The Islamic University – Gaza
Deanery of Graduate Studies
Faculty of Engineering
Civil Engineering Department
Engineering Projects Management

الجـامعــــة الإسـلاميــة – غــزة
شئون البحث العلمي والدراسات العليا
كـلـيــــة الهنـدســــة
قســــم الهنــدســــة المـدنيــة
إدارة المشــروعـــات الهنـدسيــة

Cost Estimation of Building Construction Projects in Gaza Strip Using Support Vector Machines Model (SVM)

تقدير تكلفة مشاريع المباني الانشائية في قطاع غزة باستخدام نموذج الات الدعم الناقل

Researcher

Tareq M. Rayyan

Supervised by

Dr. Nabil EL Sawalhi

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science in Civil Engineering

Gaza, Palestine

1437 – 2016

إقـــــــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Cost Estimation of Building Construction Projects in Gaza Strip Using Support Vector Machines Model (SVM)

تقدير تكلفة مشاريع المباني الانشائية في قطاع غزة باستخدام نموذج الات الدعم الناقل

أقر بأن ما اشتملت عليه هذه الرسالة إنما هو نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل أو أي جزء منها لم يقدم من قبل الآخرين لنيل درجة أو لقب علمي أو بحثي لدى أي مؤسسة تعليمية أو بحثية أخرى. وأن حقوق النشر محفوظة للجامعة الإسلامية غزة –فلسطين

Declaration

I hereby certify that this submission is the result of my own work, except where otherwise acknowledged, and that this thesis (or any part of it) has not been submitted for a higher degree or quantification to any other university or institution. All copyrights are reserves toIslamic University – Gaza strip paiestine

Student's name:	طارق ريان	اسم الطالب:
Signature:	طارق ريان	التوقيع:
Date:	2017/11/28	التاريخ:

بســـم الله الرحمن الرحيم

الجامعة الإسلامية – غزة
The Islamic University - Gaza

مكتب نائب الرئيس للبحث العلمي والدراسات العليا هاتف داخلي 1150

الرقم س.غ/35/ Ref

التاريخ 2016/03/14 Date

نتيجة الحكم على أطروحة ماجستير

بنـاءً علـى موافقـة شـئون البحـث العلمـي والدراسـات العليـا بالجامعـة الإسـلامية بغـزة علـى تشكيل لجنـة الحكم علـى أطروحـة الباحـث/ **طـارق محمـد محمـود ريـان** لنيل درجـة الماجسـتير فـي **كليـة** *الهندسة* قسم <u>الهندسة المدنية – إدارة المشروعات الهندسية</u> وموضوعها:

تقدير تكلية المباني الإنشائية في قطاع غزة باستخدام أداة الدعم المتجه (SVM)

Cost Estimation for Buliding Construction Projects in Gaza Strip Using Support Vector Machines Model (SVM)

وبعد المناقشة التي تمت اليوم الاثنين 05 جمادى الآخر 1437هـ، الموافق2016/03/14م الساعة الثانية عشرة ظهراً، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

د. نبيـــل إبـــراهيم الصـــوالحي	**مشـــرفاً و رئيســـاً**	....
د خالـد عبـد الـرؤوف الحـلاق	**مناقشـــاً داخليـــاً**	....
د. ســـاري وليـــد أبـــو شـــرار	**مناقشـــاً خارجيـــاً**	....

وبعـد المداولـة أوصـت اللجنـة بمـنح الباحـث درجـة الماجسـتير فـي **كليـة *الهندسـة* / قسـم الهندسة المدنية - إدارة المشروعات الهندسية.**

واللجنـة إذ تمنحـه هـذه الدرجـة فإنهـا توصـيه بتقـوى الله ولـزوم طاعتـه وأن يسـخر علمـه في خدمة دينه ووطنه.

والله ولي التوفيق ،،،

نائب الرئيس لشئون البحث العلمي والدراسات العليا

أ.د. عبدالرؤوف علي المناعمة

عمادة البحث العلمي والدراسات العليا
Deanship of Research and Graduate Studies

بسم الله الرحمن الرحيم

"قالوا سبحانك لا علم لنا الا ما علمتنا إنك

أنت العليم الحكيم."

صدق الله العظيم.

الآية 32 – سورة البقرة

DEDICATION

I dedicate this research

To the spirit of my father,

To My mother for her endless support,

To my dearest brothers, and sisters, colleagues and friends, for their sustainable support,

To my wife for her unlimited encouragement,

To my children who, were, missing my direct care during my study,

Hoping I have made all of them proud of me.

Tareq M. Rayyan

April, 2016

ACKNOWLEDGMENTS

First of all, all thanks and appreciations to Allah for his unlimited blessings and for giving me the ISLAM and the strength to complete this thesis.

I wish to express my profound gratitude to Dr. Nabil EL-Sawalhi for his continued guidance, supervision, constant encouragement, and comments throughout the course of this research. His dedication to helping me succeed is deeply appreciated.

I am highly indebted to the Construction Management Teaching Staff of the Islamic University for their support and encouragement.

Special thanks to all friends and colleagues especially Eng. Mohammed Mady, Eng. Salah Tayeh,and Eng. Omar Shehatto, for their helping and advices during the study.

My grateful thanks to all contractors, and engineers who participated in filling questionnaires and provided important information for this study.

ABSTRACT

Construction industry is considered an important sector for the development in Gaza Strip. Estimating process is an important element of the construction industry. Early stage cost estimate plays a significant role in the success of any construction project. The research aims to predict the parametric cost estimation in construction building projects in Gaza Strip using support vector machine model.

This research has been conducted through literature reviews of the cost estimating process, followed by a field survey done by structured interviews to define the factors which effect the parametric cost estimation of building construction projects.

The study shows that nine factors are affecting construction cost. The main factors are the area of typical floor, numbers of stories and the building type. Eighty case studies from real executed construction projects in Gaza Strip were collected to build up SVM model.

Neurosolution software version 6.07 was used to train the models. The results of the trained models indicated that SVM reasonably succeeded in estimating the cost of building projects without the need for more detailed drawings. The average error of test dataset for the adapted model was 2.3% which is largely acceptable.

One of the main recommendations of this research is to join the developed model with cost index to give an accurate estimate in any time. In addition, it encourages all parties involved in construction industry to pay more attention for developing model in cost estimation by archiving all projects data, and conducting more studies and workshops to obtain maximum advantage of this new approach.

ملخص الدراسة

يعتبر قطاع صناعة الإنشاءات من القطاعات الهامة للتطوير في قطاع غزة, وتعتبر عملية تقدير التكلفة من أهم عناصر صناعة الإنشاءات. تقدير التكلفة للمشاريع الإنشائية في المراحل المبكرة يلعب دورا هاما في نجاح أي مشروع إنشائي.

يهدف هذا البحث إلى تطوير نموذج لتقدير حساب التكاليف لمشاريع التشييد في قطاع غزة باستخدام المنطق الغامض.

اعتمد البحث على مراجعة الدراسات السابقة في المواضيع ذات العلاقة بعملية تقدير التكلفة, تبع ذلك بحث ميداني وإجراء المقابلات لتحديد العوامل التي تؤثر على تقدير حساب التكلفة في المشاريع الانشائية.

لقد أوضحت الدراسة بأنه يوجد تسعة عوامل تؤثر على تكلفة الإنشاءات, واهم هذه العوامل هي مساحة الطابق المتكرر و عدد الطوابق و نوع المبنى. وقد تم جمع 80 مشروع من المشاريع التي تم تنفيذها في قطاع غزة من أجل بناء نموذج المنطق الغامض.

تم استخدام برنامج نيوروسوليوشن لتطوير نموذج المنطق الغامض . وقد أظهرت النتائج أن نموذج المنطق الغامض لديه القدرة على إعطاء نتائج مقبولة عند تقديره للتكلفة, وكان متوسط الخطأ لمجموعة من المشاريع **2.3**% وهي نسبة مقبولة الي حد كبير.

كان من التوصيات الأساسية لهذا البحث, تشجيع المقاولين المحليين لاقتناء برنامج محوسب متخصص في تقدير التكلفة و استخدامه في تقدير الأعمال للحصول على تقدير أدق للتكلفة وتوفير الوقت وتقليل الأخطاء وإعطاء فرصة أفضل للفوز بالعطاءات التكاليف وذلك عن طريق أرشفة جميع بيانات المشاريع، وإجراء المزيد من الدراسات وورش العمل للاستفادة من هذا النهج الجديد.

TABLE OF CONTENTS

Dedication ..... **II**

Acknowledgments ..... **III**

Abstract ..... **IV**

List of Tables ..... **IX**

List of Figures ..... **X**

1 CHAPTER 1: Introduction **1**

1.1 Background and Rationale 1
1.2 Problem statement 2
1.3 Research Aim 3
1.4 Research Objectives 3
1.5 Research Scope and Limitation 3
1.6 Methodology Outline 3
1.6.1 Literature Review 3
1.6.2 Data Collection 4
1.6.3 Design and Models Development 4
1.6.4 Conclusion, Recommendations And Writing Up 4
1.6.5 Research Layout 4

2 Chapter 2: Literature Review **6**

2.1 Introduction 6
2.2 Definition of Cost Estimating 7
2.3 The Purpose of Cost Estimating 8
2.4 The Importance of Cost Estimating 9
2.4.1 Estimator Responsibility 10
2.4.2 Estimator Skills 10
2.5 Types of Construction Cost Estimates 11
2.6 Estimating Process 13
2.7 Accuracy of Cost Estimates 14
2.7.1 Factors Affecting the Accuracy of Cost Estimates 15
2.7.2 Common Errors and Omissions in Cost Estimation 16
2.8 Classification of Construction Costs 17
2.8.1 Material Cost 18
2.8.2 Labor Cost 18
2.8.3 Equipment Costs 18
2.8.4 Overheads 19
2.8.5 Markup 19
2.9 Methods of Cost Estimation 20
2.9.1 Quantitative and Qualitative Technique 20
2.9.2 Preliminary and Detailed Techniques 21
2.9.3 Traditional and Artificial Intelligence Based Techniques 21
2.10 Traditional Techniques 21
2.10.1 Artificial Intelligence-Based Techniques 22
2.11 Support Vector Machines (SVM) 22
2.11.1 Support vector machines (SVM) and neural network architecture (ANN) 23

