an estimate to allow for items, conditions, or events for which the state, occurrence, or effect is uncertain and that experience shows will likely result, in aggregate, in additional costs. Typically, estimated using statistical analysis or judgment based on past asset or project experience **(AACE 2013)**.

2.4 Types of Cost Estimating

A project goes through different levels of estimates based on its development stage. Estimates are performed throughout the life of the project **(Peurifoy and Oberlender 1989).** As shown in Fig. (2.1) and beginning with the first estimate and extending to the various phases of design and into construction it is important to note that there are different types of cost estimating as the construction project advance. Detailed estimate cannot be made based on computed quantities at the concept, preliminary design stage, since the project is not yet defined. On the other hand, the estimates process will be more expensive as more detailed and accurate techniques are implementing.

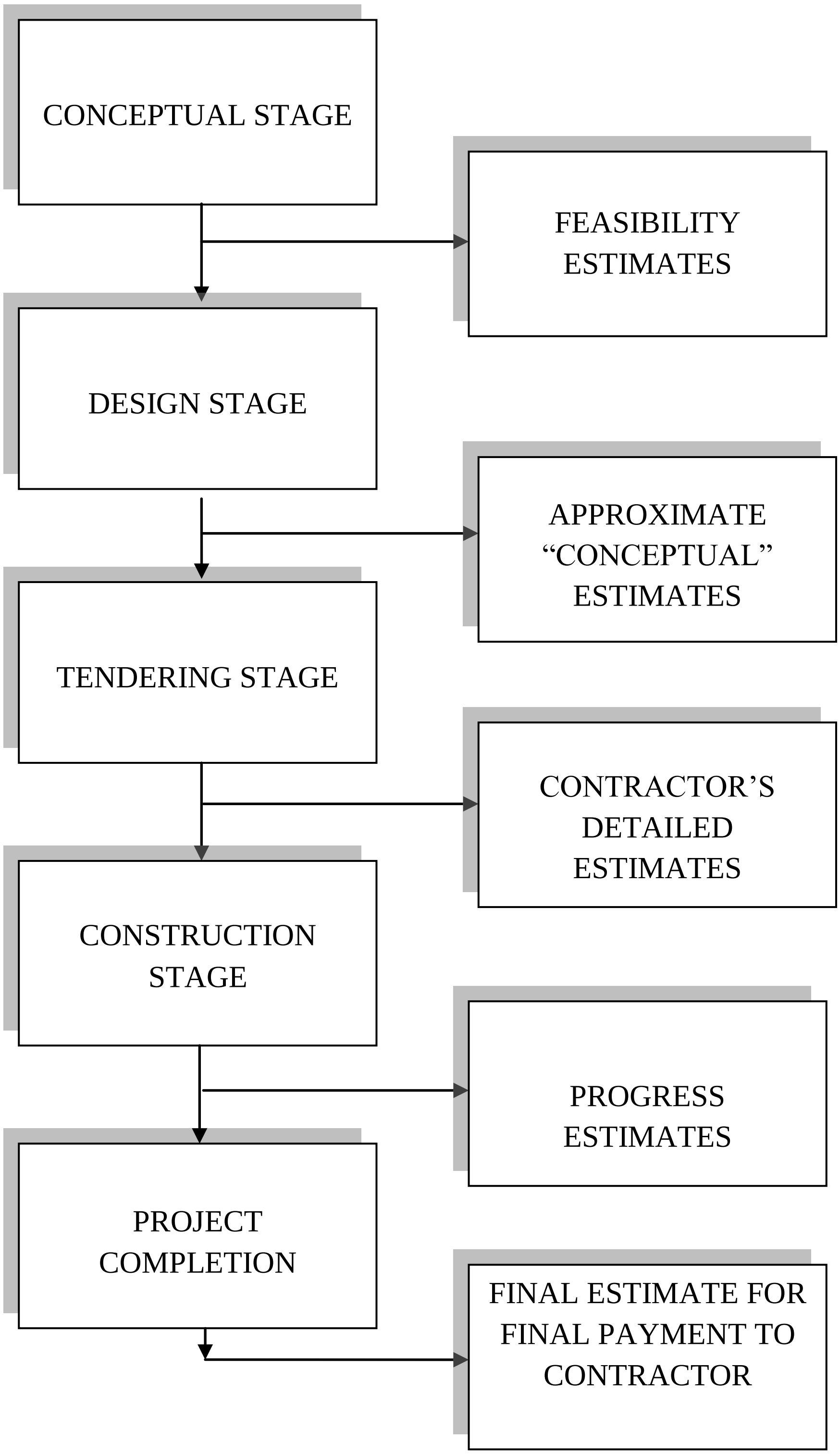

Figure (2.1): Types of Cost Estimating (adapted from Akeel 1989)

2.4.1 Feasibility Estimates

The owner will start with the definition or conception of the project. Regardless of size or type of project, the owner will perform an initial estimation. This is called feasibility estimation. There are two objectives of this estimation:

1- Determine whether to execute the project or not?

2- Help owner in obtaining funding for his project.

2.4.2 Conceptual Estimates

When the project is found to be feasible and funding is obtained, the owner will proceed in engagement of design firm in order to define project special requirements and the type and quality of construction. The design team will prepare approximate estimates of project cost at this stage. This type of estimate is known as parametric, range or conceptual estimates. The purpose of the conceptual estimates can vary depending on owner's demand and the type and size of the project.

Generally, the conceptual estimate is used to:

1- Support the owner's feasibility estimate
2- To evaluate possible design modifications in order to meet the owner's budget
3- To evaluate contractor bids
4- To be an aid in budgeting cash flow needs throughout the project **(Akeel 1989).**

There are different kinds of conceptual estimates depending on the type and size of the construction project and owner's needs. In general, a number of things should be considered when selecting kind of conceptual estimate; some of them are the following:

1- The need of the owner, hence the purpose of the conceptual estimate
2- The amount of resources available (time and money) from the owner to make an estimate
3- The amount of design information and experiential information available
4- The resources (information, data, skill) of the estimator
5- The prevailing construction market **(Barrie and Paulson 1992)**

2.4.3 Contractors' Detailed Estimates "Bid Estimates"

If the conceptual estimate is judged to be within budget, the design firm will prepare the project contract documents, which will be the basis of preparing the cost estimates by contractors in order to bid for the project. The major contract documents include the project drawings, specifications, general conditions, special conditions, agreements, and addenda. Usually the project drawings and specifications play the most significant role in the preparation of bid estimate by the contractor.

The drawings indicate the quantity of work to be performed and the specifications indicate the quality of work to be performed **(Barrie and Paulson 1992).**

After the owner invites contractors to bid, the contractors will prepare their detailed bid estimates. The purpose of these estimates is to determine the real cost of executing the project. The contractor should submit the lowest possible estimate, because the objective of the contractor is to win the bid (being lowest responsible bidder), and minimize the amount of money left on table and win his profit **(Akeel 1989).**

Detailed cost estimating is a time-consuming process. It is prepared when all documents of the construction project have been completed. Creativity and knowledge are essential for preparing a construction cost estimate. Different contractors use different processes, methods, and technologies during construction. Therefore, estimators need knowledge, creativity and experience to execute the estimating task successfully.

Detailed cost estimating consists of the following steps:

1- Dividing the project into individual work items and estimates. This is also known as quantity take off.
2- Determining of labor, equipment, and material needed for executing a work item based on the specification and the construction method.
3- Selection of the work items necessary for the element.
4- Productivity is defined as the amount of work a crew can perform in a unit of time.
5- Costs of labor, equipment and material must be decided after the work items have been determined for the elements.
6- Calculation of total cost for each work item by summing all work item costs.
7- Addition of taxes, overhead cost, and profit complete the estimate
8- Review and analysis by the estimator is also required to determine if the price of the assembly seems reasonable for the amount of work that has to be performed **(Adapted from Samphaongoen 2010)**

2.4.4 Progress Estimates

The contractor's detailed bid estimate is not the last estimate prepared for construction project. Several types of estimates will be performed during construction phase. Progress estimate is one of these types of estimates. Several progress estimates will be done during construction. The main purposes of these estimates are:

1- Estimates of cost of work related to contract change order.
2- Estimates prepared by the owner or his agent during the construction to determine the contractor percentage of completion at a certain point of time and thus determine the contractor payments **(Akeel 1989).**

2.4.5 Final Estimates:

On the completion of the project, it is necessary to make a final estimate for the whole work executed. This estimate will be done to verify quantities executed. This estimate will determine the final payment for the contractor.

2.4.6 Other Types of Estimates:

Between conceptual estimate and detailed estimate, other estimates are performed as the project becomes more defined and more information becomes available. Those estimates are required to assess most accurately the expected cost of the project at the time the estimate is carried out. They may be referred to as budget, appropriation, control, semi-detailed, design or engineering estimates, and are carried out for the purpose of assigning project budgets, and to monitor and control project costs. In addition to the above listed pre-construction estimates, other estimates are also performed during the project's construction phase or after the construction completion to assess the final actual cost of the project. The estimates in this stage are known as "definitive estimates". These estimates are updates of the detailed estimates with emphasis in actual rather than projected construction cost (**Bley 1990)**.

2.4.7 Accuracy Variation for Different Estimating Methods

As the project progresses, the amount of unknowns and uncertainties decreases, while the level of details and the project information increases. In this way, the accuracy of the estimate improves as it moves from conceptual to detailed estimate as shown in Table (2.1). Completeness of construction documents such as drawings and specifications is a factor that could affect the accuracy.

Table (2.1) Accuracy Variation for Different Estimating Methods (Holm et al. 2005)

Type of Estimate	**Construction Development**	**Expected Cost Variance**
Conceptual	Programming and schematic design	± 10 – 20 %
Semi detailed	Design Development	± 5 -10 %
Detailed	Plans and Specification	± 2 – 4 %

2.5 Previous Works

Many researches were performed on factors affecting the accuracy of construction projects cost estimating. They tried to assess these factors and their severity. They used different procedures in order to determine those factors.

2.5.1 Financial Issues

"One of the primary factors resulting in accurate estimates is the change of resource prices due to variation of economic conditions in time" **(Hwang 2009).**

Neufville et al. (1977) stated that estimating bias changes from year to year. These changes seem to coincide with what these authors term "good" and "bad" years (good and bad being defined as years with the greatest and least activity for contractors). The result of this analysis shows that estimates made in good years are generally lower than those made in bad years. The authors also claim that these differences lagged as estimators gradually become aware of the changes in construction activity and the resulting price levels.

Collier (1987) emphasized the importance of the demand for construction works. He stated that: "It would be wrong to give the impression that all estimates and bids for construction work are made up of costs of labors, materials, equipment, job overhead costs, and operating overhead costs. All estimated from determined facts and calculated probabilities, and with a profit margin precisely computed according to current economic indicators". He added**;** "there are other things that at times may have a greater influence on the amount of a bid than any variations of those costs and the most important of these is the demand for construction work".

Liu and Wang (2010) focused in their research on punctuality of cash flow. They stated: "The concern focuses not just on the amount of cash flow but also on its timing, which is critical to effective budget management during construction."

2.5.2 Bidding Situations

Kimand Reinshmidit (2010) stressed on level of competition as a major factor affecting construction estimates. He stated: "There are always possibilities of profit/ loss from a job in competitive bidding. If a contractor anticipates that its risk premium cannot cover the uncertainty, the contractor does not bid and waits for another job opportunity. Otherwise, the contractor makes a bid risk-averse to avoid the risks of large losses. They use large amount of risk premium. But simultaneously they may lose opportunities for large profits by turning down jobs".

Also **Laryea and Hughes (2011)** stated: "Contractors often consider market competition as an overriding concern when pricing work, but most analytical models hardly address this".

McCaffer (1976) made an analysis of Belgian building contracts revealed a significant negative correlation between low bid/designers' estimate ratios and the number of bids received for each contract. Consistency also appears to improve with increasing numbers of bids received for each contract.

Neufville et al. (1977) analyzed data on all new construction costing over $100,000 by the Commonwealth of Massachusetts Bureau of Building Construction from 1961 to 1974. The data included 167 contracts valued at over $900,000,000 in total (or $1,332 billion in 1974 dollars). Their analysis showed a curved negative relationship between low bid/engineers' estimate ratios and the number of bids received. This trend still appeared to hold in ·good years and "bad years".

Wilson et al (1987) provide a diagram of their summarized data which indicates a curved negative correlation between the low bid/estimate ratios and the **number of bids**. This trend exists for each of their four groups of data studied although the larger contracts have a shallower curve. The smoothness of the curves connecting the medians on accuracy improved only slightly with the increasing number of previous bills used with no improvement observed with the use of more than three bills.

2.5.3 Project Characteristics

Smith and Jolly (1985) examined the factors that should be taken into account in estimating the cost and tendering for buildings and civil engineering works. These involve the following factors:

1. The output of mechanical plant is variable, for some plant operators are more efficient than others. This is particularly applicable to plant where the operator is himself chiefly responsible for the output concerned, such as mechanical excavating plant of the skimmer, shovel, tractor and scraper type.

2. The output of labor, both skilled and unskilled, is variable, for one man produces more of a similar kind in a given time than another.

3. Weather conditions have a marked effect upon output. Under wet weather conditions, the output of excavation in particular is reduced. For site conditions become soft and heavy, excavating plant tends to become clogged, while internal transport on open sites becomes energetic.

Strandell (1978) emphasized the importance of productivity in construction. He stated that: "There is general agreement by owners, engineers and contractors that productivity in the construction industry is a problem worthy of serious study. There is no question as to its effect on the cost and time involved in completing a constructed facility."

Koehn (1985) emphasized climatic effects on construction. The relationship between overall construction productivity, and temperature and humidity are presented in his paper.

Chimwaso (2001) mentioned that design changes, inadequate planning, unpredictable weather conditions and fluctuations in the cost of building materials are common factors causing cost overruns.

Walace (1977) outlined in his paper, "Construction Costs in Saudi Arabia", the various cost differentials and project scope additions required to "convert" a Gulf Cost U.S. estimate to an Arabian base. He discussed and illustrated the conditions giving rise to cost differentials and provided an adjustment conversion technique. Although his paper is concerned primarily with construction costs, some mention has been made of factors affecting capital cost components. Some unique conditions in Saudi Arabia, such as labor laws, climate, labor nationality and local market conditions -all of which have a major impact on the cost of construction- were highlighted in his paper.

Harvey (1979) has analyzed the "time" effect in relation to several of the other factors. Using dummy variables for "years", she found no significant interaction effects with the number of bidders or geographical location but a significant interaction effect with project size and the three-way interaction of number of bidders/project size/ years.

Taylor (1977) divided capital cost estimates into the following distinct parts:

1.Those components for which **available historical information** has afforded reasonable certainty of expected costs. These items include such things as mechanical equipment, concrete and structural components as related to specific process units'. These items are relatively easy to estimate, due to extensive historical files.

2. Those components which require **precise information relating to specific philosophies of each client**, although classified as indirect items, have a very significant effect on the estimated costs.

3. Any notice of unusual **site conditions**, rock, water, heavy woods, and any mention of piling on existing structures, have tremendous impact on the estimated costs, and must be defined in the scope of work".

Morrison and Stevens (1980) examined data obtained from six separate UK public sector quantity surveying offices. These data included estimates generally produced by pricing mainly detailed, and sometimes approximate, bills of quantities immediately prior to receipt of bids. 62 contracts were analyzed from Office A. The mean error for schools contracts (34 cases) was found to be -6.50% (9.6 standard deviation), whilst the mean error for other types of projects was –4.86% (12.51 standard deviation). 213 contracts were analyzed from Office B. The mean error for schools (82 cases) was 7.23% (12.26 standard deviation), 12.14(36.92 standard deviation) for other types of projects. Office C provided details of 62 contracts of which 38 were for schools with a mean error of 3.03% (10.71standard deviation) compared with 2.67% (11.91 standard deviation), for other types of projects. Office D provided details of 222 contracts of which 37 were for schools, 82 for new housing and 46 for housing modifications. The mean error for schools was 5.41% (13.52 standard deviation), for new housing -1.04% (8.24 standard deviation), for housing modifications 3.67% (15.09 standard deviation) and for other types of projects. Office E provided details of 89 contracts of which 65 were for schools. The mean error for the schools was -1.00% (10.03 standard deviation), 1.08% (11.79 standard deviation) for the remainder.

Wilson et al (1987) have analyzed the percentage differences between the low bid and designers' for 408 governmental contracts let by the Australian state of

Victoria Public Works Department projects between 1979 and 1982. Contracts receiving more than 10 bids were omitted, leaving a total of 393 contracts for analysis. These were divided into four groups: (1) small projects valued at less than $50,000 (154) cases, (2) medium-sized projects valued from $50,000 to $250,000 (117) cases, (3) large projects valued more than $250,000 without bills of quantities (49 cases), and (4) large projects valued more than $250,000 with bills of quantities (73 cases). The approximate median low bid/designers' estimate ratio was 1.041 for the small projects, 0.921 for the medium projects and 0.963 for the large projects. These figures seem to offer little support for the notion that **percentage estimating bias is correlated with project size.**

Harvey (1979) made an analysis of variance that showed significant difference in estimating bias across the six Canadian regions studied, after parceling out the effect **of project type**. Significant **regional/project type interaction effects** were also found.