2.11.2 The using of support vector machines in construction ... *23*
2.12 Construction Cost Estimating Previous Researches ... 24

3 CHAPTER 3: METHODOLOGY ... 31
3.1 Introduction ... 31
3.2 Research Strategy ... 31
3.3 Research Design ... 32
3.4 Research Population and Sample Size ... 34
3.5 Research Location ... 36
3.6 Limitation of the Research ... 36
3.7 Defining the Factors Affecting Cost Estimating Project in Gaza Strip ... 36
3.8 Structured Interviews ... 37
3.9 Questionnaire Design ... 38
3.10 Reliability and Validity of Research ... 39
3.11 Development of the Research Model ... 40
3.12 Performance Measures ... 40
3.12.1 Mean Square Error (MSE): ... *40*
3.12.2 Normalized Mean Square Error (NMSE): ... *41*
3.12.3 Correlation Coefficient (r): ... *41*
3.12.4 Mean Absolute Error (MAE): ... *42*
3.12.5 Mean Absolute Percentage Error (MAPE): ... *42*
3.12.6 Accuracy Performance (AP): ... *43*

4 CHAPTER 4: Data Collection and Results ... 44
4.1 Introduction ... 44
4.2 Factors affecting cost estimate in building projects ... 44
4.3 Questionnaire Analysis ... 44
4.4 Part One: General Information ... 44
4.4.1 Classification of contracting companies according to PCU ... *44*
4.4.2 The position of officer who fills the questionnaire ... *45*
4.4.3 Number of company's employees ... *45*
4.4.4 Number of projects executed in the last five years ... *46*
4.4.5 The value of projects executed in the last five years ... *46*
4.4.6 The type of implemented projects ... *46*
4.5 Part two: Factors affecting on cost estimate for construction project in Gaza Strip ... 47
4.5.1 Factors related to structural (skeleton) group ... *47*
4.5.2 Factors related to external group ... *48*
4.5.3 Factors related to finishing group ... *48*
4.6 Overall ranking of factors affecting on total building cost ... 49
4.7 Ranking of groups for factors affecting on total building cost ... 50
4.8 Delphi Technique ... 50
4.9 Influential factors adopted in the research ... 51
4.10 Real building projects in Gaza Strip (projects case studies) ... 52

5 CHAPTER 5: Model Development ... 57
5.1 Introduction ... 57
5.2 Select Application ... 57
5.3 Model Limitations ... 58
5.4 Model Implementation ... 58

5.5 Training Models and Testing 63
5.6 Model cross-validation and testing 64
5.7 Model Results 65

6 CHAPTER 6: CONCLUSION AND RECOMMENDATIONS 69

6.1 Introduction 69
6.2 Conclusion 69
6.3 Recommendations 70
6.3.1 Recommendations to Owners & Consultants 71
6.3.2 Recommendations to Contractors 71
6.3.3 Recommendations to Government, Contractors' Union and Association of Engineers 72
6.3.4 Recommendations for Further Studies 72

7 References 73

LIST OF TABLES

Table 2-1: Conceptual and detailed cost estimates 13
Table 2-2: Possible estimating errors and possible procedures for minimizing the chances of occurrence 16
Table 3-1: Factors affecting cost estimating of the construction building project 36
Table 4-1: Classification of contracting companies 45
Table 4-2: Position of respondent 45
Table 4-3: Number of company's employees 45
Table 4-4: Number of executed projects 46
Table 4-5: Value of executed projects 46
Table 4-6: Type of executed projects 46
Table 4-7: Influence of skeleton factors on building cost 47
Table 4-8: Influence of external factors on building cost 48
Table 4-9: Influence of finishing factors on building cost 48
Table 4-10: Overall ranking of factors affecting on total building cost 49
Table 4-11: Ranking factors affecting on total building cost among groups 50
Table 4-12: Influential Factors of building project Cost adopted in this research 52
Table 4-13: Factors of collected real projects 52
Table 5-1: Input limitations in model .... **Error! Bookmark not defined.**
Table 5-2: Input and Ouput Factors 59

LIST OF FIGURES

Figure 2-1: Classification of construction costs 18
Figure 3-1: Research methodology flowchart 34
Figure 5-1: Tag column of data as input parameter 60
Figure 5-2: Tag column of data as desired parameter 60
Figure 5-3: Sets of model building 61
Figure 5-4: Building initial network 62
Figure 5-5: Support vector machine (SVM) network 62
Figure 5-6: Selecting the normalization limits of data 63
Figure 5-7: Training options in Neurosolution 64
Figure 5-8: Comparison between actual and estimated payment delay risk for test set 66
Figure 5-9: Results of performance measurements according to the Neurosolution app 68

LIST OF ABBREVIATIONS

AACE	American Association of Cost Engineering
AI	Artificial Intelligence.
ANN	Artificial Neural Network.
AP	Accuracy Performance.
CBR	(case-based reasoning (CBR
CER	Cost Estimate Relationship.
FL	Fuzzy Logic
GA	Genetic Algorithm.
GA	Genetic algorithm
GNP	Gross National Product
HVAC	Heating, Ventilation and Air Conditioning
LR	Linear Regression.
MAE	Mean Absolute Error.
MAPE	Mean Absolute Percentage Error.
MLP	Multi-layer Perceptron.
MSE	Mean Square Error.
NMSE	Normalized Mean Square Error.
NN	Neural Network.
PNA	Palestinian National Authority
r	Correlation factor.
SVM	(support-vector machines
TAP	Total Accuracy Performance.

CHAPTER 1: INTRODUCTION

1.1 Background

Cost is one of the major criteria in decision making at the early stages of a building design process. In today's globally competitive world, diminishing profit margins and decreasing market shares, cost control plays a major role for being competitive while maintaining high quality levels. The cost of a building is impacted significantly by decisions made at the design phase. While this influence decreases through all phases of the building project, the committed costs increase (Gunaydın, 2004).

Due to the limited availability of information during the early stages of a project, construction managers typically leverage their knowledge, experience and standard estimators to estimate project costs. As such, intuition plays a significant role in decision making. Researchers have worked to develop cost estimators that maximize the practical value of limited information in order to improve the accuracy and reliability of cost estimation work and thus enhance the suitability of resultant designs and project execution work (Cheng et al., 2010).

Effective project management techniques are important to ensure successful project performance. A poor strategy or incorrect budget or schedule forecasting can easily turn an expected profit into loss. Conceptual cost estimates are important to project feasibility studies and impact on final project success. Such estimates provide significant information that can be used in project evaluations, engineering designs, cost budgeting and cost management (Cheng et al., 2010).

Trost and Oberlender (2003) concentrated more on improving prediction accuracy by deriving four determinants influencing the accuracy of an early cost estimates. Following this, they established support-vector machines model which derived significant relationship between estimate accuracy and influencing factors such as basic process design, team experience and cost information, time allowed to prepare the estimate, site requirements, and bidding and labor climate .

Computers are expending increasingly into all aspects of daily life. The cheaper computer hardware today has boasted the rush of using the computers. However, the accounting early uses of computers by construction companies were limited to functions. With the advances in micro-computing, increased knowledge of computer capabilities, and the development of user-friendly software, computers have been used every day at construction to make quick and accurate decisions through estimating software which have reduced the amount of manual work necessary for preparing an estimate (Bhatnagar and Ghose, 2012).

As a result of the limited availability information during the early stages of a project construction managers used their knowledge experience and standard estimators to estimate project costs. Therefore, personal judgment plays a significant role in decision making. Researchers have worked to develop cost estimators that improve the accuracy and reliability of cost estimation work. Today, estimating technologies used by contractors vary tremendously from contractor to contractor. Some might still be using simple tools such as paper and pencil, while others are more technologically advanced and use computers for activities such as quantity take off, calculations and estimating report generation and use digitizing tablets, others used statistical methods to develop cost estimating models like regression models (Han et al., 2008; Ganiyu and Zubairu, 2010). Artificial intelligence approaches are applicable to cost estimation problems related to expert systems, case-based reasoning (CBR), Neural Networks (NNs), Fuzzy Logic (FL), Genetic Algorithms (GAs) and derivatives of such (Cheng et al., 2010). Many research studies have been done in this area; this research aim is to investigate the potential use of support-vector machines (SVM) as a tool for cost estimation modeling.

1.2 Problem statement

An accurate estimation of construction cost is crucial in construction projects for budgeting, planning, and monitoring for compliance with the client's available budget, time and work outstanding. In cost estimation, the experience of the estimator and the project information are significant factors. Therefore, parametric cost estimation models are very useful in the early stage of a project's life cycle when little information is known about the project's scope. These parametric cost estimation models include historical data that are currently used in practice as well as new data specific to a new project (Cavalieri et al., 2004).

In addition, A significant amount of time and money are necessary to calculate a cost estimate. Data must be compiled and functions need to be deciphered in order to produce an estimate, all of which require time and knowledge of materials, equipment, and processes. Therefore, it is desirable to create a method that helps user with little knowledge of details of the construction project to quickly create a cost estimate. This would allow cost estimates to be used more frequently and in more aspects of a product's development and manufacturing, producing a more cost efficient part.

The main problem of the models is their requirement for deciding on the class of relations between dependent variables and independent variable, in our case, between parameters and project costs.

It is not always very easy to decide on the class of relation since there are many cost components when you consider a project like mass housing.

1.3 Research Aim

The aim of this research is to develop an effective model for estimating cost for construction building projects using support-vector machines technique (SVM). This model is able to help parties involved in construction projects (owner, contractors, consultants, and others) in obtaining a cost estimate at the early stages of projects with limited available information and within possible time and high accuracy.

1.4 Research Objectives

The principal objectives of this study are:

1) Identify the most prominent parameters that affect the estimating the building project cost in Gaza Strip.
2) Develop a model for cost estimation using support-vector machines (SVM).

1.5 Research Scope and Limitation

This research focuses on buildings sector of construction industry in Gaza Strip, The data was be collected for building projects that have been implemented and finished in Gaza between 2009 and 2013, which contain the actual costs of these projects and the main parametric factors that affect the cost of the projects, then use these data in constructing a model for estimating buildings projects.