Aftab et al. (2010) mentioned that the personnel of Project Management Consultant (PMC) ranked ineffective planning and scheduling by contractors as quite significant factor affecting construction cost. This issue seems to be true as it is highly related to cash flow and financial difficulties faced by contractors.

Azzaro et al. (1987) made an empirical study commissioned by the Royal Institution Of Chartered Surveyors investigated cost estimating from the viewpoint of the quantity surveying work in contracting sector. The study based on semi-structured survey of 11 main contractors and 2 subcontractors, sought to identify current estimating techniques and the type of data base used to arrive to tender prices. Issues covered in the study included the determination of unit prices, preliminaries items and allowance for profits and overhead, as well as the adjustment of prices to take account of such factors as market conditions, site conditions, location and nature of tender documentation.

Loannov (1988) emphasized the importance of geologic uncertainty which has a significant effect on project cost. He wrote “Site investigation can reduce this uncertainty and decrease costs by reducing the contingency amounts included in bids".

2.5.4 Estimating Process

Morrison and Stevens (1980) made an analysis for six offices which reveals that office A data concluded that estimating performance was said to be somewhat better for school work than for other categories of building, adding that this might be expected in this sample where school work comprises approximately 50% of the projects undertaken. The implication of this comment is that the estimators were more familiar with, and therefore better able to estimate, school projects. Similarly, as for their Office D data, in which housing contracts were said to be more accurately estimated, it was noted that "this might be expected as housing forms a high proportion of the number of projects undertaken. Conversely, the large standard deviation recorded for the housing modification projects in this office claimed to be "caused by poor estimating performance on a small number of projects." Office D also undertook a greater proportion of larger-sized housing projects which again seemed to be better estimated, inviting the conclusion that greater experience may have contributed to better estimating although some other unexplained yearly differences were found.

Skitmore (1985) experiments with expert quantity surveyors in the UK provided evidence of significant differences in estimating accuracy between the individual surveyors involved. Although handicapped by the limited amount of data collected in his study, he was able to tentatively conclude that the most consistent estimators were found to be associated, in order of importance, with high recall abilities, self-professed expertise, low mental imaging of the physical characteristics of the building, high general and specific project estimating experience. As far as bias was concerned, low estimates were found to be associated with self-professed expertise and high estimates were associated with high recall abilities, high mental imaging and project experience. Surveyors exhibiting the greatest expertise were generally thought to be: (a) More relaxed and confident. (b) More concerned with maintaining familiarity with the market and overall price levels than others who believed the collection and careful analysis of project information to be of major importance. (c) Possibly able to recall the overall price of the projects undertaken

The level of information available to the estimator increases as the design progresses. The effect of increasing information can therefore be assessed by comparing the accuracy of estimates made in the early stages of design (conceptual estimates) with those made when the design is substantially complete (detailed estimates).

Two experimental studies by **(Jupp and McMillan 1981)** for detailed estimates and (**Skitmore 1985)** for conceptual estimates have been conducted, aimed at observing and quantifying the incremental effect of information on estimating accuracy. The results of this researches indicated that estimations were quite different from each other according to data available about projects.

Adrain (1982) emphasizes in his book, "Construction Estimating", the preparation of a general contractor's estimate for a construction project. The book illustrates how the estimator's knowledge of accounting and productivity analysis offers him the alternative construction methods that are essential to the estimating task.

Skitmore and Wilcok (1994) investigated estimating processes of smaller builders' estimators. The work investigated the process of estimating, rather than the practice of cost estimating, by looking at methods that estimators used to the price selected items from bills of quantities and the variability associated with the outcomes. The motivation for this investigation was that little descriptive material is available concerning the processes employed by builders in determining a tender price. The research concluded that the main factor determining the rating method (i.e. the method of preparing the unit rates for bill of quantities items) was the item quantity, although this varied in importance between the work sections investigated (ground work, in situ concrete and masonry). An important conclusion estimating from the research was that not enough is known about factors involved in cost estimating in practice, although there is a wealth of prescriptive literature available on the subject.

The following table (2.2) condenses literature review researches:

Table (2.2): Factors Affecting Building Construction Projects Listed in Literature Review.

No	Author	Year	Factor	No	Author	Year	Factor
1	McCaffer	1976	Level of competition	13	Collier	1987	Economic instability (demand on construction works)
2	Walace	1977	1- Economic instability 2- Weather conditions 3- Nationality of labor	14	Wilson et al.	1987	Level of competition
3	Taylor	1977	1- Availability of productivity standards 2- Precise information about client 3- Site conditions	15	Azzaro et al.	1987	1- Estimating method 2- Available data base 3- Market conditions 4- Site conditions 5- Location & nature of tender document
4	Neufville et al.	1977	1- Level of competition 2- Economic instability	16	Wilson et al.	1987	1- Project size
5	Strandell	1978	Productivity of labor & equipment	17	Loannov	1988	Site condition
6	Harvey	1979	1- Project type 2- Project location	18	Skitmore and Wilcock	1994	Estimating method
7	Morrison and Stevens	1980	Experience of estimators	19	Chimwaso	2001	1- Quality of firm's project 2- Weather conditions 3- Economic instability
8	Jupp and McMillan	1981	Data available about projects	20	Aftab et al.	2010	Availability of management and finance plans.
9	Adrain	1982	Estimator knowledge	21	Liu and Wang	2010	punctuality of cash flow
10	Smith and Jolly	1985	1- Productivity of labor & equipment 2- Weather conditions	22	Kimand Reinshmidit	2010	Level of competition
11	Skitemore	1985	1- Experience of estimators 2- Abilities of estimators 3- Available data base	23	Laryea and Hughes	2011	Level of competition
12	Koehn	1985	Weather conditions				

2.6 Predetermined List for Factors That May Affect Building Construction Projects Cost Estimating:

From previous researches, other researches and a field survey done among engineers from different experience, a predetermined list of factors that may affect the accuracy of construction projects cost estimating is collected in order to prepare them in a questionnaire.

A. Financial Issues.

1- Punctuality of periodical payments

2- Availability of management and finance plans

3- Inflation pressure

4- Economic instability

5- Uncertainty of taxes

6- Currency exchange fluctuation average

7- Accuracy of estimated financing cost

8- State of market

B. Bidding Situations

1- Number of competitors

2- Level of competition

3- Time between project announcement and bid opening average

4- Accuracy of bidding documents provided by client

C. Project Characteristics

4- Type of contract

5- Size of contract

6- Project location

7- Site condition

8- Competence and leadership of project manager

9- Experience and incentives of field staff

10- Quality of firm’s project planning and management

11- Labor and equipment required

12- Contract period

13- Content of the project specifications

14- Punitive damages

15- Arbitration clause

16- Knowledge of client and consultant average

17- Owner A/E experience level

18- Attitude towards changes

19- Environmental issues

20- Impact of project schedule "expected to delay”

21- Quality of specification codes

22- Unforeseeable change in local laws and procedures

23- Weather

24- Nationality of labor

25- Social and cultural impact

26- Religious regulation

27- Public exposure

D. Estimating Process

1- Estimating method

2- Availability of productivity standards

3- Availability of cost indexes average

4- Relevant experience of estimating team

5- Ability of estimating team

6- Standard procedure for updating cost information

7- Method used in determining contingency

Based on the previous literature review, cost estimating definitions, types of cost estimating and factors affecting building construction projects’ cost estimating discussed, a list of 43 factors was determined.

These factors were used as a base for a questionnaire survey. Such survey identifies the most important factors affecting the accuracy of the cost estimating process.

CHAPTER THREE
DATA COLLECTION

Chapter Three

DATA COLLECTION

3.1 Introduction

This chapter presents the research methodology employed by the author in the development and execution of this research study. Questionnaire survey was carried out to collect data needed, then data analysis was performed.

3.2 Data Required

The data required for this research is:

1- Survey for the different cost factors that can affect the accuracy of construction projects cost estimating through a comprehensive literature review

2- A questionnaire survey that identifies the most important factors

3- Collection and analysis of the pertinent cost data of a selected sample of construction projects to investigate the effect of the identified cost factors

3.3 Questionnaire Survey

The literature search' resulted in identifying forty-three factors that may affect the accuracy of construction projects cost estimating. These factors were defined in the previous chapter as shown in Table (3.1).

Table (3.1) Factors that May Affect Accuracy of Construction Cost Estimating

No	Factors	No	Factors
A. Financial Issues			
1	punctuality periodical payments	5	Uncertainty of taxes
2	Availability of management and finance plans	6	Currency exchange fluctuation average
3	Inflation pressure	7	Accuracy of estimated financing cost
4	Economic instability	8	State of market
B. Bidding Situations			
9	Number of competitors	11	Time between project announcement and bid opening average
10	Level of competition	12	Accuracy of bidding documents provided by client
C. Project Characteristics			
13	Type of contract	25	Knowledge of client and consultant average
14	Size of contract	26	Owner A/E experience level
15	Project location	27	Attitude towards changes
16	Site condition	28	Environmental issues
17	Competent and leadership of project manager	29	Impact of project schedule “expected to delay”
18	Experience and incentives of field staff	30	Quality of specification codes
19	Quality of firm’s project planning and management	31	Unforeseeable change in local laws and procedures
20	Labor and equipment required	32	Weather
21	Contract period	33	Nationality of labor
22	Content of the project specifications	34	Social and cultural impact
23	Punitive damages	35	Religious regulations
24	Arbitration clause	36	Public exposure
D. Estimating Process			
37	Estimating method	41	Ability of estimating team
38	Availability of productivity standards	42	Standard procedure for updating cost information
39	Availability of cost indexes average	43	Method used in determining contingency
40	Relevant experience of estimating team		

3.4 Sample Size

The number of building construction engineers in Egypt is too big. So, infinite population is used in determining sample size.

The following formula is used:

$$n = \left[\frac{Z_{\alpha/2}\,\sigma}{E}\right]^2$$ (Israel 1992)

Where:

$z_{\alpha/2}$ is known as the critical value the positive z value that is at the vertical boundary for the area of $\alpha/2$ in the right tail of the standard normal distribution.

δ is the population standard deviation.

n is the sample size as Fig.(3.1) shows.

E is the margin of error

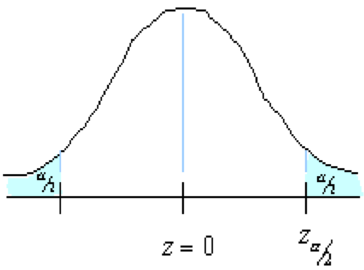

Figure (3.1) Standard normal distribution

At a 95% degree confidence and σ = 6.95, $z_{\alpha/2}$ = 1.96 and margin of error E = 2

$$n = \left[\frac{1.96 * 6.95}{2}\right]^2 = 46.39$$

Questionnaire made and translated into Arabic “appendix (A)” for respondents to be much easy and more comprehensive. The questionnaire carries both the instructions and the questions form. A cover page that contains an introduction to explain the idea and the purpose of the survey as well as the definition of the interested area of study is given to each respondent along with the questionnaire, aimed at asking the respondents to fill in the needed information. The questionnaire was either picked up on a second visit when the information was filled or received by mail.

Questionnaire is sent to experts who work for either governmental or private contractor and occupy one of the following jobs:

1- Construction project manager
2- Planner
3- Cost engineer

Data is collected through the questionnaire that was left to be answered by a key informant. Questionnaire was given to 60 experts, of whom 43 responded “Appendix (C)”.

There are three parts in the questionnaire “appendix (A)”. The first part includes general questions for participant, for example, name, graduation year, jobs occupied and experience in construction. The second part explains to participant how to fill in the third part. Third part is the questionnaire form which includes the factors affecting the accuracy of cost estimate in building construction. These factors divided into four main areas. Each area contains a group of factors, which revolve around the same topic. For each factor, the respondents have five options. These are 'very major effects', 'major effects', 'minor effects', 'very minor effects' and 'no effect’. This guarantees that questions about each factor are asked in the same way in each interview. Factors that are considered in the questionnaire revolve around the following areas:

1. Financial Issue
2. Bidding Situations
3. Project Characteristics
4. Estimating Process

Part four is reserved to any other factors or comments from participant point of view.

3.5 Classification of the Surveyed Engineers According to Their Experience

The surveyed experts shown in Appendix (D) included different years of experience. Figure (3.2) shows that about 30.5 % have more than 15 years of experience, 18.5 % have experience from 11 to 15 years, 25.5 % have experience from 5 to 10 years and 18.5 % have experience less than 5 years.

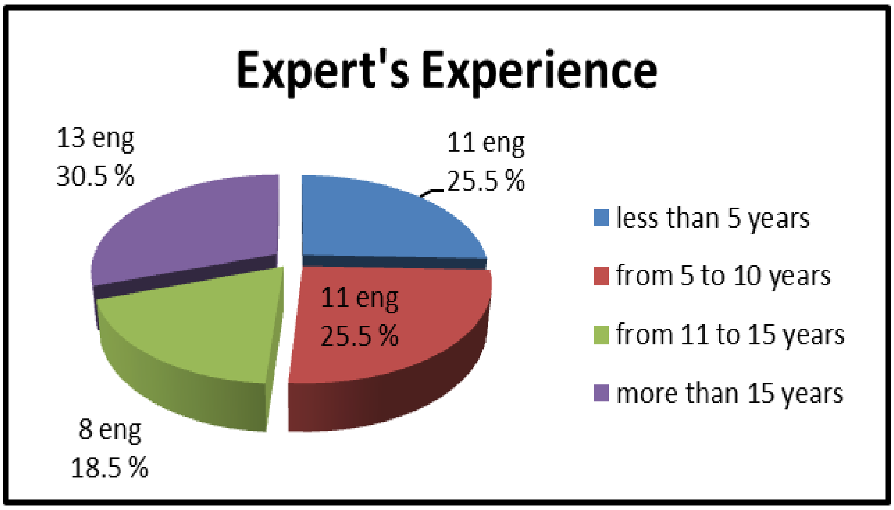

Figure (3.2): Classification of Experts According to Their Experience

3.6 Classification of the Surveyed Engineers According to Their Job Designation

Surveyed engineers occupy either management, cost estimating or scheduling jobs as Fig. (3.3) shows.

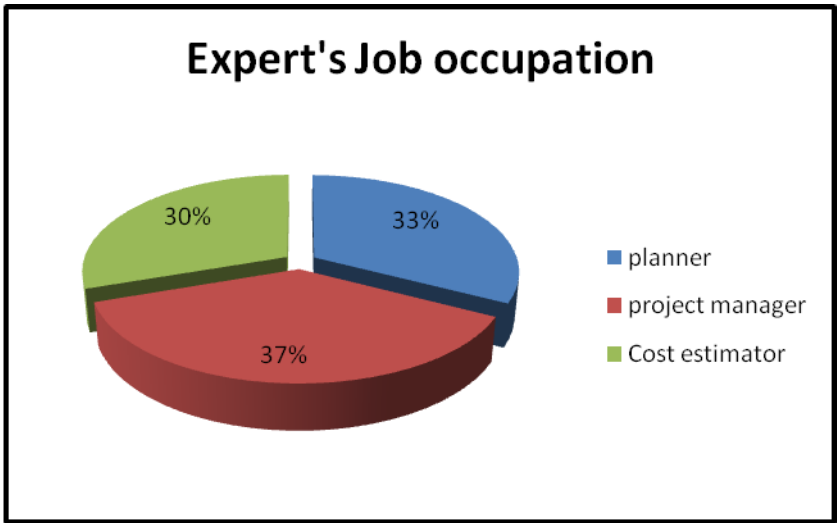

Figure (3.3) Classification of the Surveyed Experts According to Their Job Designation

3.7 Classification of the Surveyed Engineers According to Contractor They Work for

Surveyed Experts work for either governmental or private companies as Fig. (3.4) shows.