1.6 Methodology Outline

The approach used to achieve the study objectives can be summarized in the following steps:

1.6.1 Literature Review

Conduct a literature review of previous studies that are related to construction cost estimate and paying special attention of using SVM.

1.6.2 Data Collection

Proprietary data obtained from a lot of construction projects which implemented in Gaza Strip in building sector, in addition Delphi technique was used. This large collection of data will provide a rich source of information and previous experience to be used in the following stages as training.

Each project must have a cost estimate and actual budget with time scheduling in defined specifications with final report of the project hand over. This detailed data is very useful in determined the factors and the support-vector machines is a probabilistic technique in which several independent variables are used to predict some dependent variable of interest.

1.6.3 Design and Models Development

This phase covers selecting the application, choosing models types, and design models. In addition to, implement models and trained them for many times with check the validity. Furthermore includes testing models and discussing the results carefully.

1.6.4 Conclusion, Recommendations and Writing Up

This stage involves writing up the content of the dissertation and should cover the chapters proposed in the following section, and put the research in the final layout document under the reliable form of the Islamic University of Gaza templates, with all copies needed in soft and print out form.

1.7 Research Layout

This research included six chapters explained as follow:

- **Chapter (1) Introduction:** A general idea for this research was given in this chapter along with research statement of problem, aim, objectives, limitation, methodology outlined and thesis structure.
- **Chapter (2) literature Review:** This chapter presents a literature review of past research studies in parametric cost estimating, ANN and SVM applications in construction management and related fields.
- **Chapter (3) Research Methodology:** The adopted methodology in this research was presented in this chapter including the data-acquisition process of influential factors that relate to cost estimating of building projects and historical data of building projects that necessary for the proposed model.

- **Chapter (4) Data Collection:** Presents statistical analysis for surveying questionnaire, Delphi technique which consist of three phases interviews, questionnaire, expert focus group to get the most factor affecting on cost for building projects in Gaza strip
- **Chapter (5) Models Development:** This chapter contains the application, which was selected, types of models chosen and displays of the structure design. Moreover, it is including the model implementation, training and validation also optimizing the error and testing the models. Finally it is presents the results discussion.
- **Chapter (6) Conclusion and Recommendations:** Finally, this chapter outlines the conclusions and recommendations of this study. It also includes the recommendations for further studies.

2 CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Cost estimating is an essential part of construction projects, where cost is considered as one of the major criteria in decision making at the early stages of building design process (Gunaydın & Dogan, 2004). The accuracy of estimation is a critical factor in the success of any construction project, where cost overruns are a major problem, especially with current emphasis on tight budgets. Indeed, cost overruns can lead to cancellation of a project. In some cases, a potential overrun may result in changing a project to a design-to-cost task (Feng et al., 2010).

Subsequently, the cost of construction project needs to be estimated within a specific accuracy range, but the largest obstacles standing in front of a cost estimate, particularly in early stage, are lack of preliminary information and larger uncertainties as a result of engineering solutions. As such, to overcome this lack of detailed information, cost estimation techniques are used to approximate the cost within an acceptable accuracy range.

A good estimate depends on many factors including time given to the estimator, estimator's experience, and a wide range of assumptions regarding the project (Jrade and Alkass, 2007). Construction cost estimating involves collecting, analyzing, and summarizing all available data for a project (Holm et al., 2005).

Researchers have worked to develop cost estimators that maximize the practical value of limited information in order to improve the accuracy and reliability of cost estimation work and thus enhance the suitability of resultant designs and project execution work (Cheng et al., 2010). The purpose of pre-tender price estimating is to provide an indication of the probable costs of construction at a very early stage in the life of a construction project. It is one of the most important factors influencing the client's decision to build or not.

Cost models provide an effective alternative for conceptual estimation of construction costs. However, development of cost models can be challenging as there are several factors affecting on project costs. There are usually various and noisy data available for modeling (Sonmez, 2004).

This chapter will focus on conceptual estimates, the information needed for a preliminary estimate. Today's conceptual estimating technologies and the difficulties associated with conceptual estimates are also reviewed.

2.2 Definition of Cost Estimating

Cost estimating has different definition, Carr (1989) defines estimate is to produce a statement of the approximate quantity of material, time, or cost to perform construction. On the other hand, Steward (1991) reported a definition of cost estimation from the Society of Cost Estimating and Analysis (SCEA), as "the art of approximating the probable worth or cost of an activity based on information available at the time". Also Gao (2009) said that cost estimating combines science and art to predict the future cost of something based on known historical data that are adjusted to reflect new materials, technology, software languages, and development teams. Al Hamidi and Mohammed (2009); Butcher and Ahuja et al. (1994) gives another definition which is, "the estimate at best is an approximation of the expected cost of the project". Dysert (2006) defined a cost estimate as, "the predictive process used to quantify, cost, and price the resources required by the scope of an investment option, activity, or project. The output of the estimating process, the cost estimate, is typically used to establish a project budget". While, Akintoye (2000) defined cost estimate as, "is crucial to construction contact tendering, providing a basis for establishing the likely cost of resources elements of the tender price for construction work". Turochy et al. (2001) distinct that cost estimation is the process by which, based on information available at a particular phase of project development, the ultimate cost of a project is estimated.

While Hendrickson (2000) specifies that are design, bid and control. Furthermore, he defines that at the very early stage of design, the screening estimate or order of magnitude estimate is made before the facility is designed, and therefore it relies on the cost data of similar facilities built in the past. While preliminary or conceptual estimate is based on the conceptual design of the facility at the state when the basic technologies for the design are known. Moreover, the detailed or definitive estimate is made when the scope of work is clearly defined and the completed plans and specification when they are ready for the owner to solicit bids from construction contractors. Uppal (1997) quotes a definition of cost estimation from Association for the Advancement of Cost Engineering (AACE) International define the cost estimation to provide the basis for project management, business planning, budget preparation and cost and schedule control. Included in these costs are assessments and an evaluation of risks and uncertainties. ElSawy et al. (2011) consider cost estimation as the lifeblood of the firm and can be defined as the determination of quantity and the prediction or forecasting, within a defined scope, of the costs required to construct and equip a facility.

On the other hand, Dysert (2006) defined a cost estimate as, "is the predictive process used to quantify, cost, and price the resources required by the scope of an investment option, activity, or project." While, Akintoye (2000) defined cost estimate as, "is crucial to construction contact tendering, providing a basis for establishing the likely cost of resources elements of the tender price for construction work".

Association for the Advancement of Cost Engineering (AACE) International (2007) defined the cost estimation to provide the basis for project management, business planning, budget preparation and cost and schedule control. Included in these costs are assessments and an evaluation of risks and uncertainties.

2.3 The Purpose of Cost Estimating

The cost estimate becomes one of the main elements of information for decision making at preliminary stage of construction. Thus, Improved cost estimation techniques will facilitate more effective control of time and costs in construction projects (Kim, et al., 2004).

Actually, estimates are prepared and used for different purposes including feasibility studies, tendering phase, avoidance misuse of funds during the project, etc. The primary function of cost estimation is to produce an accurate and a credible cost prediction of a construction project. However, the predicted cost depends on the requirements of a client and upon the information and data available (Elhag, et al., 2005). Antohie (2009) stated that the purpose of an estimate is to postulate the costs required to complete a project in accordance with the contract plans and specification (Cited in (Abdal-Hadi, 2010)).

The other functions of cost estimate; that it allows the designer and engineer to be aware of the cost implications for the design decisions they make while still in the design phase. Reliable cost estimates also allow management to make an informed decision as to what items will be profitable and what items should be redesigned (Weckman, et al., 2010).

Moreover, cost estimate is of great importance in tendering phase, for example, Carty and Winslow (cited in (ElSawy, et al., 2011)), have considered that cost estimate as a key function for acquiring new contracts at right price and hence providing gateway for long survival in the business. Therefore an accurate estimate of the bid price for a construction project is important to securing the project contract and achieving a reasonable profit, where in practice, the available bid-estimation time is often insufficient .

Therefore, conducting comprehensive and detailed cost estimations are not always possible; taking into account, that detailed cost estimation process is both costly and time consuming.

Thus, a method that does not take much time and can approximate a proper bid price is one of the strongest needs for contractors to help them in making bid-price decisions when the available bid estimation time is insufficient (Wang, et al., 2012).

(Jitendra, et al., 2011) outlined the purpose of cost estimate through the following points:

- Provides an assessment of capital cost for a specified piece of project.
- Can help to classify and prioritize development projects with respect to an overall business plan.
- Forms the basis for planning and control by defining the scope of work and its associated estimated cost.
- Determine what resources to commit to the project with providing much of the basic information (hours, resources, tasks, and durations) which is needed for preparing a schedule.
- Projects can be easier to manage and control when resources are better matched to real needs.
- Provides the financial input required to prepare a cash flow curve.
- Customers expect actual development costs to be in line with estimated costs.
- Is a catalyst for discussion, idea generation, team participation, clarity and buy-in, it ties together much of the relevant project information within a simple document.
- Can be used to assess the impact of changes and support re-planning.

The main purpose of cost estimation is to produce an accurate and reliable cost estimate of a construction project. To reach this purpose the estimator have to look in deep to all factors that affect the project cost and make sure from the information source.

2.4 The Importance of Cost Estimating

Most public owners are obliged to select the lowest bidder. In addition, the contractor must successfully pass a qualification screening, in this situation the contractor must be prepared to lower the bid cost, reduce the project completion date, or accept additional owner requirements, but not to lose money. This can be achieved through a good cost estimation done by qualified estimator. Cost estimates allow owners and planners to evaluate project feasibility and control costs effectively in detailed project design work (Feng et al., 2010). Estimating purpose is to provide information to construction decisions. Typical decisions include procurement and pricing of construction, establishing contractual amounts for payment and controlling actual quantities by project management (Carr, 1989). Dysert (2006) said that the cost estimate, is typically used to establish a project budget, but may also be used for other purposes, such as:

• determining the economic feasibility of a project;

• evaluating between project alternatives; and

• providing a basis for project cost and schedule control.