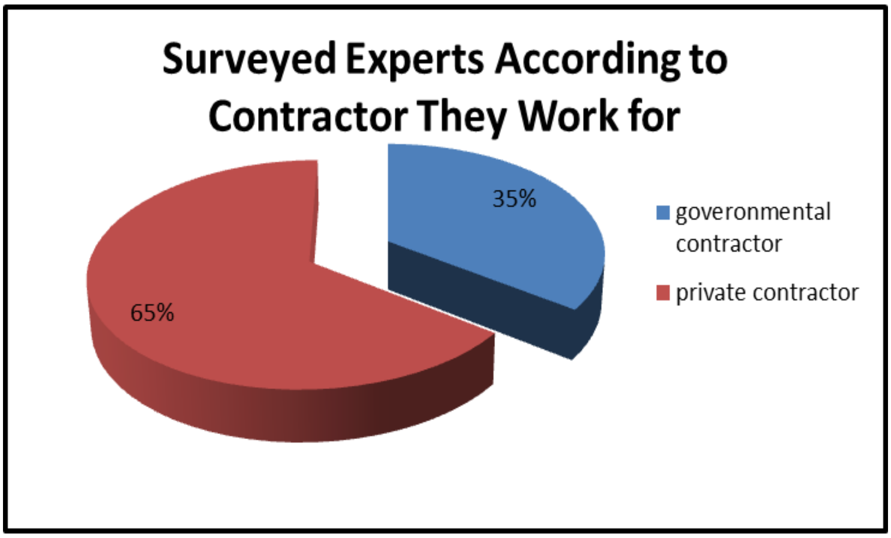

Figure (3.4): Classification of the Surveyed Experts According to Contractor They Work for

3.8 Calculation of Importance Index

Participants have provided numerical scoring expressing their opinions based on their experience in the construction field in Egypt. Importance index is calculated for every factor using the following formula:

Importance index for every factor = $\frac{\sum \text{No. of responds} * \text{relative score}}{\text{totalscore}}$

Table (3.2): Importance Index

No.	Category	Factor	Importance Index
1	Financial Issues	Punctuality of periodical payments	0.855813953
2		Availability of management and finance plans	0.897674419
3		Inflation pressure	0.772093023
4		Economic instability	0.925581395
5		Uncertainty of taxes	0.71627907
6		Currency exchange fluctuation average	0.702325581
7		Accuracy of estimated financing cost	0.846511628
8		State of market	0.83255814
9	Bidding Situations	Number of competitors	0.772093023
10		Level of competition	0.781395349
11		Time between project announcement and bid opening average	0.706976744
12		Accuracy of bidding documents provided by client	0.851162791
13	Project Characteristics	Type of contract	0.809302326
14		Size of contract	0.837209302
15		Project location	0.860465116
16		Site condition	0.837209302
17		Competence and leadership of project manager	0.851162791
18		Experience and incentives of field staff	0.762790698
19		Quality of firm’s project planning and management	0.906976744
20		Labor and equipment required	0.879069767
21		Contract period "expected to delay”	0.804651163
22		Content of the project specifications	0.8
23		Punitive damages	0.706976744
24		Arbitration clause	0.669767442
25		Knowledge of client and consultant average	0.739534884
26		Owner A/E experience level	0.772093023
27		Attitude towards changes	0.697674419
28		Environmental issues	0.674418605
29		Impact of project schedule	0.851162791

30		**Quality of specification codes**	**0.790697674**
31		**Unforeseeable change in local laws and procedures**	**0.669767442**
32		**Weather**	**0.697674419**
33		**Nationality of labor**	**0.627906977**
34		**Social and cultural impact**	**0.534883721**
35		**Religious regulations**	**0.502325581**
36		**Public exposure**	**0.68372093**
37	**Estimating Process**	**Estimating method**	**0.879069767**
38		**Availability of productivity standards**	**0.795348837**
39		**Availability of cost indexes average**	**0.8**
40		**Relevant experience of estimating team**	**0.906976744**
41		**Ability of estimating team**	**0.893023256**
42		**Standard procedure for updating cost information**	**0.818604651**
43		**Method used in determining contingency**	**0.706976744**

3.9 Most Important Factors

By examining the importance indices of each factor in table (3.2), it can be decided that some factors are heavily considered to have high impact. For example, economic instability, quality of firm's project planning and management, relevant experience of estimating team, availability of management & finance plans, ability of estimating team and labor & equipment required. On the other hand, factors such as public exposure, environmental issues, arbitration clause, unforeseeable change in local laws and procedures, nationality of labor, social and cultural impact, and religious regulations, have low impact.

Pareto analysis technique assumes that 20% of factors can have the most important effect. Therefore, this percentage will lead us to the selection of the first nine factors as shown in figure (3.5).

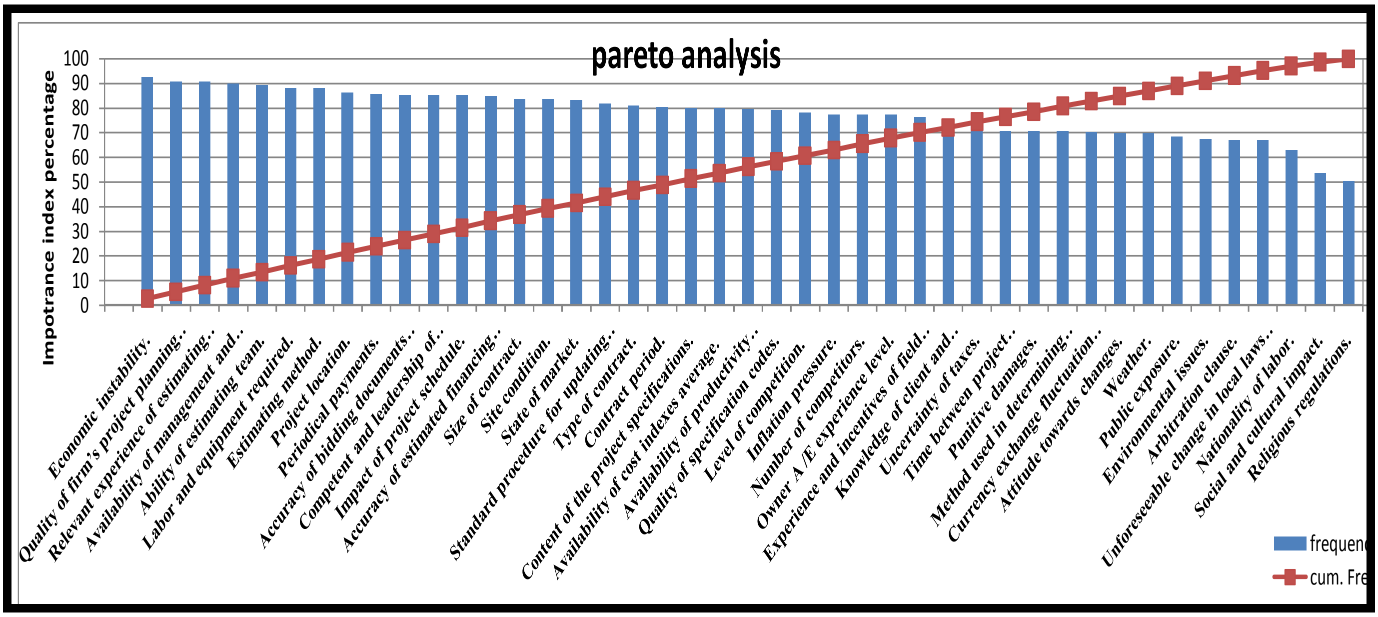

Figure (3.5): Pareto Analysis Chart

For more precision, the first twelve factors will be selected "factors with importance index higher than 85%" as shown in Table (3.3).

Table (3.3) Factors that have severity greater than or equal to (0.85)

No	Factor	Importance Index
1	Economic instability	0.925581395
2	Quality of firm's project planning and management	0.906976744
3	Relevant experience of estimating team	0.906976744
4	Availability of management and finance plans	0.897674419
5	Ability of estimating team	0.893023256
6	Labor and equipment required	0.879069767
7	Estimating method	0.879069767
8	Project location	0.860465116
9	Punctuality of periodical payments	0.855813953
10	Accuracy of bidding documents provided by client	0.851162791
11	Competence and leadership of project manager	0.851162791
12	Impact of project schedule "expected to delay"	0.851162791

3.10 Project Cost Data

The scope of this study is confined only to the building construction projects in Egypt, hence the number of those projects is unknown. Therefore, the same sample size of the previous questionnaire is used. As a result, our sample size will be 47 projects.

3.11 Data Collection

Based on research methodology, factors determined from literature review, were analyzed using questionnaire form. Analysis led to (12) factors that are severely affecting building construction cost estimating.

Data for training and testing the proposed artificial neural networks model were collected. These data were gathered from (47) real life projects conducted in Egypt as shown in Appendix (D) using another data collection form as shown in Appendix (B). Data collected was the measurements of the severity of the most important factors affecting the accuracy of building construction cost estimating process from participants' points of view.

CHAPTER FOUR
PROJECTS’ DATA ANALYSIS

Chapter Four

PROJECTS' DATA ANALYSIS

4.1 Introduction

In the previous chapter, forty-three factors were assigned as the main factors that affect construction projects cost estimating accuracy. A group of forty-three engineers responded to questionnaire survey to assign factors that severely affect construction projects cost estimating accuracy. The questionnaire resulted in twelve factors that severely affect construction projects cost estimating accuracy. Data gathered from forty-seven real life projects conducted in Egypt using another data collection form as shown in Appendix (B).The main objectives of this chapter are the analysis of the collected projects data and trying to investigate the relations between the twelve factors and the accuracy of the project cost estimating. Cost variance is considered as an indicator of the cost estimating accuracy.

4.2 Collected Projects Data

Appendix (D) exemplifies information regarding the collected projects' data such as project name, estimated cost, actual cost, project duration, size of contract and type of contract.

4.2.1 Projects Type

The collected forty-seven projects contain residential, administration, commercial buildings and other building construction projects. Figure (4.1) shows that administration, commercial, residential and other construction projects represent 42%, 11%, 28% and 19 % respectively of the surveyed projects.

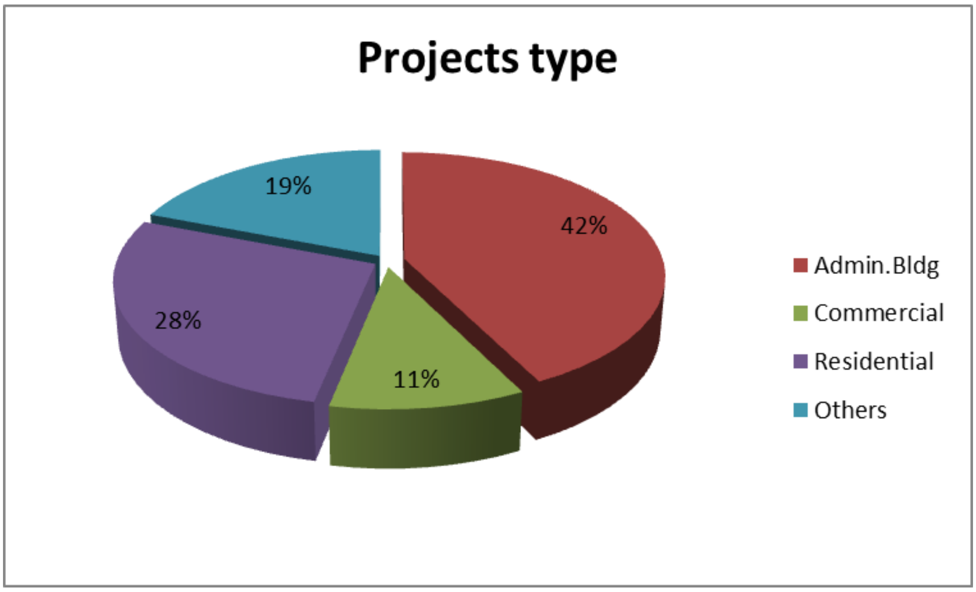

Figure (4.1): Classification of Projects According to Project Type

4.2.2 Projects Duration

The surveyed projects are divided into three different categories based on their actual duration. The first category includes those projects with an actual duration ranging between 6 months to 1 year, more than 1 year to 2 years and more than two years. The number of projects and their relative percentages within each category are shown by Figure (4.2).

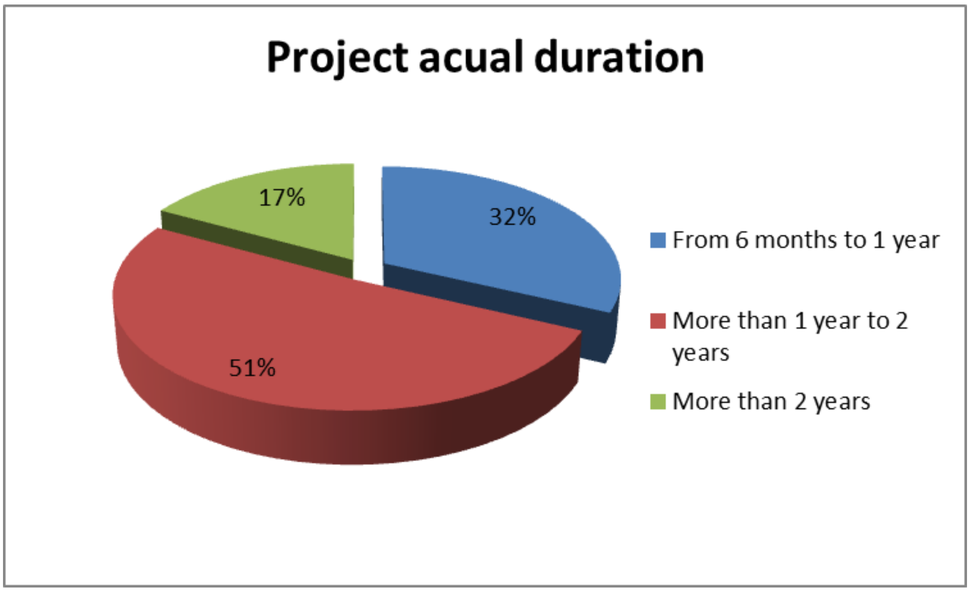

Figure (4.2): Classification of Projects According to Actual Duration

4.2.3 Project Size

According to project size, the surveyed projects are divided into three different categories. Categories include project size more than 50 million EGP, from 20 to 50 million EGP and Less than 20 million EGP. Such categories with its relative percentages are shown in Figure (4.3).

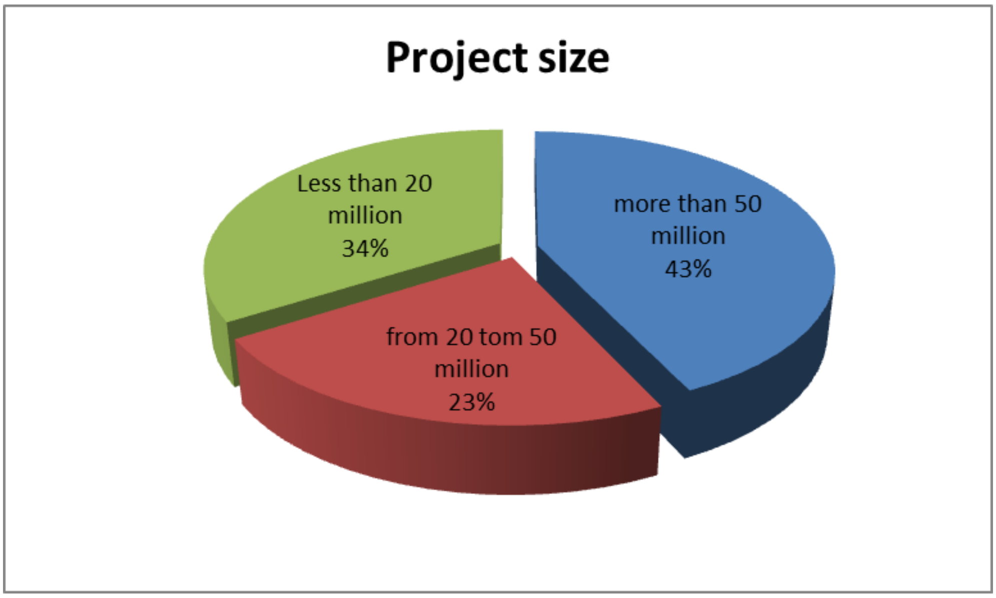

Figure (4.3): Classification of Projects According to Project Size

4.2.4 Contract Type

Based on the type of contract, the selected projects are categorized into four groups: cost plus percentage, cost plus fixed fee, unit price (BOQ) and lump sum contract. Figure (4.4) is a graphical presentation for these categories. The largest category was unit price (BOQ) contracts that represented 74% from total number of projects. The smallest category was cost plus percentage contracts that represented 2% from total number of projects.