While Gao (2009) believes that cost estimates have two general purposes:

(1) To help managers evaluate affordability and performance against plans, as well as the selection of alternative systems and solutions.
(2) To support the budget process by providing estimates of the funding required to efficiently executing a work.

2.4.1 Estimator Responsibility

Enshassi et al. (2007) said that the success or failure of a project is dependent on the accuracy of several estimates throughout the course of the project, which can influence issues ranging from project feasibility to profitability. It's the estimator's responsibility to assist the owner of the project to plan and budget for the construction of the project (Choi, 2004). For early estimates, the estimator is often working directly with the business unit in gaining alignment on the project scope to be estimated. It is the estimator responsibility to make early communication between the him and the project team or business unit on the expectations for the estimate. It is the estimator responsibility to ensure that a project team understands the information needs for the estimate, then ensure that a project team understands the information needs for the estimate, then ensure that the information provided is suitable to produce the quality of estimate desire (Dysert, 2005). The estimator responsibility is to produce an estimate that is an accurate reflection of reality, before the completion of the design he must have the vision to see beyond the obvious components and their primary costs of construction (Carr, 1989).

2.4.2 Estimator Skills

The best contractor in the area cannot make a profit or stay in business for long if taken contracts are below the real cost, so to be a good competitors at the construction industry the best contractor needs a good estimator. Dysert (2005), Popescu et al. (2003) and Carr (1989) stated that an effective estimating organization requires highly knowledgeable personnel, possessing technical skills. Moreover they define a set of skills as estimating core competencies as follows:

1) Ability to read and understand contract documents, with special skills in reading construction drawings for all specialties and related specifications.
2) Ability to accurately take off the quantities of construction work for which he or she is preparing the detail estimate.
3) Ability to visualize the future building from drawings, which usually requires some years of construction site experience.
4) Knowledge of arithmetic, basic geometry, and statistics.
5) Familiarity with estimating software in depth and with available building cost databases.
6) Knowledge of building construction methods.
7) Knowledge of labor productivity, crew composition, and impacts of various forecasted site conditions on crew output.
8) Possession of office managerial skills in organizing project-related cost information.
9) Ability to work under pressure and to meet all bid requirements and deadlines.

2.5 Types of Construction Cost Estimates

The type of estimate is a classification that is used to describe one of several estimate functions. However, there are different types of estimates which vary according to several factors including the purpose of estimates, available quantity and quality of information, range of accuracy desired in the estimate, calculation techniques used to prepare the estimate, time allotted to produce the estimate, phase of project, and perspective of estimate preparer (Humphreys, 2004; Westney, 1997).

Generally, the main common types of cost estimates as Marjuki (2006) outlined are:

(1) **Conceptual estimate**: a rough approximation of cost within a reasonable range of values, prepared for information purposes only, and it precedes design drawings. The accuracy range of this stage is -50% to +100%.

(2) **Preliminary estimate**: an approximation based on well-defined cost data and established ground rules, prepared for allowing the owner a pause to review design before details. The accuracy range in this stage is -30% to +50%.

(3) **Engineers estimate**: Based on detailed design where all drawings are ready, prepared to ensure design is within financial resources and it assists in
bids evaluating. The accuracy in this stage is -15% to +30%.

(4) **Bid estimate**: which done by contractor during tendering phase to price the contract. The accuracy in this stage is -5% to +15%.

Halpin (cited in (Marjuki, 2006)) commented on previous four levels saying that as the project proceeds from concept through preliminary, to final and bidding phase, the level of detail increases, allowing the development of a more accurate estimate.

Some researchers classified estimate types into three main types as Samphaongoen (2010) which are conceptual, semi-detailed, and detailed cost estimates types where the error percentage ranges from 20% in conceptual stage to 5% in detailed estimate. However, according to (AACE Recommended Practice and standard, 1990) there are three specific types of estimate based on the degree of definition of a project are:

1) Order of magnitude range of accuracy is between (- 30% to +50%)
2) Budget estimate range of accuracy is between (- 15% to +30%)
3) Definitive estimate range of accuracy is between (- 5% to +15%)

Otherwise, Some researchers as Clough (1986), abbreviated previous types into two main levels by merging conceptual and preliminary estimate into conceptual (preliminary) estimates, and integrating engineers and bid estimates into detailed (definitive) estimates. In general, building projects have two types of estimates: conceptual estimates (sometime called preliminary, approximate or budget estimates) and detailed estimates (sometimes called final, definitive, or contractor"s estimates),

Conceptual estimate is normally produced with an accuracy range of – 15% to +30%, while definitive estimates are detailed and normally produced within an accuracy range of –5% to + 15% (Enshassi, et al., 2007).

Table 2.1 summarizes the views of researchers about conceptual and detailed estimate (Abdal-Hadi, 2010; Choon & Ali, 2008; Leng, 2005; Humphreys, 2004; Hinze, 1999; Al-Thunaian, 1996;).

Table 2.1: Conceptual and detailed cost estimates

	Conceptual estimate	Detailed estimate
When	At the beginning of the project in feasibility stage and no drawing and details are available.	The scope of work is clearly defined and the detailed design is identified and a takeoff of their quantities is possible.
Available of information	No details of design and limited information on project scope are available.	Detailed specifications, drawings, subcontractors are available.
Accuracy range	-30% to +50%	-5% to +15%
Purpose	Determine the approximate cost of a project before making a final decision to construct it.	Determine the reliable cost of a project and make a contract.
Requirements	Clear understanding of what an owner wants and a good "feel" for the probable costs.	Analysis of the method of construction to be used, quantities of work, production rate and factors that affect each sub-item.

2.6 Estimating Process

Process is a series of steps or actions that produces a result. However, estimating is one of many steps in the project management process, yet it is a process into itself, which has 11 steps as (Westney, 1997) stated as the following:

Step 1: Project Initiation: The purpose of project Initiation is to set a definition for overall parameters of a project where the key of project success is beginning with a project definition.

Step 2: Scope Definition: The purpose of definition the scope is to make an overview of the project by providing design basis, detailed scope of work, work breakdown structures, categorical breakdowns, code of accounts, and formatting required by end users.

Step 3: Pre-Estimate Planning: It reduces the total effort that can be spent to develop the estimate, it also provides associated information to other project participants.

Step 4: Quantity Take-Offs and Item Descriptions: Estimate items must be listed and quantity take-offs start with estimate detail sheets for all work items in the project (Popescu, et al., 2003).

Step 5: Data Sources and Costs: There are numerous sources that data can be obtained as quotes, histories or commercially available data sources, or old estimates in the estimating files.

Step 6: Summary and Cover Sheets: The main purpose of the summary sheet is to state the total estimated cost for the project by providing a format for summarizing all the project"s direct costs and indirect costs. Where;

Direct cost: are mainly the materials, labor, plant, and subcontractor costs involved in executing the works (Al-Shanti, 2003).

Indirect cost: are costs other than direct costs of construction activities, and they are not physically traceable (Marjuki, 2006).

Step 7: Documentation and Checking: Documentation and checking is essential for verifying that calculations are valid.

Step 8: Management Review: Management plays a key role in reviewing the estimate because they are usually responsible for oversight of estimate preparation and they typically have the insight and experience to know "what could go wrong".

Step 9: Estimate Issue and Filing: The estimate numbering systems need to be well thought out to be easyfor retrieval and comfortable for users.

Step 10: Cost Feedback Continual Improvement: This is step is very important to develop the accuracy of the estimating data, estimator performance, and project histories.

2.7 Accuracy of Cost Estimates

Popescu et al. (2003) said that "all building estimates are probably either higher or lower than the true cost. The word "accuracy" is defined as 1) the condition or quality of being true, correct, or exact; precision; exactness. 2) The extent to which a given measurement agrees with the standard value for that measurement. The conceptual estimate accuracy is defined as a percentage difference between the engineering estimates compared to the price of the contract award". Accuracy is the degree to which a measurement or calculation varies to its actual value; thus estimate accuracy is an indication of the degree to which the final cost outcome of a project may vary from the single point value used as the estimated cost for the project. Estimate accuracy is traditionally represented as a +/- percentage range around the point estimate; with a stated confidence level that the actual cost outcome will fall within this range (Dysert, 2006).

In early pre-construction stage, accuracy degree is relatively low because of insufficient information. But, as project is going on and amounts of information are more gained, it is generally improved (Han, et al., 2008).

2.7.1 Factors Affecting the Accuracy of Cost Estimates

A key factor for a successful project is the preparation of an accurate estimate, which can be influenced by many factors that affecting this accuracy. Yong and Mustaffa (2012) find that the financial capability of the clients is the major critical factor to the success of a construction project in Malaysia. All three groups of participants in the industry opined that apart from financial capability, "project stakeholders' factors" such as competence, cooperation in solving problems, commitment and communication are significant factors ensuring the success of a construction project. External factors such as availability of resources and weather conditions also played a crucial role in contributing to the success of a construction project. While Odeyinka and Lowe, (2002) find the major factors at the UK are client's changes to initial design, inclement weather, architect's variation to works, labour shortage, production target slippage, delay in agreeing variation/ day works, delay in settling claims, problems with foundations, underestimating project complexity, estimating error and undervaluation.

Various studies indicate to these factors affecting the construction cost estimation at Gaza Strip. Abdal-Hadi (2010) conclude that the main factors affecting accuracy of pre-tender cost estimate are: material (prices /availability /supply /quality /imports), closure and blockade, project team's experience in the construction type, the experience and skill level of the consultant, clear and detail drawings and specifications, quality of information and flow requirements, completeness of cost information, accuracy and reliability of cost information, currency exchange fluctuation, and finally clear contract conditions. Enshassi et al. (2005) concluded that the main factors affecting the accuracy of cost estimation are: location of the project, segmentation of Gaza Strip and limitation of movements between areas, political situation, financial status of the owner, increase in unit cost of construction materials, experience of consultant engineer, clarity of project drawings, and clarity of information before execution and tender currency.

2.7.2 *Common Errors and Omissions in Cost Estimation*

Developing a good cost estimate requires stable program requirements, access to detailed documentation and historical data, well-trained and experienced cost analysts, a risk and uncertainty analysis, the identification of a range of confidence levels, and adequate contingency and management reserves. During the estimating process, errors occur. The magnitude of these errors in an estimating department can spell disaster (GAO, 2009).

Popescu et al. (2003) organize the causes of possible estimating errors and omissions while at the same time associating these with possible procedures for minimizing their chances of occurrence during estimating and bid proposal preparation as shown in Table 2.2.

Table 2-2: Possible estimating errors and possible procedures for minimizing the chances of occurrence

Errors	Possible estimating errors	Procedures for reducing errors
Ordinary	Arithmetic, location of decimal point	Standardization of estimating forms
	Unit of measure, unit price relation	
	Errors in data input in estimating software	Quiet environment and adequate work station for estimators
	Errors in transferring data from quantity take off to cost summary	
Shortcuts/rush/ short time to prepare the estimate	Estimating quantities	Use of known average ratios to check relationship between quantities
	Failure to check the estimate	
	Guessing the site overhead cost	Review finished pricing sheets and computer printouts
	Filling in for missing subcontractor costs	
Carelessness	Omitting work items	Use summary checklist for each type of building
	Omitting subcontractor quotes	
	Using obsolete productivity data files	
	No allowance for waste of materials	List of subcontractor specialty for the project
	No allowance for possible major	

Errors	Possible estimating errors	Procedures for reducing errors
	construction equipment breakdown	
	Omitting profit	
Poor estimating management	Not attending the prebid conference	Selection of the best estimator
	Missing addenda	New estimators in-house training
	Missing the time/date of the bid	Acquire state-of-the-art estimating software
	Incomplete proposal	Updating internal files related to labor productivity
	Not visiting the project site	
	Not reviewing historical	Update subcontractor files
	Not considering the time faster for pricing labor and materials	Last call to A/E office to check number of addenda issued
	Not having a summary schedule	Develop bid day checklist

2.8 Classification of Construction Costs

According to researches (Ostwald, 2001; Marjuki, 2006; Hinze, 1999); construction costs can be classified into five types, which constitute the total cost of the project; they can be classified as follows: material cost, labor cost, equipment cost, overheads, and markup. These types are briefed in Figure 2.2 below.

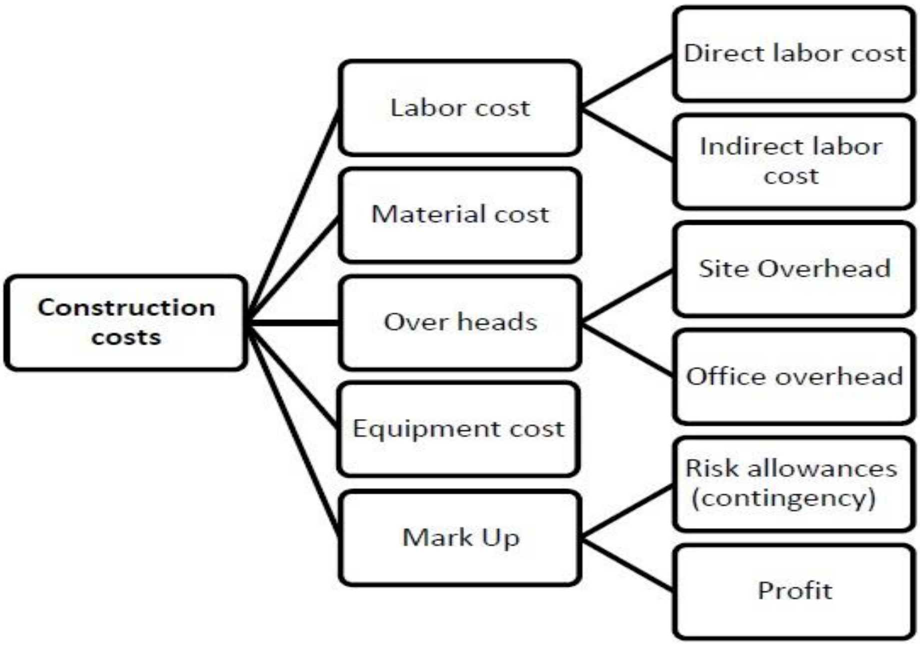

Figure 2-1: Classification of construction costs

2.8.1 Material Cost

The cost of materials includes not only the direct cost of the material items, but also any other costs that may be obtained except labor or equipment for installation. Additional items of cost to be considered are; transportation, sales taxes and freight costs, delivery, storage and other taxes and losses.

2.8.2 Labor Cost

The labor cost component in a building project often ranges from 30% to 50%, and can be as high as 60% of the overall project cost. It consists of direct and indirect labor cost which vary depending on the extent of their relationship to the project.

2.8.3 Equipment Costs

Equipment can be classified as specific use or general use as following:

I. **Specific use equipment:** This equipment is only for specific construction operations and it is removed from the jobsite soon after the task is completed.

II. **General use equipment:** General use equipment has shared utilization by all subcontractors on the construction site and it is not associated with any particular work item or items.

2.8.4 Overheads

Overheads cost are construction costs of any kind that cannot be attributed to any specific item of work. In general, Overheads are a significant item of expense and will generally run from (5% to 15 %) of the total project cost, depending somewhat on where certain project costs are included in the cost estimate.

2.8.5 Markup

In construction industry, markup is defined as the amount added to the estimated direct cost and estimated job into overhead cost to recover the firm"s main office allocated overhead (general overhead) and desired profit. In general, markup can be classified into two main categories as:

I. Risk allowance (Contingency): The contingency is a specific provision; it must be included to account for unforeseen elements of cost (Ahuja et al. cited in (Al-Shanti, 2003)). Ostwald (2001) stated that contingency is the amount of money added to an estimate to cover unforeseen needs of the project, construction difficulties, or estimating accuracy. In addition, he quoted the main items that make many chief estimators or contractor to executives add a contingency to the estimate to cover one or possibly more of the following:

- Unpredictable price escalation for materials, labor, and installed equipment for projects with an estimated duration greater than 12 months;
- Project complexity;
- Incomplete working drawings at the time detail estimate is performed;
- Incomplete design in the fast-track or design-build contracting approach;
- Soft spots in the detail estimate due to possible estimating errors, to balance an estimate that is biased low;
- Abnormal construction methods and startup requirements;
- Estimator personal concerns regarding project, unusual construction risk, and difficulties to build; and
- Unforeseen safety and environmental requirements.

Accordingly, contingency is not a potential profit and it should not be treated as an allowance. It includes risk and uncertainty but explicitly excludes changes in the project scope (change orders).

II. Profit: The amount of profit is generally computed as a percentage of the contract, or in some cases, as a percentage of each item in the contract. Generally, the magnitude of desired profit must be decided by the owner for each individual bid, depending on local market conditions, competition, and the contractor‟s need for new work.

2.9 Methods of Cost Estimation

Cost estimation methods can be categorized into several techniques as;

2.9.1 Quantitative and Qualitative Technique

Qualitative approaches rely on expert judgment or heuristic rules, and quantitative approaches classified into statistical models, analogous models and generative-analytical models (Duran, et al., 2009; Caputo & Pelagagge, 2008). Quantitative approach has been divided into three main techniques according to (Cavalieri, et al., 2004).

(a) Analogy-Based Techniques

This kind of techniques allows obtaining a rough but reliable estimation of the future costs. It based on the definition and analysis of the degree of similarity between the new project and another one. The underlying concept is to derive the estimation from actual information. However, many problems exist in the application of this approach, such as:

- The difficulties in the measure of the concept of "degree of similarity".
- The difficulty of incorporating in this parameter the effect of technological progress and of context factors.

(b) Parametric Models

According to these techniques, the cost is expressed as an analytical function of a set of variables. These usually consist in some features of the project (performances, type of materials used), which are supposed to influence mainly the final cost of the project (known also as "cost drivers"). Commonly, these analytical functions are named "Cost Estimation Relationships" (CER), and are built through the application of statistical methodologies.

(c) Engineering Approaches

In this case, the estimation is based on the detailed analysis and features of the project. The estimated cost of the project is calculated in a very analytical way, as the sum of its elementary components, comprised by the value of the resources used in each step of the project process (raw materials, labor, equipment, etc.).

Due to this more details, the engineering approach can be used only when all the characteristics of the project process are well defined.

2.9.2 Preliminary and Detailed Techniques

For both preliminary and detailed technique its own methods, especially since preliminary methods are less numeric than detailed methods. However, most of researchers seek for perfect preliminary method that gives good results. Ostwald (2001) outlined commonly methods that are divided into two sets qualitative preliminary methods as opinion, conference, and comparison similarity or analogy and quantitative preliminary methods as unit method, unit quantity, linear regression...etc.

2.9.3 Traditional and Artificial Intelligence Based Techniques

In fact, most of earlier traditional methods fall into one of the following categories;
Time referenced cost indices, cost capacity factors, component ratio, and parameter costs. However, many researches addressed these traditional parametric methods Mahamid & (Bruland, 2010 , Kim, et al., 2004).

Recently new approaches were introduced in the last years based on the concept of parametric models that based on computerized techniques such as artificial intelligence, which attempt to simulate human intelligence such as Artificial Neural Network (ANN), Fuzzy logic, etc., where it stills under research and development especially in construction sector.

2.10 Traditional Techniques

For the past half century, the forecasting techniques that have been used usually depend on quantitative approaches. They can be stochastic or deterministic. Examples of deterministic methods are regression methods (linear regression and multiple regressions). Many researchers used traditional parametric cost estimation techniques due to their simple formulations such as (Khosrowshahi & Kakakt 1995, Skitmore & Thomas 2003, and Mahamid & Bruland, 2010). Khosrowshahi and Kakakt (1995) adapted an improvised iterative technique for conducting the multi-variety regression analysis by developing two separate models and proposed them for the estimation of project cost and duration for the project definitions within the category of housing projects in the U.K. The efficiency or accuracy of the models reflected on their statistical performance, which is measured in terms of the adjusted coefficient of determination, which is calculated to be 81.4% and 92.7% for cost and duration models respectively. Skitmore and Thomas (2003) also conducted a similar effort, using standard regression and a forward Cross Validation (C.V) regression analysis for the development of several models for forecasting actual construction time and cost using a set of 93 Australian construction projects. Mahamid & Bruland, (2010) developed a linear regression model to predict the cost of road construction activities based on 100 set of data in the west Bank of Palestine. The prediction models were developed for three major road construction activities, which are earthworks, base course works, and asphalt works. Three groups of models for each activity were developed based on used dependent variable; they are total cost of construction activity, cost per meter length, and cost per meter square. The proposed independent variables are road length, pavement width, base course width, terrain condition, soil drill ability, and soil suitability. The coefficients of determination r^2 for the developed models ranged from 0.57 to 0.96. These research efforts, while were constrained by the limitations of traditional tools, provide insights into the elements that need to be considered in the development of effective parametric models. Traditionally, cost-estimating relationships are developed by applying regression analysis to historical project information. The development of these models, however, is a difficult task due to the inherent limitations of regression analysis (Hegazy & Ayed, 1998).