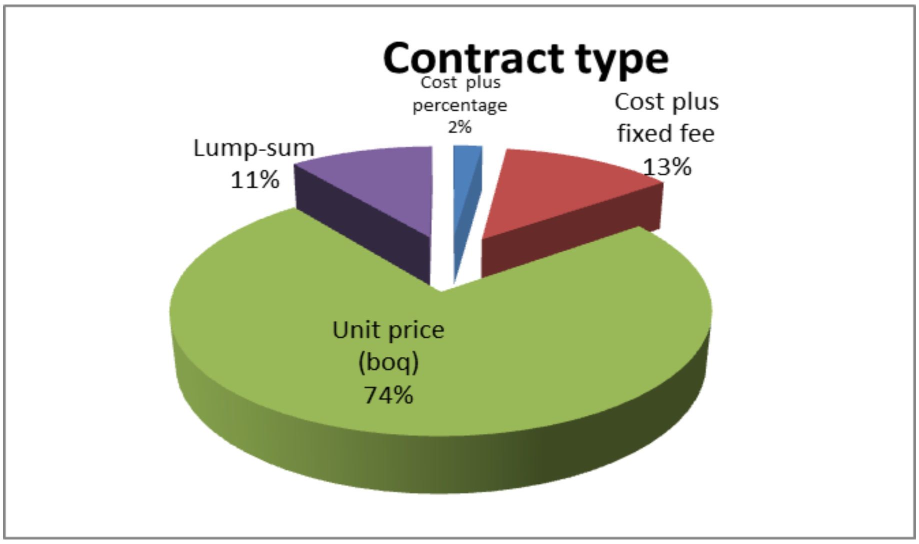

Figure (4.4): Classification of Projects According to Contract Type

4.2.5 Cost Variance

As stated in chapter 2, cost variance in this research is calculated by subtracting the estimated cost/value of project from the actual cost/value of the same project. Figures (4.5), (4.6), (4.7) and (4.8) show classifications of surveyed projects' cost variance according to project type, project actual duration, project actual cost and contract type.

a- Project Type

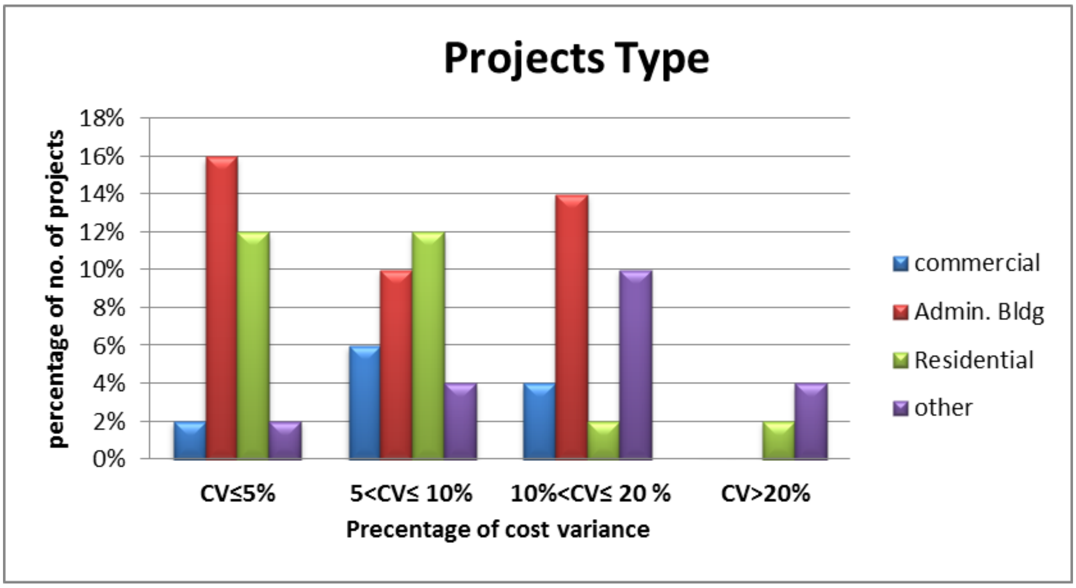

Figure (4.5): Classification of Projects According to Project Type and Cost Variance

Analysis for figure (4.5) shows that 32% of surveyed projects have cost variance from 0% to 5%, 32% of projects have cost variance from 5% to 10%, 30% of projects have cost variance from 10% to 20% and 6% of projects have cost variance more than 20%.

Administrative buildings were 42% of surveyed projects. About 40% of administrative projects have cost variance from 0% to 5% (57% of them were banks), about 25% of administrative projects have cost variance from 5% to 10% (43% of them were offices) and about 35% of administrative projects have cost variance from 10% to 20% (50% of them were banks and 33% of them were schools).

Analysis also reveals that residential buildings were 28% of surveyed projects. About 46% of residential projects have cost variance from 0% to 5% (60% of them were housing) and about 46% of residential projects have cost variance from 5% to 10% (66% of them were apartment blocks).

b- Project Actual Duration

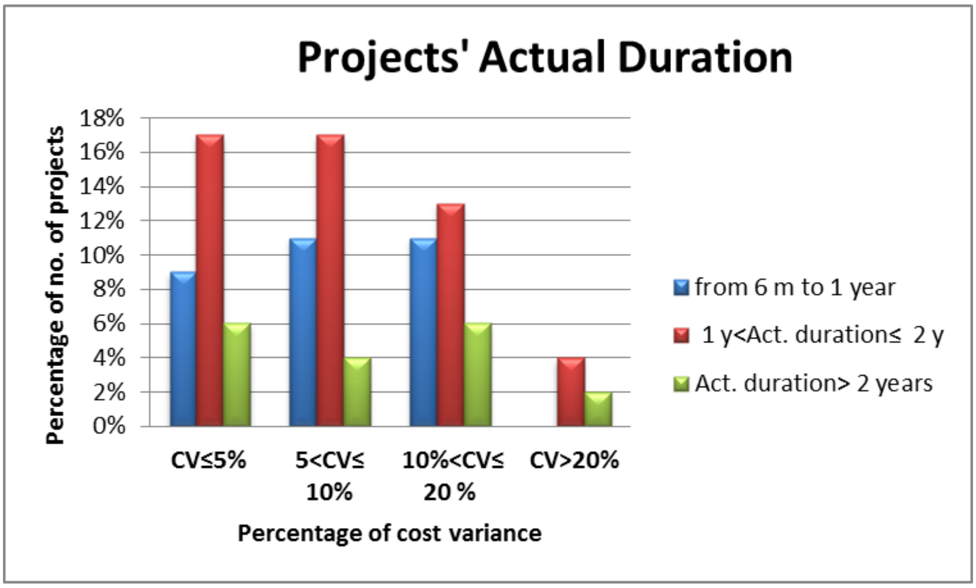

Figure (4.6): Classification of Projects According to Project Actual Duration and Cost Variance

By analyzing figure (4.6), it is clear that 32% of projects that have duration from 6 months to 1 year. About 30% of them have cost variance from 0% to 5% (75% of them were residential buildings). About 35% of them have cost variance from 5% to 10% and about 35% of them have cost variance from 10% to 20%.

In addition, it was discovered that about 51% of projects that have duration from 1 year to 2 years. About 26% of them have cost variance from 0% to 5% (50% of them were administrative buildings), about 37% of them have cost variance from 5% to 10 % (50% of them were administrative buildings also) and about 37% of them have cost variance from 10% to 20% (50% of them were other type of buildings).

c- Project Actual Value

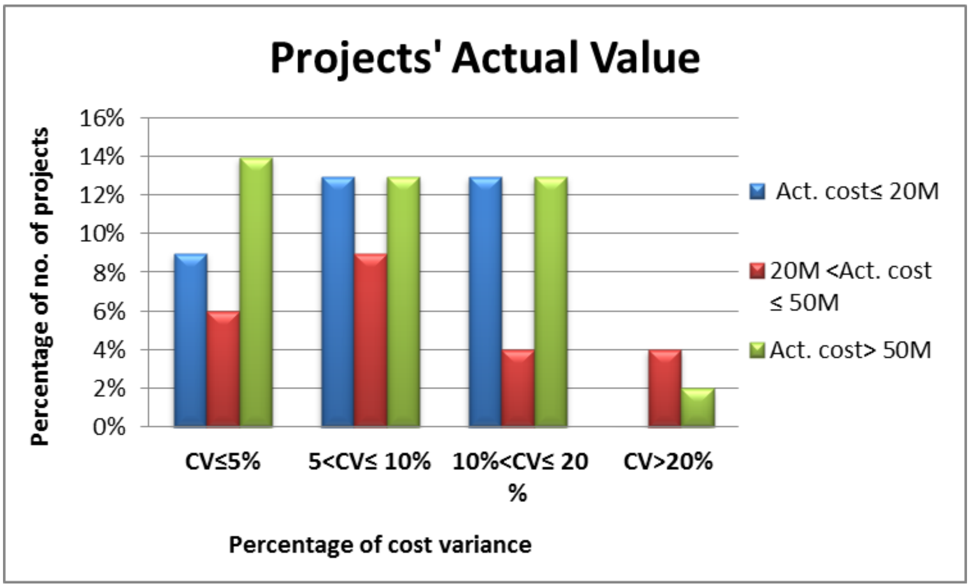

Figure (4.7): Classification of Projects According to Projects' Actual Value and Cost Variance

Analysis for figure (4.7) shows that projects that have actual cost more than 50 million EGP represent 43% of surveyed projects.

About 35% of projects that have actual cost more than 50 million EGP have cost variance from 0% to 5 % (57% of them were administrative projects). About 30% of projects that have actual cost more than 50 million EGP have cost variance from 5% to 10% (66% of them were residential projects). About 30 % of projects that have actual cost more than 50 million EGP have cost variance from 10% to 20% (66% of them were administrative projects).

Analysis also reveals that projects that have actual cost less than or equal to 20 million EGP were 34% of surveyed projects. About 26% of projects that have actual cost less than or equal to 20 million EGP have cost variance from 0% to 5 % (75% of them were residential projects). About 37 % of projects that have actual cost less than or equal to 20 million EGP have cost variance from 5% to 10% (66% of them were apartment blocks) and about 37 % of projects that have actual cost less than or equal to 20 million EGP have cost variance from 10% to 20% (50% of them were commercial projects).

d- Contract Type

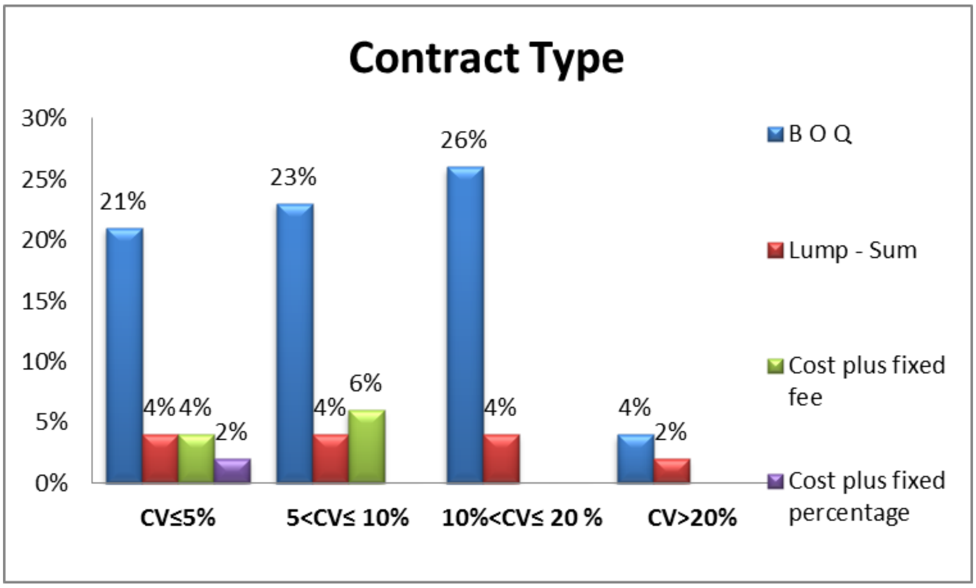

Figure (4.8): Classification of Projects According to Contract Type and Cost Variance

Analysis of figure (4.8) shows that BOQ projects represented 74% of surveyed projects. About 29% of BOQ projects have cost variance from 0% to 5 % (60% of them were administrative projects). About 33 % of BOQ projects have cost variance from 5% to 10% (43% of them were residential projects) and about 36 % of BOQ projects have cost variance from 10% to 20%.

4.3 Analysis of Factors Affecting Building Construction Projects Cost Estimating Accuracy:

The questionnaire in chapter three resulted in twelve factors that severely affect the construction projects cost estimating accuracy.

4.3.1 Data Gathering Results

The collected cost data from forty-seven projects to measure how the twelve factors affect the construction projects cost estimating accuracy. The following sections discuss the effect of each of the previously identified factors on construction projects cost estimating accuracy. Factor effect is measured by measuring the percentage of difference between estimated cost and actual cost as an indicator of the cost estimating accuracy.

4.3.2 Effect of Economic Instability

Economic instability is considered to be the first factor affecting construction projects cost estimating accuracy according to its importance index. The effect of this factor was measured by calculating the percentage of difference between estimated and actual cost.

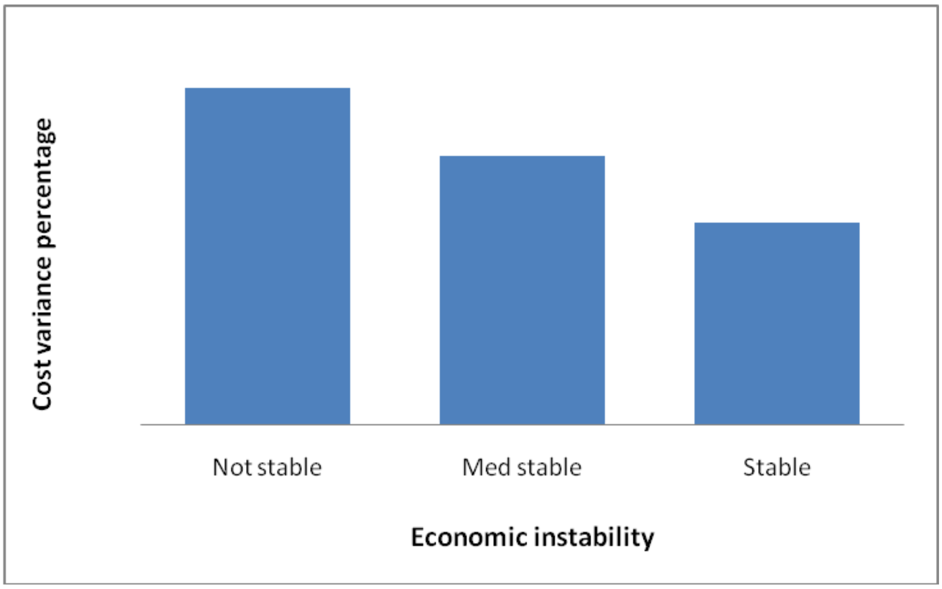

Figure (4.9): Effect of Economic Instability

Economic instability was measured with three levels of severity "stable, med stable and not stable". It can be measured by identifying currency exchange rate, materials prices "stable, rising or fluctuating", labor salaries and taxes. A closer inspection to Figure (4.9) illustrates that there is a direct proportion between economic instability and the percentage of cost variance. In other words, the difference between estimated cost and actual cost has increased with the increasing of economic instability. This result clearly shows that the extensive study of economic situation in the whole country may help to reduce the variance between estimated and actual cost.

4.3.3 Effect of Quality of Firm's Project Planning and Management

Quality of firm's project planning and management is the second most important factor affecting construction projects cost estimating accuracy according to its importance index. Such effect is assessed by calculating the percentage of the difference between the estimated and the actual cost.

Figure (4.10): Effect of Quality of Firm's Project Planning and Management

Figure (4.10) illustrates that there is an inverse proportion between qualities of firm's project planning and management and the percentage of cost variance. For instance, quality of firm's project planning and management was excellent, good, sufficient and insufficient. On the other side, the percentage of cost variance is high when the quality of firm's project planning and management was sufficient. Analysis of projects data shows that "Oman embassy residential building and construction of Pool Aswan Olympian Sports Club" are the reason of that jump and that was because other driving factors "project location, ability of estimating team, accuracy of bidding documents, estimating method and site condition" were insufficient. Therefore, it can be concluded that the relation between quality of firm's project planning and management and cost variance is an inversely proportional relation. In other words, the percentage of cost variance decreased with the Improvement of the quality of firm's project planning and management.

4.3.4 Effect of Relevant Experience of Estimating Team

The third most important factor affecting construction projects cost estimating accuracy according to its importance index is relevant experience of estimating team.

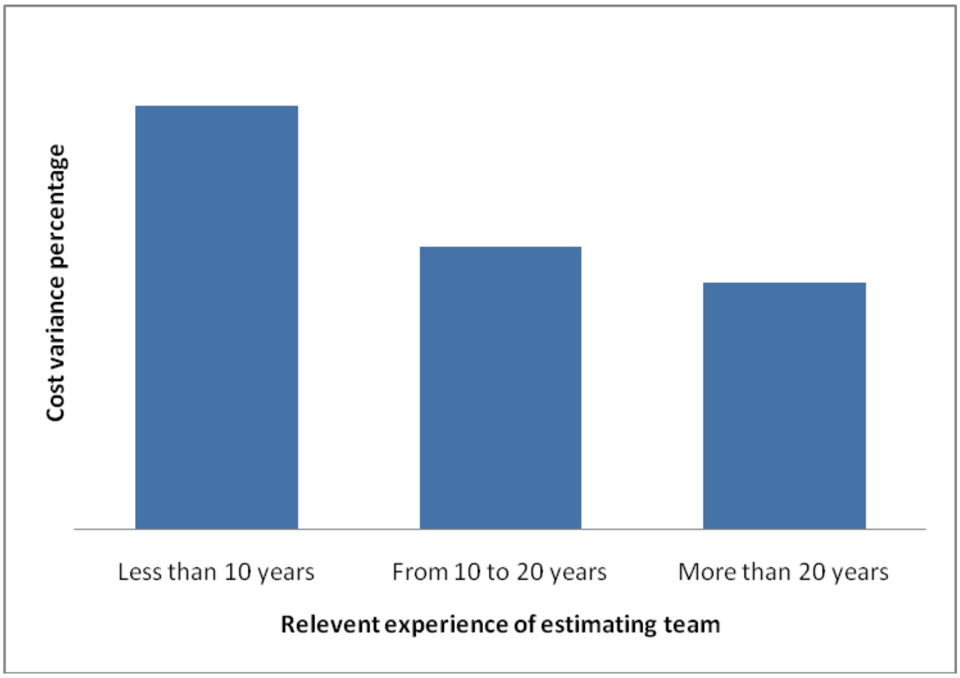

Figure (4.11): Effect of Relevant Experience of Estimating Team

A careful inspection to Figure (4.11) illustrates that there is an inverse proportion between relevant experience of estimating team and difference between estimated cost and actual cost. This means that the percentage of cost variance decreased with increasing of relevant experience of estimating team. In conclusion, the more experience the estimating team has, the more accurate cost estimating resulted.

4.3.5 The Effect of Availability of Management and Finance Plans

Availability of management and finance plans is the fourth most important factor affecting construction projects cost estimating accuracy.

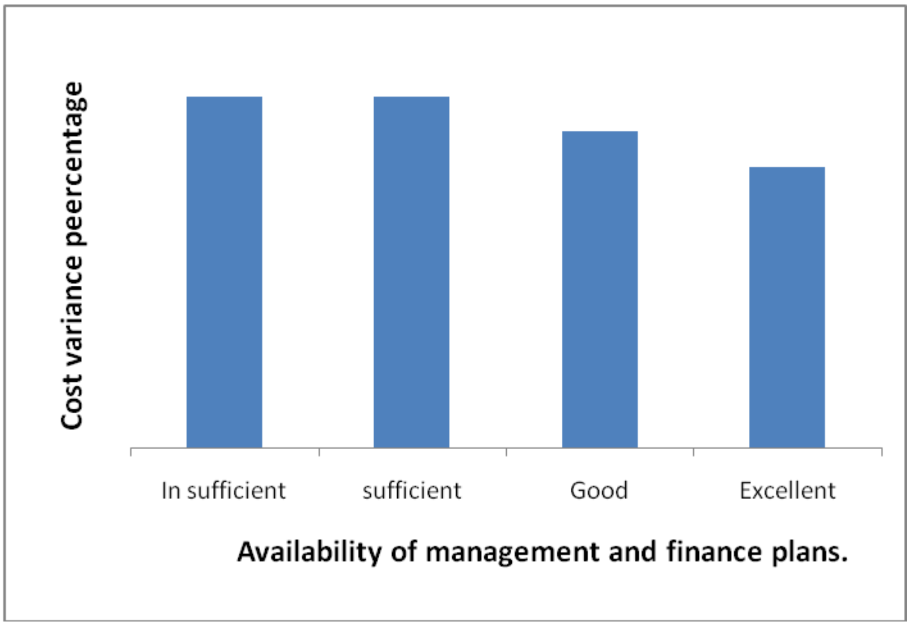

Figure (4.12): Effect of Availability of Management and Finance Plans

Figure (4.12) reveals the inverse proportion relationship between availability of management and finance plans and cost variance. Hence, the percentage of cost variance decreased with increasing of availability of management and finance plans. This result shows that the more availability of management and finance plans, the more reduced the percentage of cost variance will be.

4.3.6 The Effect of Ability of Estimating Team

Ability of estimating team is the fifth most important factor affecting construction projects cost estimating accuracy

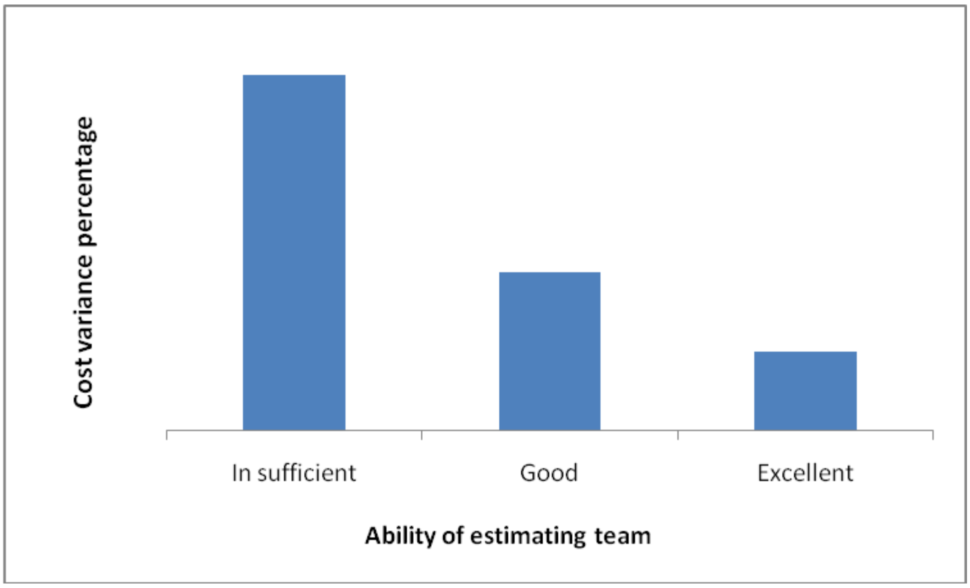

Figure (4.13): Effect of Ability of Estimating Team

(Alroono et al. 2010) analyzed cost-estimator competences. Research began with 23 factors and ended up with seven factors. These factors are:

1- Estimator's communication and work behavior
2- Basic knowledge required by an estimator
3- Preliminary tasks for developing quantity of work
4- Estimator's ability to analyze project scope and deal with the profession pressure
5- Ability to put together the project pieces and make decision
6- Construction process knowledge and judgment skill
7- Ability to produce a reliable estimate

Ability of estimating team is measured by four degrees of severity: excellent, good, sufficient and insufficient. Inspecting Figure (4.13) illustrates that there is an inverse proportion between ability of estimating team and the percentage of cost variance. This relationship explains the decrease of cost variance with the improvement of ability of estimating team.

4.3.7 The Effect of Availability of Labor and Equipment Required

Relating to importance index, availability of labor and equipment required is considered the sixth factor affecting construction projects cost estimating accuracy. Calculating the percentage of difference between estimated and actual cost shows effect of factor.

Figure (4.14): Effect of Availability of Labor and Equipment Required

As Figure (4.14) illustrates the percentage of cost variance decreases with increasing of availability of labor and equipment required. When availability of labor and equipment were "not available" the percentage of cost variance jumped with a big value.

The project shows that “Oman embassy residential building” is the reason of that jump and that is because other driving factors “Project location and Site condition” which were insufficient. In conclusion, those results clearly show that the more of the required labor and equipment are available, the more reduced the percentage of cost variance will be**.**

4.3.8 The Effect of Project Location

Project location is the eighth most important factor affecting construction projects cost estimating accuracy according to its importance index.

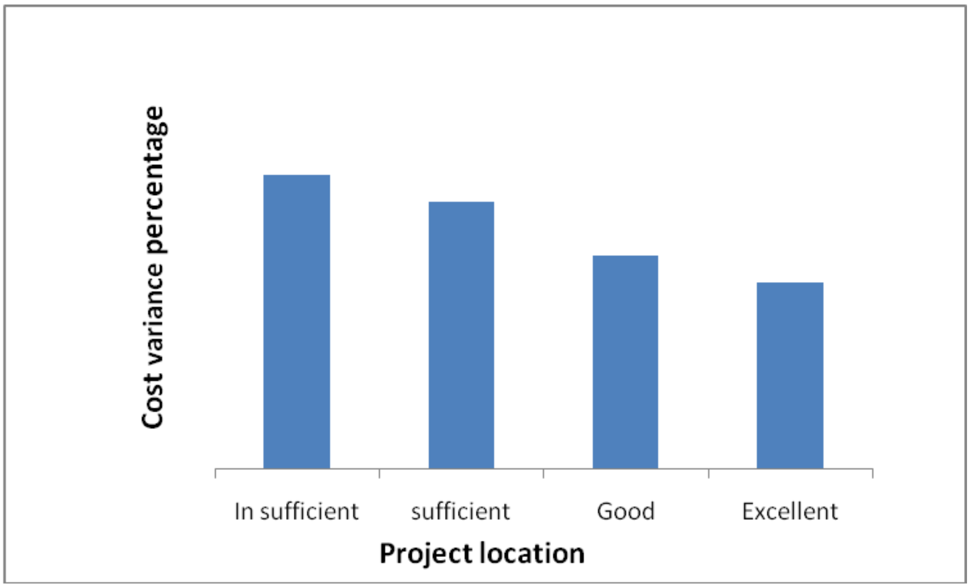

Figure (4.15): Effect of Project Location

Project location quality is measured by many factors such as: availability and transportation of material, being away from risks of locals and proximity to a main paved road. There is an inverse proportion between quality of project location and the average percentage of cost variance as figure (4.14) shows. Figure Inspection leads us to logic results relevant to common experience.

4.3.9 The Effect of Punctuality of Periodical Payments

As questionnaire results reveal, the ninth most important factor affecting construction projects cost estimating accuracy is the effect of punctuality of periodical payment.

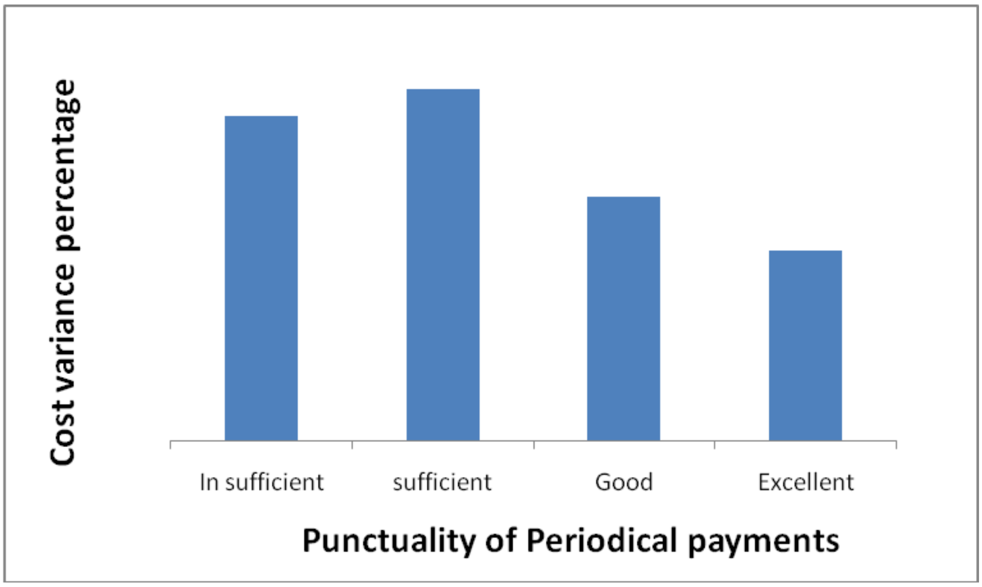

Figure (4.16): Effect of Punctuality of Periodical Payments

It is obvious from figure (4.16) that the average percentage of cost variance decreases when punctuality of periodical payment improves. Inspection of projects shows that the increase of cost variance when periodical payments were insufficient and this is because of two projects “Future University (F.U.C)-New Cairo) and Conrad Hotel”. That was due to other driving factors “availability of management and finance plans and site condition” which were excellent. In conclusion those results clearly show that the more the punctuality of periodical payments, the more reduced the difference between estimated cost and actual cost will be. Hence, the average percentage of cost variance decreased with the punctuality of periodical payments.

4.3.10 The Effect of Accuracy of Bidding Documents

Accuracy of bidding documents is the tenth most important factor affecting construction projects cost estimating accuracy according to its importance index.

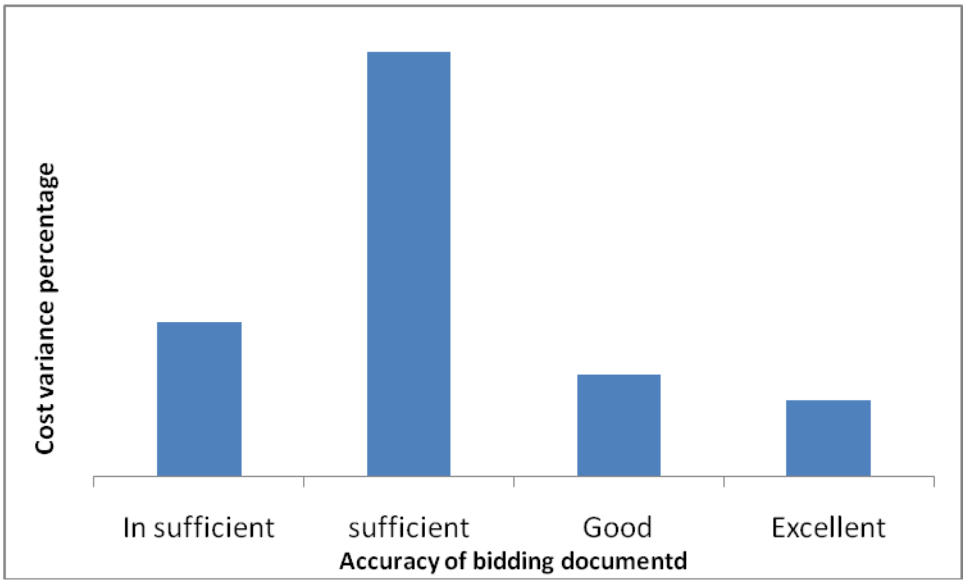

Figure (4.17): Effect of Accuracy of Bidding Documents

As shown in figure (4.17), there is an inverse proportion between accuracy of bidding documents and the average percentage of cost variance when accuracy of bidding documents was excellent, good, and insufficient. It is clear that the average percentage of cost variance is high when accuracy of bidding documents was sufficient. A closer inspection of projects shows that “Oman embassy residential building” is the reason of that jump and that was due to other driving factors “project location and site condition” which were insufficient. Therefore, it is concluded that the more the accuracy of bidding documents, the more reduced the average of cost variance will be.

4.3.11The Effect of Competence and Leadership of Project Manager

Competence and leadership of project manager is the eleventh most important factor affecting construction projects cost estimating accuracy according to its importance index. Interpersonal skills of managers are listed in **(PMBOK 2013)** as follows:

1- Effective communication
2- Influencing the organization
3- Leadership
4- Motivation
5- Negotiation and conflict management
6- Problem solving

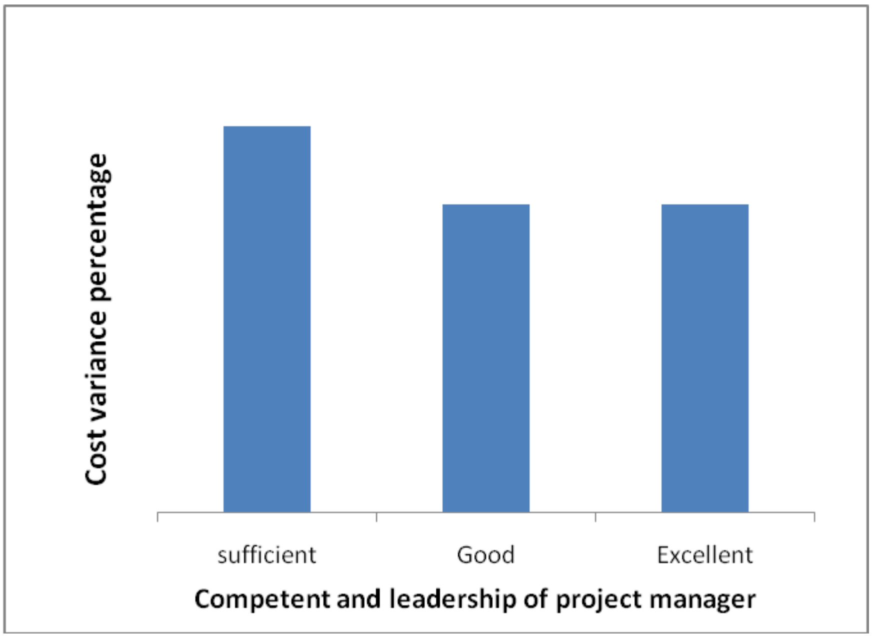

Figure (4.18): Effect of Competence and Leadership of Project Manager

If we inspect precisely fig (4.18), it will be clear that there is an inverse proportion between competence and leadership of project manager and the average percentage of cost variance. This result proves that the competence and leadership of project manager may help to reduce the average percentage of cost variance.

4.3.12The Effect of Impact of Accuracy of Project Schedule "Expected to Delay"

Referring to importance index, the twelfth factor affecting construction projects cost estimating accuracy is impact of accuracy of project schedule "expected to delay".