2.10.1 Artificial Intelligence-Based Techniques

Recently several attempts were made to introduce parametric models for cost estimation based on various computerized techniques. Artificial Intelligence (AI) has been a rapidly growing field of computer science that has direct applications in the construction industry (Ayed, 1997). Neural Networks are applied to those fields of computer science attempt to simulate human intelligence. Neural networks are among the current Artificial Intelligence research areas (Dikmen & Akbiyikli, 2009).

2.11 Support Vector Machines (SVM)

A Neural Network training program, NeuroSolution, was used as a standalone environment for support-vector machines (SVM) development and training. Moreover, for verifying this work the plentiful trial and error process was performed to obtain the best model architecture.

The support-vector network is a new learning machine for two-group classification problems. The machine conceptually implements the following idea: input vectors are non-linearly mapped to a very high dimension feature space. In this feature space a linear decision surface is constructed. Special properties of the decision surface ensures high generalization ability of the learning machine. The idea behind the support-vector network was previously implemented for the restricted case where the training data can be separated without errors (Cortes and Vapnik, 1995).

The theory that underlies support vector machines (SVM) represents a new statistical technique that has drawn much attention in recent years. This learning theory may be seen as an alternative training technique for polynomial, radial basis function and multi-layer percept classifiers. SVM are based on the structural risk minimization (SRM) induction principle (Lin, 2004).

The SVM deals with classification and regression problems by mapping the input data into high-dimensional feature spaces. Its central feature is that the regression surface can be determined by a subset of points or support-vectors (SV); all other points are not important in determining the surface of the regression (Chen and Shih, 2006).

2.11.1 Support vector machines (SVM) and neural network architecture (ANN)

According to Chen and Shih (2006) the SVM, which originated as an implementation of Vapnik's Structural Risk Minimization (SRM) principle, is now being used to solve a variety of learning, classification and prediction problems. In many ways, a SVM performs the same function as neural network architecture (ANN). For example, when both the input and output data are available (supervised learning in ANN), the SVM can perform classification and regression; but when only the input data are available, it can perform clustering, density estimation and principle component analysis. The SVM is more than just another algorithm. It has the following advantages over an ANN:

1. It can obtain the global optimum.
2. The over fitting problem can be easily controlled.
3. Empirical testing has shown that the performance of SVMs is better than ANNs in classification (Cai and Lin, 2002; Morris and Autret, 2001) and in regression (Tay and Cao, 2011).

2.11.2 The using of support vector machines in construction

There are plenty of learning approaches for applications in the engineering fields. Scholars have utilized approaches such as neural networks, case based reasoning, and self-organizing feature map based optimization to deal with practical construction problems. SVM is one popular type of learning approach which has been utilized in the engineering fields, especially for pattern classification. Recently this approach has also been adapted for the construction industry, for example, for the solving of cost estimates, contract risk, and construction safety problems. Construction material suppliers are usually exposed to financial risks as a consequence of a high debt capital structure and the nature of the material import business. There is demand for a tool that is able to predict whether such a material supplier, based on its financial status, should use derivatives to hedge financial risks. a prediction model using the Support Vector Machine (SVM) was developed to determine whether employing risk hedging based on derivatives usage would be beneficial. The SVM prediction model, based on the kernel radial basis function and normalized data, yields a prediction accuracy rate of 80.65%. The evaluation, using logistics and small sets of data. A ten financial determinates are proven candidates for financial risk hedging. SVM prediction model appeared feasible for construction material suppliers to apply the model (Chen and Lin, 2010).

2.12 Construction Cost Estimating Previous Researches

Several researches have studied the cost estimating in general, the accuracy of cost estimate, factors affecting cost estimating and the computer applications in cost estimating.

Globally there are many researches such as Zheng and Guang (2012); Bhatnagar and Ghose (2012); Bo and Albert (2011); Memon et al., (2010); Ray et al., (2010); Cheng et al., (2010) and Adeli and Jiang, (2003).

Zheng and Guang (2012) said that the main factors influencing the construction engineering cost in China are:

(1) Geological conditions of the engineering and hydrological geological conditions;

(2) Structural features of the building;

(3) Construction techniques and mechanical equipment;

(4) Influence of the construction unit.

In their study they found that the computational speed and accuracy were more significantly improved by using the global random search capability of genetic algorithm and the learning ability and robustness of neural network than the traditional methods.

While Bo and Albert (2011) studied the key parameters that measure the degree of project complexity in China. They identified that the six key measures of project complexity include, (1) building structure & function; (2) construction method; (3) the urgency of the project schedule; (4) project size/scale; (5) geological condition; and (6) neighboring environment.

While Memon et al. (2010) studied the factors affecting construction cost at MARA which is one of the government agencies of Malaysia. They present the results of a questionnaire survey conducted among the personnel of Project Management Consultant. They concluded that cash flow and financial difficulties faced by contractors, contractor's poor site management and supervision, inadequate contractor experience, shortage of site workers, incorrect planning and scheduling by contractors are most severe factors while changes in scope of project and frequent design changes are least affecting factors on construction cost.

Ray et al. (2010) reported that the results show that the quality of predictions made by the intelligent system is comparable to the quality assured by the experienced expert. The proposed expert system is superior to traditional cost accounting system and assists inexperienced users in predicting the optimum process cost within the shortest possible time.

While Bhatnagar and Ghose (2012) reported that fuzzy logic is the best model for predicting early stage effort estimation, they found that Mamdani FIS was able to predict the early stage efforts more efficiently in comparison to the neural network based models.

On the other hand Cheng et al. (2010) proposed a conceptual cost estimate model by the Evolutionary Fuzzy Neural Inference, they presents Evolutionary Web-based Conceptual Cost Estimators which can be deployed to estimate conceptual construction cost more precisely during the early stages of projects.

Adeli and Jiang (2003) developed neuro-fuzzy logic model for estimation of the freeway work zone capacity. The new model in general provides a more accurate estimate of the work zone capacity.

Locally many searches were done for the accuracy of cost estimate. Factors affecting cost estimating and the computer applications in cost estimating, like Shehatto (2013), Arafa and Alqedra (2011); Abdal-Hadi (2010); Aljarosha (2008); Al-Najjar (2008); Abu Shaban (2008); Al-Shanti (2003); Madi (2003) and El-Sawalhi (2002).

Shehatto (2013) studied the significant parameters that effect the early stage cost estimation of construction projects in Gaza. Shehatto reported that the factors affecting the cost of construction projects are divided into two main groups' structural skeleton and finishes.

The structural skeleton groups were including 13 factors, he founded the degree of importance for each factors and the most significant factors at this group were:

1- Area of the typical floor.
2- Number of stories.
3- Area of the returning wall.
4- Type of the building (residential, schools, hospital, mosque, university).
5- Type of footing (isolated, combined, raft, piles).
6- Number of elevators.
7- Type of the slab (hollow, solid, drop beam).

The finishes groups included 18 factors. He founded the degree of importance for each factors and the most significant factors in this group were:

1- External finishing (plaster, tyrolean, oixus. composites).
2- Type of tiles (terrazzo, ceramic, porcelain, marble).
3- Area of glassed elevations.
4- HVAC volume.
5- Type of electrical works.
6- Type of mechanical works.
7- False ceiling area.

Arafa and Alqedra (2011) developed a model for early cost estimation of construction projects at Gaza. The model were built using artificial neural network depends on seven significant factors for the structural skeleton namely ground floor area, typical floor area, number of stories, number of columns, type of footing, number of elevators and number of rooms.

Arafa and Alqedra reported that the results obtained from the trained models indicated that neural networks rationally succeeded in predicting the early stage cost estimation of building using basic information of the projects and without need for more detailed design.

Abdal-Hadi (2010) reported about that factors affecting accuracy of pre-tender cost estimate at Gaza Strip. An exploration of 85 factors affecting the accuracy of pre-tender cost estimate was conducted in order to find the degree of importance for each factor. The 85 factors where divide into five main groups which are:

1. Factors related to clients characteristics;

2. Factors related to consultants, design parameters and information;

3. Factors related to project characteristics;

4. Factors related to contract requirement and procurement method;

5. External factors and market conditions.

Abdal-Hadi said that the factors that are related to consultants, design parameters and information were ranked in the first position among other groups. The factors that are related to external factors and market conditions were ranked in the second position. The factors that are related to contract requirement and procurement method were ranked in the third position. The factors that are related to clients characteristics were ranked in the fourth position, while the factors that are related to project characteristics were ranked in the last position. Which emphasized that, the consultants, design parameters and information are crucial in accurate estimation of construction costs at the pre-tender stage.

Aljarosha (2008) explored the impact of conditions of contract for construction on the cost estimating. He investigated the using of computer applications to deal with liabilities and risks associated with the construction projects. He found the majority of contractors do not use formalized techniques for estimating contingencies when preparing tenders. They do not use computerized tools to evaluate and manage responsibilities and risks and, in general, there is no commitment to employ an experienced person or team for evaluating and managing responsibilities and risks.

Abu Shaban (2008) identified 17 cost factors that affecting the performance of construction projects. He recommended the construction companies to have a structured methodology and technique should be identified to overcome the effect of local political and economic situations on the performance of construction projects in the Gaza Strip.

Al-Najjar (2008) study the factors influencing time and cost overruns on construction projects in the Gaza Strip, he said that it is well known that most construction projects in Gaza Strip exposed to time and cost overrun or both. So the cost estimator must be more accuracy and take the factors affecting the cost estimation at his consideration.