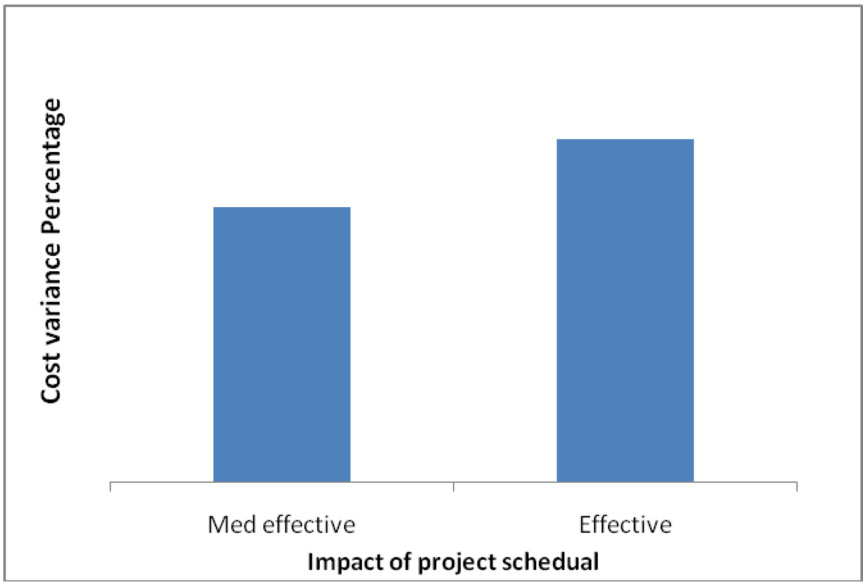

Figure (4.19): Effect of Impact of Accuracy of Project Schedule

As Figure (4.19) illustrates, the relation between impact of project schedule and the average percentage of cost variance is a direct proportion relationship. This result reveals that the accuracy of project schedule and commitment to it may help to reduce the average percentage of cost variance.

As discussed in this chapter, factors that severely affect construction cost estimating accuracy were twelve factors. The biggest effect was economic instability and the smallest effect was impact of project schedule. Hence, construction parties could reduce percentage of cost variance by the following:

1- Consider economic instability and project location when defining contingency value
2- Enhance the quality of planning and management of project
3- Assign project manager and estimating team with long period of experience and good abilities
4- Apply good management and finance plans
5- Provide sufficient numbers of labor and equipment
6- Use detailed estimates
7- Use accurate bidding documents
8- Adhere to project schedule

CHAPTER FIVE
DEVELOPMENT OF ARTIFICIAL NEURALNETWORKS MODEL

Chapter Five

DEVELOPMENT OF ARTIFICIAL NEURAL NETWORKS MODEL

5.1 Introduction

The objective of this chapter is to develop a decision support tool that can help the contractor to identify the expected cost variance. Hence, a decision can be made regarding the expected contingency that should be added to the base estimate. This chapter is slanted to shed a great deal of light on the sequences of the proposed neural network model development. General view on learning process, training network concept, trial and error practices, neural connection software, model training and model testing will be presented.

5.2 Neural Networks and Regression Analysis Trade-Off

Many researchers studied neural networks in comparison with multi regression analysis, most of them found out that neural network models are more accurate than multi regression analysis.

Berly et al. (1996) made a comparison between them. He stated: “Because of the parallel evaluation of both methods, our results showed ANN to perform slightly but significantly better in predicting population P/B ratio than MLR”.

Hsiao (2006) used standardized linear regression and nonlinear ANN models with panel data to explain firm characteristics that determine capital structure in Taiwan. He stated: “Non-linear ANN models generate a better fit and forecast of the set panel data than the regression model and ANNs are able of catching sophisticated non-linear integrating effects in both industries”.

5.3 Neural Networks: An Overview

“The brilliance in neural networks is that they allow the researcher to construct nonlinear models of the relationships between variables” **(Andrew 1999).**

Many researchers used ANN to develop models for predicting future values

Liu and Ling (2005) performed their research "Modeling a Contractor’s Markup Estimation” for predicting contractor mark up value.

Jafarzadeh et al. (2014) applied ANN in their study "Application of Artificial Neural Network Methodology for Predicting Seismic Retrofit Construction Costs”. Predictor enables a reliable estimation of the retrofit net construction cost (RNCC) to be made at the early development stage of a seismic retrofit project when little information is known about the project.

Moselhi, et al. (1991) discussed neural network application for developing an optimum markup estimation. Future possibilities of integrating neural networks and expert systems as a basis for developing efficient intelligent systems are described in his research.

There are two types of neural networks. The first type handles classification problems (e.g., into which category of customers targeted by a company does an individual fall?). The second type handles prediction problems. The structure of a neural network model includes an input layer that receives input from the outside world, hidden layers that serve the purpose of creating an internal representation of the problem, and an output layer, or the solution of the problem. Once data is input into the network, it is fed through the network to the hidden layers where random weights are assigned to each layer and adjusted in iterations until the desired output is achieved. This adjustment in the weights minimizes the error between the predicted values and the actual values. Before solving a problem, neural networks must be "trained". Networks are trained as they examine a smaller portion of the dataset just as they would examine a normal-sized dataset. Through this training, a network learns the relationships between the variables and establishes the weights between the nodes. Once this learning occurs, a new case can be entered into the network resulting in solutions that offer more accurate prediction or classification of the case**.**

5.3.1. The Learning Process

The learning rule is a procedure for modifying the weights and biases of a network to produce a desirable state. The purpose is to train the network to perform a task (classification or prediction). The types of neural network learning processes are:

1. The supervised learning in which the network is provided with a set of examples, inputs and outputs are presented to the network. Supervised learning requires an external "teacher" who evaluates the behavior of the system and directs the subsequent modifications. As the inputs are applied to the network, the network outputs are compared to targets. The learning rule is then used to adjust the weights in order to move the network outputs closer to the targets.

2. The unsupervised learning requires no "teacher". The network self-organizes to produce the desired changes. In unsupervised learning, only inputs are provided to the network, the outputs are not known. In advance the network is allowed to settle to a suitable state. The

weights are modified in response to network inputs only; there are no target outputs available.

3. The reinforcement learning is similar to supervised learning, but instead of being provided with the correct output for each network input, the algorithm is only given a grade. The grade is a measure of the network performance over some sequence of inputs. In addition there are three types of learning rules to specify how the connections are modified when presented with a learning example:

4. Delta rule (Adeline rule, Widrow-Hoff rule, Least Mean Square rule): modifying the weight of the incoming connections reduces the error between the neuron output and the desired output. The delta rule is just one method of determining the weights to give the least square error.

5. Competitive learning (winner takes all rule): neurons compete and the neuron with the closest output to a given input modifies itself to become more like that input.

6. Hebbian learning: it is an associative update rule, suitable for remembering patterns. A system trained with Hebbian rule will output high values when presented with a familiar pattern and weak when presented with an unfamiliar one. The big disadvantage with the Hebbian rule is that it is unstable and will always diverge over time **(Hanafy 2009).**

5.3.2. Back-Propagation1 (BP) Neural Network

It is the most popular and widely used network-learning algorithm. The back-propagation network is multilayer feed-forward neural network architecture. This model is used to provide mapping between some input and output quantities by forming a continuous function. In a BP network, no interconnections between neurons in the same layer are permitted. However, each neuron on a layer provides an input to each neuron on the next layer. The BP network uses supervised learning, so the input and output patterns must be both known. In BP, the error calculated at the output of the network is propagated through the layers of neurons in order to update the weights**.** The architecture of BP model consists of a collection of input units connected to a set of output units by a set of modifiable connecting weights Figure (5.1).

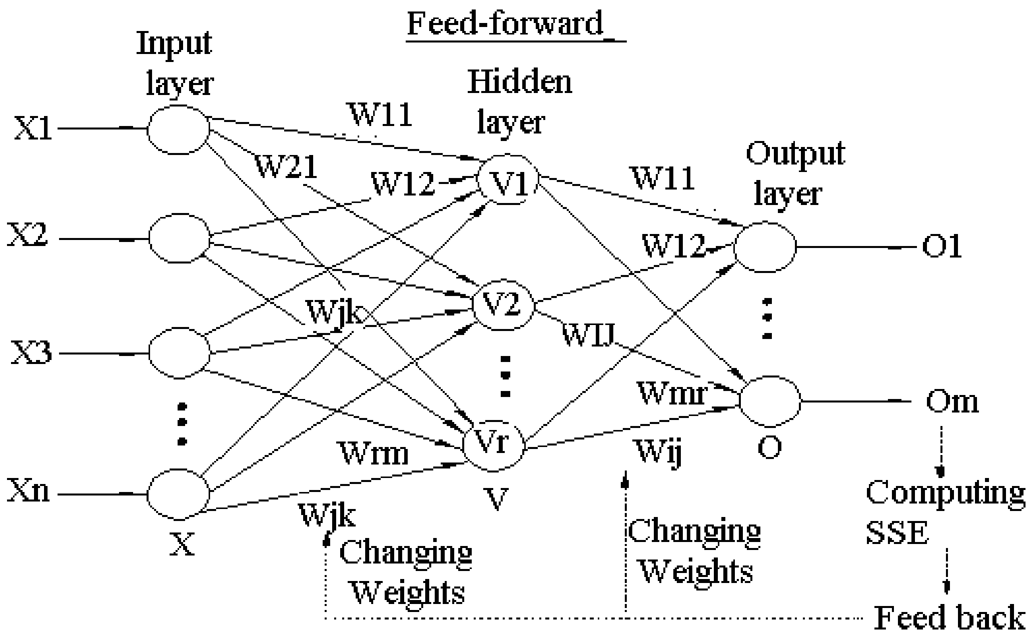

Figure (5.1): Schematic Drawing for a Multilayer Neural Network Training Using the Back-Propagation Learning Fundamentals (Hanafy 2009)

The delta rule minimizes the squares of the differences between the actual and desired output values, which are summed over the output units and the number of training patterns. Back propagation of error, calculates the error at each output unit and changes the value of the weights that led to the error. The weights are then changed so that the error is slightly reduced if the same input/output pair was presented again. Back-propagation networks employ a bias unit as a part of every layer except the output layer. This unit has a constant activation value of 1.0. Each bias unit is connected to all units in the next layer, and its weights to them are adjusted during the back-error propagation. The result is sometimes an improvement on the convergence properties of the network**.**

5.4 Design of the Networks Model

Design of the neural network model includes two main steps:

1- Selection of the Neural Network Simulation Software
2- Determining the best network architecture **(Abd El Azeem 2008)**

5.4.1. Neural Networks Software

Many design software is used for creating neural network models. Many researchers used Neural Network software in construction management. Figure (5.2) illustrates main steps to design an ANN model.

In this study, the BrainMaker professional for Windows Neural Network Simulation Software Version 3.7 is used to develop the Neural Network Model because it is more precise for number of inputs that research deal with.

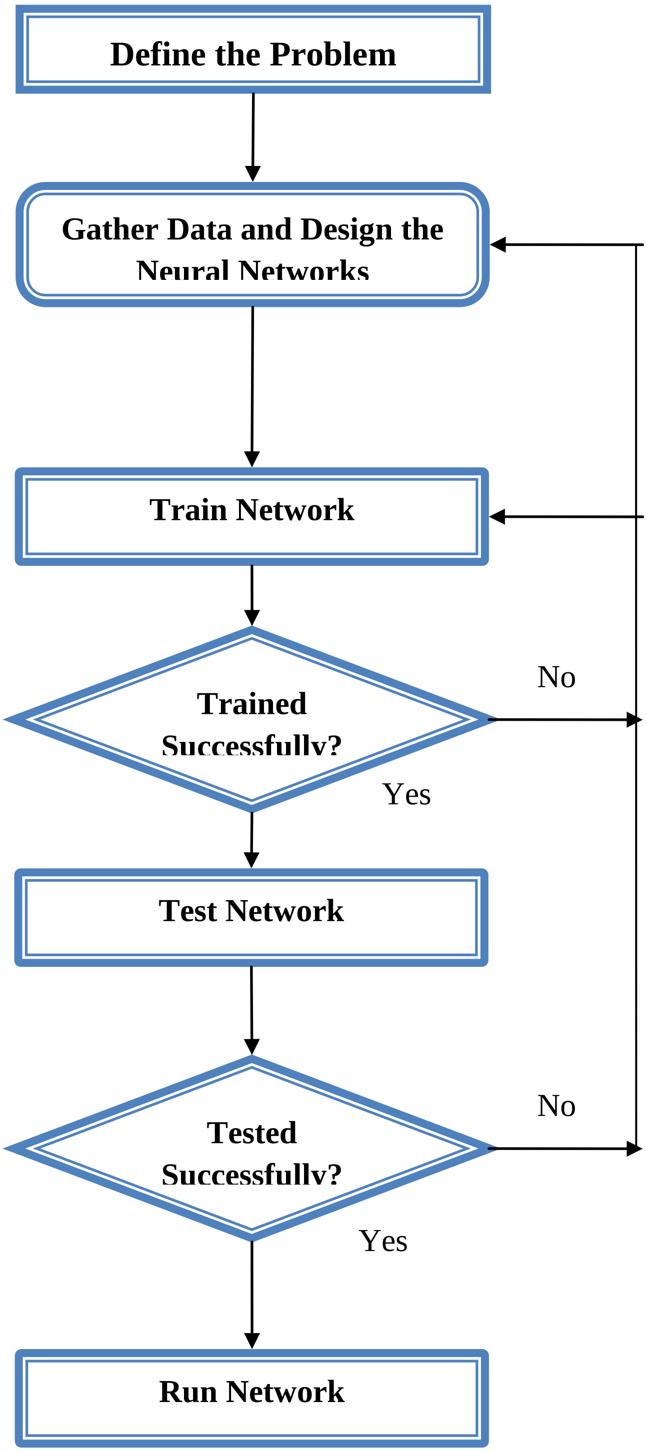

Figure (5.2): Neural Network Design (Lawrence 1994)

5.4.2. Determining the Best Network Architecture

The total collected data were forty-seven projects. Three projects are removed due to extremeness of data. The model development trials and errors are applied on forty-one projects. Three projects are chosen randomly for testing the network. To confirm that the input data is enough or not, the following test should be done.

Guideline 1: Number of Training Facts **(brainMaker Neural Network Simulation Software User's Guide and Reference Manual).**

Minimum Number of Training Facts = 2 * (Inputs + Hidden + Outputs)

Maximum Number of Training Facts = 10 * (Inputs + Hidden + Outputs)

This formula suggests that the number of training facts needed is between two and ten times the number of neurons in your network. Where:

- Inputs = factors affecting construction cost estimating = 12
- Outputs = percentage of difference between estimated cost and actual cost = 1
- Hidden: hidden neurons in a hidden layer store the information needed for network to make predications.

There are several ways to determine a good number of hidden neurons. One solution is to train several networks with varying numbers of hidden neurons and select the one that tests best. A second solution is to begin with a small number of hidden neurons and add more while training if the network is not learning. A third solution is starting to get the right number of hidden neurons by using the following guideline:

Guideline 2: Number of Hidden Neurons **(brainMaker Neural Network Simulation Software User's Guide and Reference Manual).**

Number of Hidden Neurons = (Inputs + Outputs) / 2

= (12 + 1) / 2 = 6.5 ≈ 7 Neurons

Substituting the result of applying the equation of guideline 2 in equations of guideline 1 introduces

- Minimum Number of Training Facts = 2 * (12 + 7 +1) = 40 Facts
- Maximum Number of Training Facts = 10 * (12 + 7 +1) = 200 Facts

The number of the actual data that obtained is forty-one. Therefore, this number is satisfactory because it is more than the recommended minimum number that obtained from guideline 1. These two guidelines can help in getting started with first network architecture.

Then, after training and testing phases, the changes in the number of hidden layers and the number of hidden neurons will be performed in each layer guided by the percentage of error of the network until the best network is obtained.

5.5 Training the Neural Networks Model

The training data contains examples of inputs together with the corresponding outputs, and the network learns to infer the relationship between the two. Training data is usually taken from historical records.

5.5.1. Neural Networks Training: An Overview

Based on previously discussed steps of designing the Artificial Neural Networks model, it is time now to start training the network. All trial models experimented in this research are trained in supervised mode by a back-propagation learning algorithm. Inputs are fed to the proposed network model and the outputs were calculated. The differences between the calculated outputs and the actual outputs are then evaluated. The back propagation algorithm develops the input to output mapping by minimizing a root mean square error (RMS) which is expressed by the following equation :**(Ballard 1997)**:

RMS = $\sqrt{\sum_{i=1}^{n}(O_i - P_i)^2}$ **(Ballard 1997)**

Where: (n) is the number of samples to be evaluated in the training phase.

(Oi) is the actual output related to the sample.

(Pi) is the predicted output.

This value is calculated automatically by the Brainmaker professional.

The training process stopped when the value mean square error remains unchanged.

5.4.2. Training the Network Using Brain Maker Software

The following steps are to be followed to create the proposed neural networks model:

Input data of the neural networks is prepared in format of Microsoft Office Excel sheet. Input fields contain twelve fields that present the factors affecting cost estimating accuracy which are previously concluded in chapter 3.

Output (Target) field contains the percentage of difference between estimated cost and actual cost.

5.4.3. Trials and Errors Practices

The characteristics of the model's learning rule as well as training and testing tolerance are set automatically by the program and the variables that the program requires setting during the design stage are the number of hidden layers. Number of hidden nodes in each layer and the type of transfer function (sigmoid, gaussian or step) that the program will use in the following alteration sequences:

A. One hidden layer with **sigmoid** transfer function: (Table 5-1).

B. One hidden layer with **gaussian** transfer function: (Table 5-2).

C. One hidden layer with **step** transfer function: (Table 5-3).

D. Two hidden layers with sigmoid and gaussian transfer function in each: (Table 5-4)

Table (5-1): Experiments for Determining the Best Model

Trial no.	No. of hidden layers	Learning rate	No. of hidden nodes		Type of function	Avg. error	R M S error
1	1	0.1	12	0	Sigmoid	0.0681	0.0743
2	1	0.09	12	0	Sigmoid	0.0641	0.0701
3	1	0.08	12	0	Sigmoid	0.0571	0.0619
4	1	0.07	12	0	Sigmoid	0.0582	0.0527
5	1	0.06	12	0	Sigmoid	0.071	0.0831
6	1	0.1	13	0	Sigmoid	0.0649	0.0722
7	1	0.09	13	0	Sigmoid	0.0639	0.0686
8	1	0.08	13	0	Sigmoid	0.0641	0.0698
9	1	0.07	13	0	Sigmoid	0.0514	0.0569
10	1	0.06	13	0	Sigmoid	0.0526	0.0588
11	1	0.1	11	0	Sigmoid	0.0703	0.0761
12	1	0.09	11	0	Sigmoid	0.0638	0.069
13	1	0.08	11	0	Sigmoid	0.072	0.0776
14	1	0.07	11	0	Sigmoid	0.0535	0.0568
15	1	0.06	11	0	Sigmoid	0.0598	0.0694
16	1	0.1	10	0	Sigmoid	0.072	0.0775
17	1	0.09	10	0	Sigmoid	0.0693	0.0739
18	1	0.08	10	0	Sigmoid	0.0726	0.0803
19	1	0.07	10	0	Sigmoid	0.0513	0.0587
20	1	0.06	10	0	Sigmoid	0.0511	0.057

Table (5-2): Experiments for Determining the Best Model

Trial no.	No. of hidden layers	Learning rate	No. of hidden nodes		Type of function	Avg. error	R M S error
21	1	0.1	12	0	Gaussian	0.54	0.63
22	1	0.09	12	0	Gaussian	0.0639	0.0981
23	1	0.08	12	0	Gaussian	0.058	0.0825
24	1	0.07	12	0	Gaussian	0.0729	0.0977
25	1	0.1	13	0	Gaussian	0.0703	0.1
26	1	0.09	13	0	Gaussian	0.14	0.19
27	1	0.1	11	0	Gaussian	0.052	0.079
28	1	0.09	11	0	Gaussian	0.0641	0.0835
29	1	0.1	10	0	Gaussian	0.0611	0.0797
30	1	0.09	10	0	Gaussian	0.0551	0.0707
31	1	0.08	10	0	Gaussian	0.056	0.073
32	1	0.07	10	0	Gaussian	0.0802	0.0967

Table (5-3): Experiments for Determining the Best Model

Trial no.	No. of hidden layers	Learning rate	No. of hidden nodes		Type of function	Avg. error	R M S error
33	1	0.1	12	0	step	0.42	0.53
34	1	0.09	12	0	step	0.43	0.54
35	1	0.1	13	0	step	0.41	0.52
36	1	0.01	11	0	step	0.36	0.47
37	1	0.09	11	0	step	0.44	0.55
38	1	0.1	10	0	step	0.45	0.56
39	1	0.09	10	0	step	0.28	0.38

Table (5-4): Experiments for Determining the Best Model

Trial no.	No. of hidden layers	Learning rate	No. of hidden nodes		Type of first function	Type of second function	Avg. error	R M S error
40	2	0.1	10	30	Sigmoid	Sigmoid	0.0655	0.0715
41	2	0.1	10	50	Sigmoid	Sigmoid	0.064	0.069
42	2	0.1	20	50	Sigmoid	Sigmoid	0.0588	0.065
43	2	0.07	20	50	Sigmoid	Sigmoid	0.065	0.086
44	2	0.1	20	60	Sigmoid	Sigmoid	0.15	0.19
45	2	0.1	20	50	Sigmoid	Gaussian	0.087	0.1
46	2	0.1	10	50	Gaussian	Sigmoid	0.15	0.2
47	2	0.1	12	12	Sigmoid	Sigmoid	0.808	0.1
48	2	0.1	12	7	Sigmoid	Sigmoid	0.061	0.069
49	2	0.09	12	7	Sigmoid	Sigmoid	0.066	0.076
50	2	0.09	11	7	Sigmoid	Sigmoid	0.072	0.084
51	2	0.09	10	7	Sigmoid	Sigmoid	0.059	0.065
52	2	0.09	12	6	Sigmoid	Sigmoid	0.0589	0.0650
53	2	0.09	11	6	Sigmoid	Sigmoid	0.065	0.0811
54	2	0.09	10	6	Sigmoid	Sigmoid	0.058	0.051
55	2	0.09	12	5	Sigmoid	Sigmoid	0.028	0.0603
56	2	0.09	11	5	Sigmoid	Sigmoid	0.4471	0.7310
57	2	0.09	10	5	Sigmoid	Sigmoid	0.059	0.066
58	2	0.08	10	6	Gaussian	Gaussian	0.055	0.071

59	**2**	**0.08**	**10**	**5**	**Gaussian**	**Gaussian**	**0.51**	**0.76**
60	**2**	**0.08**	**12**	**7**	**Sigmoid**	**Sigmoid**	**0.067**	**0.081**
61	**2**	**0.08**	**12**	**5**	**Sigmoid**	**Sigmoid**	**0.076**	**0.1**
62	**2**	**0.08**	**11**	**7**	**Sigmoid**	**Sigmoid**	**0.050**	**0.062**
63	**2**	**0.07**	**12**	**7**	**Sigmoid**	**Sigmoid**	**0.65**	**0.070**
64	**2**	**0.07**	**10**	**5**	**Sigmoid**	**Sigmoid**	**0.051**	**0.058**
65	**2**	**0.07**	**20**	**50**	**Sigmoid**	**Sigmoid**	**0.054**	**0.063**
66	**2**	**0.07**	**50**	**10**	**Sigmoid**	**Sigmoid**	**0.044**	**0.058**
67	**2**	**0.07**	**50**	**30**	**Sigmoid**	**Sigmoid**	**0.54**	**0.063**
68	**2**	**0.1**	**12**	**7**	**Gaussian**	**Gaussian**	**0.083**	**0.10**
69	**2**	**0.09**	**12**	**5**	**Gaussian**	**Gaussian**	**0.056**	**0.063**
70	**2**	**0.09**	**11**	**7**	**Gaussian**	**Gaussian**	**0.049**	**0.065**
71	**2**	**0.09**	**12**	**7**	**Gaussian**	**Gaussian**	**0.056**	**0.067**
72	**2**	**0.09**	**10**	**5**	**Gaussian**	**Gaussian**	**0.085**	**0.076**
73	**2**	**0.09**	**20**	**50**	**Gaussian**	**Gaussian**	**0.129**	**0.018**
74	**2**	**0.09**	**50**	**10**	**Gaussian**	**Gaussian**	**0.076**	**0.09**
75	**2**	**0.09**	**50**	**30**	**Gaussian**	**Gaussian**	**0.092**	**0.11**
76	**2**	**0.08**	**11**	**5**	**Gaussian**	**Gaussian**	**0.080**	**0.10**
77	**2**	**0.08**	**10**	**5**	**Gaussian**	**Gaussian**	**0.052**	**0.061**
78	**2**	**0.07**	**12**	**6**	**Gaussian**	**Gaussian**	**0.058**	**0.06**
79	**2**	**0.07**	**10**	**6**	**Gaussian**	**Gaussian**	**0.051**	**0.076**
80	**2**	**0.07**	**12**	**5**	**Gaussian**	**Gaussian**	**0.053**	**0.064**

5.6 Testing the Validity of the Model

Testing the network is essentially the same as training it, except that the network is being shown facts it has never seen before in the testing phase, and no corrections are made. It is important to evaluate the performance of the network after the training process. If the results are good, the network will be ready to use. Table (5.5) presents the actual and predicted percentage of cost variance, which is calculated using the developed NN model.

Table (5.5) Predicted and Actual Values of Percentage of Cost Variance

Project Name	Predicted Value	Actual Value	Percentage Error
Arura	**3.8220%**	**5%**	**-23.6%**
Bloom Bank Head Quarter	**14.735%**	**12%**	**+22.8%**
Seven Stars Mall, New Cairo	**14.728%**	**13%**	**+13.3%**

Previous table shows that percentage error varies from -23.6% to +22.8% of the actual percentage of cost variance. That means that the model error in prediction is approximately ± 23%. When using this model, It is recommended for contractor to put this percentage of error into consideration after applying his experience.

CHAPTER SIX
CONCLUSIONS & RECOMMENDATIONS

Chapter Six

Conclusions & Recommendations

6.1 Introduction:

The research study is presented in six chapters encircling the whole research essence. This Chapter, which presents the summary of the study, ultimately reveals the digest of major findings drawn from the study. The research findings are presented while considering the final model, and their interpretations are also briefly mentioned. The chapter also cites the appropriate current recommendations, which the researcher developed based on the conclusions of the research study. Some recommendations for further studies in the same area are also presented and suggested according to the perception of the researcher.

6.2 Summary:

Cost estimating is an assessment of the expected cost of any construction project. The accuracy of such estimate has a serious effect on the expected profit of the construction contractor. Hence, a certain contingency premium should be added to the base estimate to increase the level of confidence. Such premium is materially affected by many factors. Through this study, the main factors that are expected to affect the accuracy of the construction project cost estimate are clearly identified. Cost variance is used as an indicator of the cost estimating accuracy. The most important factors identified are twelve factors. These factors are: economic instability, quality of firm's project planning and management, relevant experience of estimating team, availability of management and finance plans, ability of estimating team, labor and equipment required, estimating method, project location, periodical payments, accuracy of bidding documents provided by client, competence and leadership of project manager and impact of the accuracy of project schedule (expected delay). Pertinent cost data of a selected sample of construction projects are investigated to find out the effect of these factors on the construction project cost variance. Finally, a neural network model was developed that can greatly help to assess the expected cost variance of any future construction project. The validity of the proposed model was tested to confirm that the model can assess the expected cost variance at a satisfactory level of accuracy.

6.3 Research Conclusions:

The following conclusions are drawn from this research:

1- Through literature review, potential factors that affect the accuracy of the cost estimating for construction projects were identified. Twelve factors are identified. These factors are: economic instability, quality of firm's project planning and management, relevant experience of estimating team, availability of management and finance plans, ability of estimating team, labor and equipment required, estimating method, project location, periodical payments, accuracy of bidding documents provided by client, competence and leadership of project manager and impact of project schedule.

2- Measurements of the twelve factors show that improvement of the quality of firm's project planning and management, relevant experience of estimating team, availability of management and finance plans, ability of estimating team, availability of labor and equipment required, estimating method, project location, periodical payments, accuracy of bidding documents provided by client and competence and leadership of project manager can greatly reduce the average cost variance. While economic instability and impact of project schedule "expected to delay" are found to have a bad effect on the average percentage of cost variance.

3- A satisfactory neural network model is developed through eighty experiments for predicting the average percentage of cost variance for any future building construction projects in Egypt. This model consists of one hidden layer with twelve hidden nodes with a sigmoid transfer function. The learning rate of this model is (0.07), while the training and testing tolerance are set to the same value. Testing the validity of the proposed model shows that the model can assess the expected cost variance of any construction project at an average accuracy of about 80%. However, with the availability of more cost data in the future, such accuracy can be greatly enhanced.

6.4 Recommendations:

It is recommended for construction parties to take the twelve factors that may severely affect building construction cost variance as mentioned in this study into consideration when preparing cost estimate for any future project as follows:

- Consider economic instability and project location when defining contingency value.
- Assign qualified project manager, estimating team and planners.
- Applying good management and finance plans.

- Provide sufficient numbers of labor and efficient equipment.
- Use detailed estimates if possible.
- Use accurate bidding documents.

The following potential areas of studies, if explored, would provide increased validity to the findings of this research:

- The model should be augmented to take into consideration the other different types of construction projects. For example: The infrastructure construction projects and heavy construction projects.
- The development of artificial neural network models or any other technique requires the presence of structured and well-organized database of the completed projects in construction firms. Unfortunately, most Egyptian construction firms have no structured database system that can provide researchers with the required information. It is recommended that a standard database system for storing information about all completed projects should be developed and applied by the construction companies in Egypt.

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Appendix (A)

Questionnaire

1- Questionnaire Cover

كلية الهندسة و التكنولوجيا

قسم الدراسات العليا الهندسية

نموذج استبيان في موضوع بحث رسالة ماجستير

العوامل المؤثرة فى دقة تقديرات تكاليف مشروعات التشييد

الغرض من الاستبيان:

يهدف الاستبيان الى معرفة العوامل الاكثر تأثيرا في دقة تقديرات تكاليف المشروعات الانشائية .

أقسام الاستبيان:

القسم الأول: بيانات المهندس المشارك في البحث.

القسم الثاني: شرح طريقة التدوين في نموذج الاستبيان.

القسم الثالث: نموذج الاستبيان.

القسم الرابع: عوامل اخرى من وجهة نظر المهندس المشارك.

القسم الاول:بيانات المهندس المشارك فى الاستبيان.

الاسم:

سنة التخرج:

الوظائف التي اشتغل بها:

1-

2-

3-

4-

5-

أهم المشروعات التي عمل بها:

1-

2-

3-

4-

5-

القسم الثاني : شرح طريقة التدوين في نموذج الاستبيان.

الجدول يمثل اغلب العوامل التى تؤثر على دقة تقديرات التكاليف للمشروعات الهندسية في بحوث سابقة.

أمام كل عامل يوجد (5) درجات من التأثير:

مؤثر جدا – مؤثر – تأثير بسيط – تأثير بسيط جدا- غير مؤثر

يتم وضع علامة (√) في المربع المناسب لدرجة تأتير العامل على دقة تقديرات التكاليف.

3- Questionnaire Sample

No	Category	Factor	Severity				
			V. major effect (5)	Major effect (4)	Minor effect (3)	V. minor effect (2)	No effect (1)
1	Financial Issues	Periodical payments					
2		Availability of management and finance plans					
3		Inflation pressure					
4		Economic instability					
5		Uncertainty of taxes					
6		Currency exchange fluctuation average					
7		Accuracy of estimated financing cost					
8		State of market					
9	Bidding Situations	Number of competitors					
10		Level of competition					
11		Time between project announcement and bid opening average					
12		Accuracy of bidding documents provided by client					
13	Project Characteristics	Type of contract					
14		Size of contract					
15		Project location					
16		Site condition					
17		Competent and leadership of project manager					
18		Experience and incentives of field staff					
19		Quality of firm's project planning and management					
20		Labor and equipment required					
21		Contract period					
22		Content of the project specifications					
23		Punitive damages					
24		Arbitration clause					
25		Knowledge of client and consultant average					
26		Owner A- /E experience level					
27		Attitude towards changes					
28		Environmental issues					

29		**Impact of project schedule**					
30		**Quality of specification code**					
31		**Unforeseeable change in local laws and procedures**					
32		**Weather**					
33		**Nationality of labor**					
34		**Social and cultural impact**					
35		**Religious regulations**					
36		**Estimating method**					
37		**Public exposure**					
38	**Estimating Process**	**Availability of productivity standards**					
39		**Availability of cost indexes average**					
40		**Relevant experience of estimating team**					
41		**Ability of estimating team**					
42		**Standard procedure for updating cost information**					
43		**Method used in determining contingency**					

4- Comments, Other factors from your opinion

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Appendix (B)

1- Data Collection Cover

كلية الهندسة و التكنولوجيا

قسم الدراسات العليا الهندسية

نموذج جمع بيانات في موضوع بحث رسالة ماجستير

قياس العوامل الأكثرتأثيرا فى دقة تقدير تكاليف مشروع تشييد

الغرض من جمع البيانات:

يهدف جمع البيانات الى قباس العوامل الاكثر تأثيرا في دقة تقديرات تكاليف مشروعات التشييد .

أقسام جمع البيانات:

القسم الأول: شرح طريقة التدوين في الاستبيان

القسم الثانينموذج جمع البيانات.

القسم الثالث: الاقتراحات.

القسم الأول : شرح طريقة التدوين فى نموذج جمع البيانات.