Al-Shanti (2003) explored the project cost estimation in Gaza strip. He investigated the using of computer applications in cost estimating. He concluded that most of contracting companies are still estimating the projects manually. Shortage of user friendly estimating software packages and lack of available qualified personnel in using computer-based estimating systems are considered the main obstacles in using computer in construction estimating.

Madi (2003) investigated the essential factors affecting the accuracy of cost estimating in Gaza Strip to show the degree of importance of 51 factors in cost estimation practice. Madi classified the 51 factor into 8 groups:

1. Group 1 related to project complexity;
2. Group 2 related to project information and resources;
3. Group 3 related to technological requirements;
4. Group 4 related to contract requirements.
5. Group 5 related to efficiency and resources of company;
6. Group 6 related to market requirements;
7. Group 7 related to project and its duration;
8. Group 8 related to project risks.

Madi found that the most important group in cost estimating practice is group 8 related to project risks. This group is ranked first. Group 2 related to project information and resources is ranked second and group 6 related to market requirements is ranked third. He found that the main factors are: location of the project, segmentation of the Gaza Strip and limitation of movements between areas, political situation and closure of the Gaza Strip, financial status of the owner and increase in unit costs of construction materials (Enshassi et al., 2007).

Also Madi investigated the using of computer in tender estimation. He concluded that the main reasons for not using computer in estimating is lack of suitable software for estimating, shortage of qualified employees, the wrong belief that using computer gives inaccurate results, and difficulty in operating computer software.

Al-Shanti (2003) quoted El-Sawalhi (2002) explored the project management practice by public owners and contractors in Gaza Strip. He investigated the using of computer applications in supporting implementation of project management in cost estimating. He concluded that the main reason for low using of computer applications in cost estimating may be referred to the inefficient using in estimating computer applications. He also referred this partly for the lack of efficient training for using such programs.

Arafa and Alqedra (2011) developed ANN model to predict the early stage cost of buildings. The data was collected from 71 construction projects. The analysis of the training data revealed that there are seven key parameters and the ANN model had one hidden layer with seven neurons. One output neuron representing the early cost estimate of buildings. A comparison between the actual cost values of the testing set and values obtained from the ANN model showed that the mean, standard deviation and coefficient of determination (R^2) of the ratio between the actual and predicted cost are 0.960, 0.420 and 97%, respectively. The performed sensitivity analysis showed that the ground floor area, number of storeys, type of foundation and number of elevators in the buildings are the most effective parameters influencing the cost estimates of buildings.

Gunaydın and Dogan (2004) built a neural network model to estimate the cost in early phases of building design process. Cost and design data from thirty projects were used for training and testing the neural network methodology with eight design parameters utilized in estimating the square meter cost of reinforced concrete structural systems of 4–8 storey residential buildings in Turkey, an average cost estimation accuracy of 93% was achieved.

Kim et al. (2004) used the back-propagation network (BPN) model incorporating genetic algorithms (GAs) to cost estimation. GAs were adopted in the BPN to determine the BPN's parameters and to improve the accuracy of construction cost estimation. Previously, there have been no appropriate rules to determine these parameters. The construction cost data for 530 residential buildings constructed in Korea between 1997 and 2000 were used for training and evaluating the performance of the model. This study showed that a BPN model incorporating a GA was more effective and accurate in estimating construction costs than the BPN model using trial and error.

In their recent study, Ahadzie et al. (2008) proposed a multiple regression model for the prediction of the outcome for the performance of project managers at the construction stage of mass housing projects. Also, the independent variables affecting the success of project managers were identified. The methodology used by Ahadzie et al. (2008) can also be implemented for predicting the performance of project managers in the different project types.

In Gaza strip, few researchers discussed the effective techniques for obtaining an accurate cost estimation, Madi (2003), for example, conducted a research on the factors that affecting the accuracy of cost estimation. The research documented that the contracting companies in Gaza strip continue to use traditional techniques for tender cost estimation, therefore, the recommendation of that research stated that more efforts should be spent to develop special pricing software in order to improve the cost estimation practice in Gaza Strip.

3 CHAPTER 3: METHODOLOGY

3.1 Introduction

Developing of a parametric cost estimation model using support-vector machines is the essence of this study, which takes the building projects in Gaza strip as a case study to predict the final cost at early stage of project preparation.

This research adopts historical data analysis as the foundation to this methodology. As well, the use of historical data assists in providing a relation between the main factors affecting the cost of the building projects to make estimates for new projects.

This chapter provides the information about the research strategy and design, factors affecting cost of the building projects, process of data collection and analysis.

3.2 Research Strategy

Research strategy in general means a plan of action of how the research objectives can be questioned, and it can be classified into two types namely, quantitative approach and qualitative approach (Naoum, 2007).

Qualitative approach seeks to gain insights and to understand people's perceptions, or opinion towards a particular object. As well, it is used when a limited amount of knowledge about the topic are available (Naoum, 2007).

Quantitative approach seeks to collect factual data and to study relationship between facts and how such facts and relationships accord with theories and findings of any research executed previously (Al-Shanti, 2003).

In this study, both quantitative and qualitative approaches were used. The qualitative approach was used to determine the main factors affecting the cost of building projects in Gaza strip at conceptual phase by using Delphi technique. In addition, quantitative approach was used to gather the data from resources by filling a form for each project, which contains the input factors and the cost as the output.

3.3 Research Design

The purpose of this research is to explore the significant factors affecting the cost estimating of construction projects at Gaza Strip and develop a computerized cost estimating system using support vector machine to be used in early cost estimation.

This research consists of eight phases:

1. Topic Selection and Thesis Proposal Phase

Topic is selected, problems are defined, objectives are established and, research plan is developed.

2. Literature Review Phase

It include the studies that reviewed the relevant literature on the subject of parametric cost estimation methods and looking at previous models, papers, reports and thesis, which studied non-traditional methods for parametric cost estimation.

3. Data Collection Phase

The third phase of the research included a field survey which included owners, contractors and consultants through personal interview which was used in this research to collect factual information as well as opinions. It was decided that the most appropriate approach was to carry out a structured interview which mean questions are presented in the same order and with the same wording to all interviewees. Interviews were used as a step of Delphi method to identify the main factors, which need to be considered in cost estimation at the conceptual phase. The Delphi technique can be used to anonymously elicit the opinions of experts concerning factors affected on the project's cost. It provides feedback to experts in the form of distributions of their opinions and reasons. They are then asked to revise their opinions in light of the information contained in the feedback. This sequence of questionnaire and revision is repeated until no further significant opinion changes are expected. This technique is designed to protect anonymity of the expert's opinions and reasoning (Creedy et al., 2006)

The following steps have been followed to achieve the Delphi method:

- Seven exploratory interviews were done with experts. The experts worked in various positions: cost engineers, managers and site engineers. They worked in consultant offices, municipalities and contractor companies.

- The factors that affect the cost of construction projects, which have been drawn from previous studies, were presented to them.
- Then the expert's opinions were collected that showed consensus on nine factors, which have the greatest impact on the construction project cost in Gaza strip. They took in consideration the ability to gather the related information and the ability to know these factors at the early stage of the project.

Support-vector machines require a lot of data. Therefore, a lot of historical building projects were collected which were done between 2010 and 2013 in Gaza strip. These research include areal data collecting from 169 construction projects. These projects were residential, schools, mosque and organization buildings.

4. Model Development Phase

After analyzing the data, many models were built and trained with various structures by using support-vector machines technique in this stage, the NeuroSolutions 6.07 application and Microsoft Excel 2007 were selected to build the models. Many models were implemented with various structures and were trained many times with checking the validity. The final models were tested and the results were presented through comparison between models performance to choose the best.

5. Model Validity

The fifth phase of the research focused on model validity by comparing the model results of 21 projects with real cost of these projects.

6. Conclusion and Recommendations Phase

In this stage, the content of the dissertation was written and the research chapters were covered. Moreover, the research was summarized in the conclusion section with some recommendations.

The approach used to achieve the study objectives can be summarized as shown in Figure (3.1).