نموذج جمع البيانات عباره عن قسمين

يتم ملئ القسم الاول و الخاص ببيانات المشروع و المهندس المشارك.
القسم الثاني عبارة عن 12 عامل يعتقد أنهم الاكثر تأثير في تقدير تكلايف المشروعات الهندسية و أمام كل عامل توجد عدة اختيارات لقياس هدا العامل في المشرع. يتم اختيار القياس المناسب.

2- Data Collection Sample

This form was prepared to gather some specific data of construction projects.

FACTORS AFFECTING THE ACCURACY OF CONSTRUCTION PROJECTS COST ESTIMATING

1- **Completed Projects**
2- **Project Location in Egypt**
3- **Non Industrial Projects**

You are kindly requested to mark (√) in front of each factor according to its influence or insert a number.

Respondent's information	
Respondent's Name	
Mobile No.	
Project Name	**Project Location**
Contract type	BOQ ( ) Cost plus fixed fee ( ) Lump Sum ( ) Cost plus percentage ( )
Contract actual duration	
Project Type	Admin. Buildings ( ) Commercial ( ) Residential ( ) Others ( ) please specify.
Project estimated cost	**Project actual cost**

No.	Factor	Effect			
1	**Economic instability**	( ) Stable	( ) Med stable	( ) Not stable	
2	**Quality of firm's project planning and management**	( ) Excellent	( ) Good	( ) sufficient	( ) Insufficient
3	**Relevant experience of estimating team**	( ) More than 20 years	( ) From 10 to 20 years	( ) Less than 10 years	
4	**Availability of management and finance plans**	( ) Excellent	( ) Good	( ) sufficient	( ) Insufficient
5	**Ability of estimating team**	( ) Excellent	( ) Good	( ) sufficient	( ) Insufficient
6	**Labor and equipment required**	( ) Available	( ) Semi-available	( ) Not Available	
7	**Estimating method**	detailed	Semi- detailed	Conceptual	
8	**Project location**	( ) Excellent	( ) Good	( ) sufficient	( ) Insufficient
9	**Periodical payments**	( ) Excellent	( ) Good	( ) sufficient	( ) Insufficient
10	**Accuracy of bidding documents provided by client**	( ) Excellent	( ) Good	( ) sufficient	( ) Insufficient
11	**Competent and leadership of project manager**	( ) More than 20 years	( ) From 10 to 20 years	( ) Less than 10 years	
12	**Impact of project schedule "expected to delay"**	( ) Effective	( ) Med effective	( ) Not Effective	

3- Comments and Recommendations

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<u>Appendix (C)</u>

List of Respondents for Questionnaire

No	Respondent Personal Information			Company Information
	Name	**Position**	**Years of Experience**	**Company Name**
1	Mohamed Alaa el din	Scheduling Manager	10-20 years	Arab Contractors
2	Magdy Abd el wahab	Project Manager	10-20 years	MEMAAR Co. for Eng. & Contracting
3	Shereef rabeaa	S. Project M.	10-20 years	Hasan Allam construction co
4	Mohamed Handousa	Scheduling Manager	10-20 years	Jet contractors
5	Hassan Shalan	planner	10-20 years	Orascom
6	Mostafa Abed Elrahamn	Cost Manager	10-20 years	Hasan Allam construction co.
7	Waffa El-ahwal	Area Manager	>20 years	Arab Contractors
8	Ahmed Samir	planner	10-20 years	Hasan Allam construction co
9	AmrZakaria	S. Project M.	>20 years	Asma contractor
10	Ahmed Samy	Cost control	10-20 years	Orascom
11	Ahmed Ibraheem	planner	10-20 years	Petrojet
12	AmrAdss	Cost Manager	<20 years	Arab Contractors
13	Nabil Abd El baset	Cost Manager	>20 years	Ramo contractors
14	Amir El Taher	Scheduling Manager	<20 years	Petrojet

15	KhaledShalaby	Scheduling Manager	10-20 years	Tiba - contracting and real state
16	Mohamed Anees	Project M.	10-20 years	Al delta contracting
17	Ehab Gouda	Cost engineer	<20 years	Arab Contractors
18	MazharSalh	Project M.	>20 years	Al shouroq contractors
19	Ahmed Atta	Area manager	>20 years	Orascom
20	Wael galal	Project M.	10-20 years	El masrya el yabanya contaracting
21	Adel mohamed	Cost engineer	10-20 years	Tiba - contracting and real state
20	AtefEwida	Cost Manager	>20 years	Arab office contractor
23	Moustafa Mohamed	Planner	10-20 years	Hasan Allam construction co
24	Mohamed ragab	Project Manager	10-20 years	Arab Contractors
25	Albeer Emil	planner	10-20 years	Hyundai engineering and construction
26	khaledAdly	Cost Manager	10-20 years	Hasan Allam construction co
27	Islam Mohamed	Scheduling Manager	10-20 years	Abo EL Hanna ikhwan for general Contracting
28	Mohamed Aboud	Project Manager	10-20 years	Arab Contractors
29	Mohamed Oukda	Project Manager	10-20 years	Alexandria Construction Co
30	Khaled Shalaby	Scheduling Manager	10-20 years	Orascom
31	Sady El zouheiry	Scheduling Manager	10-20 years	Tiba - contracting and real state
32	Thoria Helmy	Project Manager	10-20 years	Hasan Allam construction co
33	Salah Eldin el hosieny	Cost Manager	>20 years	El Nasr Building and Construction Egypt

34	Mohamed Shibl	Project Manager	10-20 years	Roya contractors
35	Khaled Rakha	Cost Manager	>20 years	Orascom
36	Hazem Hosieny	Scheduling Manager	10-20 years	Hasan Allam construction co
37	George Fikry	Project Manager	10-20 years	Diar Al Tamer Company
38	Mohamed Mahmoud	Scheduling Manager	10-20 years	AL Shafar General Contracting - ASGC-Egypt office
39	Amr Okeil	Cost Manager	10-20 years	Orascom
40	Hesham Samy	Project Manager	>20 years	Roya contractors
41	Waleed Moustafa	Project Manager	10-20 years	Global Consultant Engineers
42	Ahmed shoukry	Cost Manager	10-20 years	Diar Al Tamer Company
43	Mohamed shourbagy	Cost Manager	10-20 years	Petrojet

Appendix (D)

Detail List of Selected Projects for Evaluation

Type	No	Project Name	Contract Value	Actual Contract Value	Duration	Type Of Contract
Administrative Buildings	1	Bank Of Alexandria - San Paolo	EGP 63,000,000	EGP 64,247,400	24 m	Unit price (BOQ)
	2	Tanta Central Bank	EGP 23,277,997	EGP 23,776,146	22m	Unit price (BOQ)
	3	Beltone Financial New Head Office Smart Village	EGP 88,999,332	EGP 89,889,326	19 m	Unit price (BOQ)
	4	Development & Agricultural Insurance Bank of Egypt	EGP 124,759,440	EGP 137,235,384	30 m	Unit price (BOQ)
	5	Core & Shell Offices - Smart Village	EGP 38,034,000	EGP 41,076,720	20m	Unit price (BOQ)
	6	Local Popular Council in Luxor	EGP 4,500,000	EGP 4,734,000	12 m	Unit price (BOQ)
	7	Arrura	EGP 57,788,945	EGP 60,747,739	20 m	Unit price (BOQ)
	8	Bloom Bank Head Quarter	EGP 121,530,978	EGP 136,053,930	28 m	Unit price (BOQ)
	9	Madkour quotas primary School in Dakahlyah	EGP 1,824,409	EGP 2,098,070	12 m	Unit price (BOQ)
	10	Bdeer Al Hadydy secondary industrial school in Dakahlyah	EGP 5,409,552	EGP 6,172,840	12 m	Unit price (BOQ)
	11	Rayahbulding Smart Village.	EGP 49,000,000	EGP 53,998,000	25 m	Unit price (BOQ)
	12	EFG Hermes New Headquarter - Smart Village	EGP 190,687,009	EGP 193,547,314	24 m	Cost plus fixed fee
	13	Ahli United Bank of Egypt, New Head Office Building	EGP 154,350,000	EGP 170,711,100	42 m	Unit price (BOQ)
	14	Piraeus Bank Egypt, Smart Village	EGP 115,212,739	EGP 116,019,228	20 m	Cost plus percentage

Type	No	Project name	Contract value	Actual contract value	Duration	Type of contract
Administrative Buildings	15	luxor culture palace	EGP 45,000,000	EGP 49,140,000	24 m	Unit price (BOQ)
	16	Ekhnatoon School-New Cairo, Fifth District, Cairo Governorate	EGP 65,700,000	EGP 70,824,600	24 m	Cost plus fixed fee
	17	NSGB Head Quarter	EGP 32,710,256	EGP 33,233,620	20 m	Lump-sum
	18	visitors center in Karnak museum	EGP 12,524,000	EGP 13,400,680	12 m	Unit price (BOQ)
	19	Administrative Building - Misr for Central Clearing, Depository and Registry	EGP 166,257,900	EGP 175,734,600	20 m	Lump-sum
Commercial Buildings	20	Maady City Center (Extension)	EGP 60,000,000	EGP 61,920,000	18 m	Unit price (BOQ)
	21	Mall building Madinaty	EGP 45,322,735	EGP 46,682,417	25 m	Unit price (BOQ)
	22	First mall food court	EGP 12,000,000	EGP 13,800,000	18m	Unit price (BOQ)
	23	Seven Stars Mall, New Cairo	EGP 61,967,700	EGP 70,581,210	40 m	Lump-sum
	24	karnak museum trading center	EGP 9,000,152	EGP 9,919,068	12 m	Unit price (BOQ)

Type	No.	Project Name	Contract Value	Actual Contract Value	Duration	Type Of Contract
Residential Buildings	25	Renewal of Al Jazeera Sofitel Hotel.	EGP 200,000,000	EGP 220,000,000	22 m	Unit price (BOQ)
	26	Oman Embassy residential building	EGP 81,000,000	EGP 107,730,000	36 m	Lump-sum
	27	Housing Building (reconstruction of ezbet haredy area)	EGP 20,700,000	EGP 21,383,100	16 m	Unit price (BOQ)
	28	Orphanage in Luxor	EGP 6,028,000	EGP 6,522,296	10 m	Unit price (BOQ)
	29	Residential Building- New Cairo / Cairo	EGP 2,889,450	EGP 3,051,259	18 m	Cost plus fixed fee
	30	Residential Building (12 Building, 14 floors each) Gabalaughod residential compound	EGP 43,078,050	EGP 46,653,528	38 m	Cost plus fixed fee
	31	Zamalek Residence	EGP 65,226,737	EGP 65,422,417	12 m	Lump-sum
	32	Borg Arab stadium players hotel	EGP 18,000,000	EGP 18,594,000	12 m	Unit price (BOQ)
	33	Residential Building- New Cairo / Cairo	EGP 3,138,041	EGP 3,329,462	18 m	Cost plus fixed fee
	34	Residential Building (11 Story Building)	EGP 10,800,000	EGP 11,404,800	20 m	Cost plus fixed fee
	35	construction 50 housing units Owainat	EGP 5,000,000	EGP 5,500,000	6 m	Unit price (BOQ)
	36	Fremont Nile City	EGP 254,682,159	EGP 256,464,934	18 m	Unit price (BOQ
	37	Conrad	EGP 325,000,000	EGP 370,500,000	24 m	Unit price (BOQ)
	38	Housing Building (reconstruction of al-aagaiz area)	EGP 14,000,000	EGP 14,756,000	8 m	Unit price (BOQ)

Type	No.	Project Name	Contract Value	Actual Contract Value	Duration	Type Of Contract
Other Buildings	39	Arab Mall	EGP 20,000,000	EGP 21,200,000	24 m	Unit price (BOQ)
	40	Future University (F.U.C)-New Cairo)	EGP 320,000,000	EGP 368,000,000	24 m	Unit price (BOQ)
	41	AL-Ahly Bank Social and Sporting Club.	EGP 80,000,000	EGP 91,280,000	24 m	Unit price (BOQ)
	42	Raise the efficiency of Sohag Olympian Pool Sports	EGP 16,823,000	EGP 17,209,929	12 m	Unit price (BOQ)
	43	construction of Pool Aswan Olympian Sports Club	EGP 19,000,000	EGP 23,408,000	12 m	Unit price (BOQ)
	44	Rowing Club Luxor	EGP 13,852,000	EGP 15,140,236	12 m	Unit price (BOQ)
	45	construction of a sports city in Al-Arish	EGP 29,695,766	EGP 37,119,708	24 m	Unit price (BOQ)
	46	The establishment of the establishment of a training pool Sea Club in Qena	EGP 16,985,000	EGP 19,074,155	12 m	Unit price (BOQ)
	47	Ismaelia sports hall	EGP 30,129,000	EGP 33,834,867	24 m	Unit price (BOQ)

Arabic Summary

الخلاصة

تقدير التكلفة هوتقييم التكلفة المتوقعة في أي مشروع تشييد. دقة تقدير هذه التكاليف لها تأثيرشديد على الأرباح المتوقعة لمقاول البناء.وبالتالي، ينبغي أن تضاف علاوة طوارئ معينة لتقدير التكاليف لزيادة مستوى الثقة. وتتأثر هذه العلاوه ماديا بالعديد من العوامل.

من خلالهذا البحث، تم تحديد العوامل الرئيسية التي من المتوقع أن تؤثر على دقة تقديرتكاليف مشروعات التشييد بوضوح من خلال البحث في الدراسات السابقه و كان عددهم 47 عامل. و قد تم عمل استبيان وتوزيعه على عدد من المهندسين من خبرات و وظائف مختلفه. شمل هذا البيان ثلاث أجزاء مترجمهه للغه العربيه للتيسير على المهندسين المشاركين. قام بالرد منهم عدد 43 مهندس وكانت أهم العوامل التي قد تؤثر بشده في دقة تقديرات تكاليف مشروعات التشييد 12عامل. وكانت هذه العوامل: عدم الاستقرار الاقتصادي، نوعية تخطيط مشاريع الشركة وإدارتها، الخبرات ذات الصلة لفريق تقدير التكاليف، توافر خطط الإدارة والتمويل، قدرات فريق تقدير التكاليف، العماله والمعدات اللازمة، طريقة تقديرالتكاليف، موقع المشروع، الالتزام بمواعيد المدفوعات الدورية، دقة وثائق العطاء التي قدمهاالعميل، الخصائص القيادية لمدير المشروع وأخيرا تأثيرالجدول الزمني للمشروع (توقع التأخير). هذه العوامل يعتقد أنها الأكثر تأثيرا على دقة تقدير تكاليف مشروعات التشييد.

وقد تم جمع بيانات التكاليف ذات الصلة لعينة مختارة من مشاريع البناءلإظهارتأثير هذه العوامل على نسبة التباين بين التكلفة الفعلية و التكلفة التقديرية للمشروع حيث تم تحليل هذه البيانات للوقوف على مدى تأثير كل عامل و العلاقه بين تلك العوامل والفرق بين التكاليف الفعليه لمشروعات التشييد و التكاليف التقديريه لها من حيث كونها علاقه طرديه أو عكسيه.وكان أكبر تأثير عدم الاستقرار الاقتصادي، وكان أصغر تأثير تأثير الجدول الزمني للمشروع. و من خلال تحليل تلك البيانات تم اعداد توصيات و مقترحات من شأنها أن تساعد على دقة تقديرات التكاليف لمشروعات التشييد ومن ثم تحسين قيمة الأربح المتوقعه لمقاول البناء منها:الأخذ في الاعتبار في عدم الاستقرار الاقتصادي وموقع المشروع عند تحديد قيمة للطوارئ"contingency" و تعيين مدير للمشروع مؤهل و فريق تقدير تكاليف ومخططين بخبرات و كفاءات عاليه و تطبيق اسلوب إدارة

وخطط تمويل جيدة و كذلك توفير أعداد كافية من المعدات و عماله ذات كفاءة و استخدام تقديرات أسعار مفصلة إذا كان ذلك ممكنا واستخدام وثائق عطاءات دقيقة قدر الامكان.

وأخيرا،تم تطويرنموذج الشبكات العصبية والتي يمكن أن تساعد إلى حد كبير في تقييم الفروق بين التكاليف الفعليه لمشروعات التشييد و التكاليف التقديريه المتوقعة لأي مشروع تشييد في المستقبل مما يعطي ثقه أكبر لمقاول البناء.

بلغ إجمالي البيانات التي تم جمعها من سبع وأربعين مشروع. أزيلت ثلاثة مشاريع بسبب بيانات غير منطقيه. تم تطبيق التجارب والأخطاء لتطوير نموذج على واحد وأربعين مشروعا. وقد تم اختيار ثلاثة مشاريع عشوائيا لاختبار الشبكة.

كما تم اختبارصحة النموذج المقترح للتأكد من أن النموذج يمكنه تقييما لفروق في التكاليف المتوقعةعلى مستوى مرض من الدقة والوقوف على نسبة الخطأ المتوقعه من النموذج في تقدير قيمة الفرق بين التكلفة الفعلية و التكلفة التقديرية للمشروع.