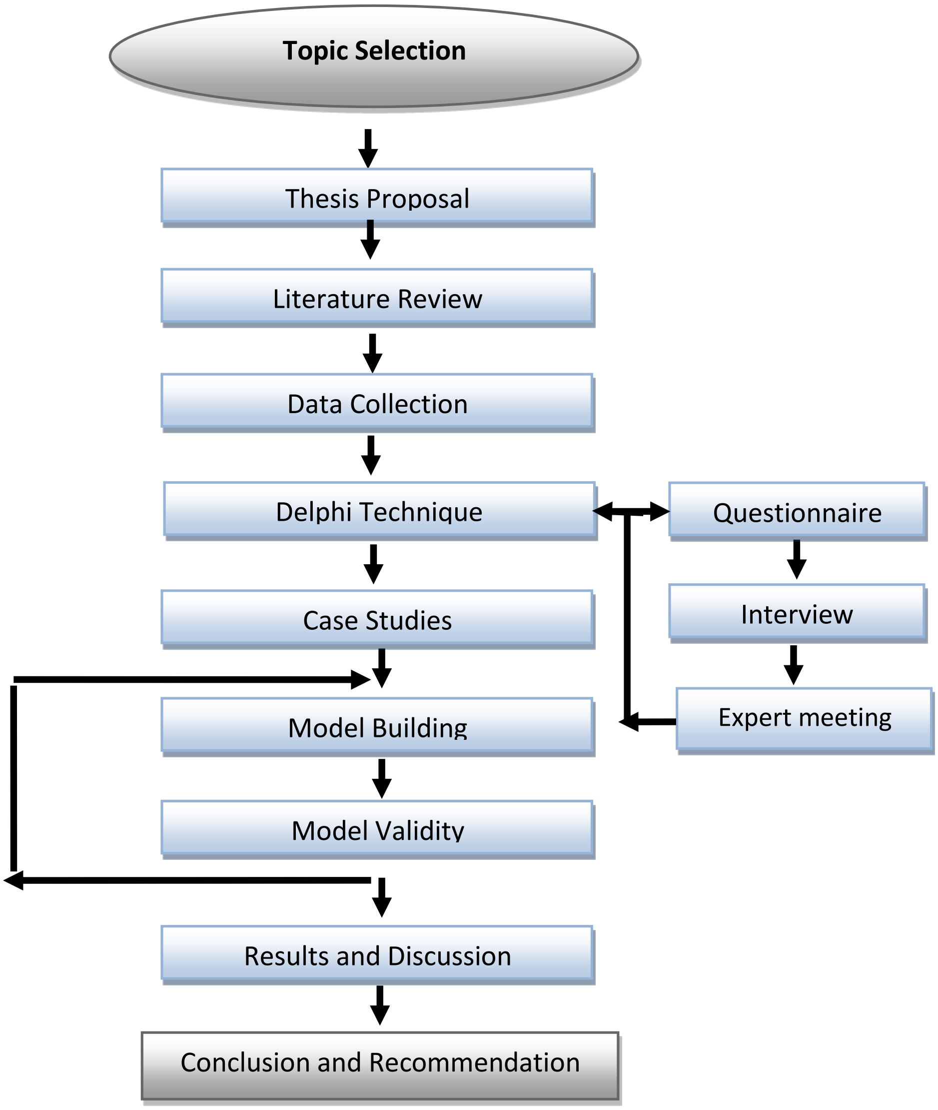

Figure 3-1: Research methodology flowchart

3.4 Research Population and Sample Size

The studied population consists of experts, engineers, and managers from different organizations with experience and with direct contacts in their jobs to the cost estimation process, preparing estimates, and to supervisions and management of construction projects in Gaza Strip. The targeted sample was divided into three categories, this category only for interviews, and contractor for questionnaire:

1- Clients: this category includes ministries, municipalities, governmental bodies, donors and NGOs. The total numbers of interviews with this category were five.
2- Consultants: this category can be hired by some clients because of their experiences. The total numbers of interviews with this category were four.
3- Contractors: the first, second and third category who have valid registration in 2012 from the Contractors Union, were include in this category. The total numbers of interviews with this category were twelve.

The studied population includes contractors who have a valid registration by the Palestinian Contractors Union (PCU) in buildings specialization in Gaza Strip at year 2012. The total number of contractors who have valid registration under first, second and third category are 154 companies. The first class has56 companies, the second class has 65 companies, and the third class has 33 companies.

A systematic random sample to ensure a representative sample of all contractors was selected. To determine the sample size for each population of contractors , Kish (1965) equation was used. Several studies such as Assaf et al (1999, 2001) and Abdul-Hadi (1999) used this equation. According to the Engineers' Association in Gaza strip the population of the contractors is 154

$$\mathbf{n= n'/ [1+(n'/N)]}$$

Where:

n': is the sample size from infinite population, which can be calculated from this formula [$n' = S^2/V^2$]. The definitions of all variable can be defined as the following:

n: sample size from finite population.

N: Total population (154 contractors)

V: Standard error of sample population equal 0.05 for the confidence level 95 %, t =1.96.

S^2: Standard error variance of population elements, $S^2= P (1-P)$; maximum at P= 0.5

The sample size for the contractors' population can be calculated from the previous equations as follows:

$n' = S^2/V^2 = (0.5)^2/(0.05)^2 = 100$

$$n= 100/ [1+(100 / 154)] = 64$$

This means that the questionnaire should be distributed to 64 contractor organizations in order to achieve 95% confidence level

3.5 Research Location

The research was carried out in Gaza Strip, which consists of five governorates, the North, Gaza, the Middle, Khan Younus and Rafah. These five governorates are considered the southern governorates of Palestinian National Authority (PNA).

3.6 Limitation of the Research

This thesis is restricted by the following items:

1. Due to time constraint, this research is concerned with construction building projects only (housing, schools, etc.), and will not take into account the other categories of engineering projects like civil projects (tunnels, highways, bridges), or utilities projects (sewage and water supply), and industrial projects (factories and workshops).
2. As a result of model training the type of construction buildings that were included in the finial model were residential and organization buildings. The hospitals, schools, mosques and universities were excluded because there is a big gap in the cost of these types.
3. Contractors of first, second and third class represent the population in this research, while contractors of fourth and fifth category will be excluded for increasing the accuracy of study.

3.7 Defining the Factors Affecting Cost Estimating Project in Gaza Strip

A thorough literature review was conducted to identify the factors that affecting cost estimating by researchers and practitioners in this field. Combining this literature review as discussed in chapter 2 with researcher experience, the factors affecting cost estimating were identified. They are categorized into two groups (main factors). Each group is divided into sub-factors as shown in Table 3.1.

Table 3.1: Factors affecting cost estimating of the construction building project

No.	Main Factor	Sub-factors
1	Structural skeleton works	Type of the building
		Type of soil
		Type of the foundation in the building
		Area of ground floor

No.	Main Factor	Sub-factors
		Area of typical floor
		Type of the slab
		Number of stores in the building
		Number of columns
		Number of rooms in the building
		Number of elevators
		location of the project
2	Finishes works	Type of external finishing
		Type of tiles
		Type of painting
		Type of electrical works
		Type of mechanical works
		False ceiling and gypsum board area
		Type of aluminum works
		Type of metal works
		Type of carpentry works

3.8 Structured Interviews

It was decided that the most appropriate approach was to carry out structure interviews with a number of experts, engineers, and managers in order to get a better understanding of most important factors affecting the cost estimating of construction projects.

Since the Arabic language is much effective and easier to be understood to get more realistic results the structured interviews was conducted in Arabic language.

A covering letter was sent to the selected organizations. The letter indicated the objectives of the research and requested that the interviewee should be a staff member responsible for cost estimating activities in the organization. A two-page in length protocol with 2 questions was prepared based on a combination of an extensive review of the literature dealing with factors affecting cost estimating practice in Gaza Strip. The covering letter was sent to construction organizations.

The structured interviews schedule also sought information regarding the following areas:

1. Characteristics of responding organizations in term of position of respondent, years of experience for the organization and total number of employees.
2. Factors affecting cost estimating.
3. Suggestions regarding any other factors and improvements required in estimating.

The structured interviews were conducted and lasted for 20 to 30 minutes for each one.

3.9 Questionnaire Design

According to literature review related to the concern subject and after discussions with the supervisor and interviewing sample of contractors, a well designed questionnaire was developed with mainly closed ended questions. The questionnaire was built from two sections that cover the main questions of the study. The first section is related to the company profile and some information about the project. This section includes 6 questions about classification of contracting companies according to PCU , the position of officer who fills the questionnaire, number of company's employees, number of projects executed in the last five years, the value of projects executed in the last five years, the type of implemented projects

The second section is related to factors affecting pricing proses. It includes 3 groups of factors such as: factors related to structural (skeleton) group which includes 10 factors, factors related to external group which includes 5 factors, factors related to finishing group which includes 18 factors The original questionnaire was developed in English language. English language questionnaire is attached in (Appendix 1). In order to avoid any misunderstanding. The questionnaire would be much effective and easier to be understood and to get more realistic results, the questionnaire was translated to the Arabic language and the Arabic language questionnaire is attached in (Appendix 2). An explanatory letter was attached to explain the way of responding, the aim of the study and the security of the information. A draft questionnaire was designed with the help of supervisor. This draft was discussed with a group of specialists. They advised some changes such as modifying the wording of some questions. Some of them recommended adding questions. Some of them also recommended changing the answer options in questions. Other changes were also made after the pilot study to clarify confusion and ambiguity reported by the pilot study subjects.

The Relative Importance Index

The relative index technique has been widely used in construction research for measuring attitudes with respect to surveyed variables. Several researches such as Abdal-Hadi (2010), Al-Najjar (2008); Madi (2003) and Akintoye (2000) used the relative importance index in their analysis of factors affecting the accuracy of cost estimate. This study used this technique to determined factors affecting cost estimating. Likert scaling was used for ranking questions that have an agreement levels. The respondents were required to rate the importance of each factor on a 5-point Likert scale using 1 for not important, 2 for of little importance, 3 for somewhat important, 4 for important and 5 for very important. Then, the relative importance index was computed using the following equation:

$$\text{Relative Importance Index} = \frac{\sum W}{AN} = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5N}$$

Where W is the weighting given to each factor by the respondent, ranging from 1 to 5, (n1 = number of respondents for not important, n2 = number of respondents for little importance, n3 = number of respondents for somewhat important, n4 = number of respondents for important, n5 = number of respondents for very important). "A" is the highest weight (i.e 5 in the study) and N is the total number of samples. The relative importance index ranges from 0 to 1 (Tam and Le, 2006).

3.10 Reliability and Validity of Research

Reliability is the extent to which a test or procedure produces similar results under constant conditions on all occasions (Bell, 2005). Reliability can be equated with the stability, consistency, or dependability of a measuring tool. There are a number of devices for checking reliability in scales and tests, such as ‘test–retest’ (administering the same test some time after the first), the ‘alternate forms method’ (where equivalent versions of the same items are given and results correlated) or the ‘split-half method’ (where the items in the test are split into two matched halves and scores then correlated) (Bell, 2005).

Validity refers to the degree to which an instrument measures what it is supposed to be measured. When an instrument is valid, it truly reflects the concept it is supposed to measure (Bell, 2005).

Checking validity can be done by tell other people (colleagues, pilot respondents) what you are trying to find out or to measure and ask them whether the questions or items you have devised are likely to do the job.

The validity content of the structured interviews was tested by three experts. Each of them has full information about the research objectives. Each of them was requested to evaluate validity content for each item.

The three experts do agree that the structured interview was valid and suitable enough to measure the concept of interest with some amendments.

3.11 Development of the Research Model

The results of this study show that the existing common practice in estimating is simple where most of contractors were still estimating the construction cost manually or by using a personal excel sheets. The computer applications were rarely used for bid analysis in construction companies. The goal of this study to develop a computerized estimating system.

Based on the main factors and sub-factors affecting cost estimating generated from combining the results of gathering structured interviews and literature review, a research model was developed to facilitate the research study.

The selected factors for the model were nine factors they are: area of typical floor, number of stories, type of the building, type of the foundation, type of the slab, number of elevators, type of external finishing, volume of HVAC works, type of tilling and type of electro-mechanic works.

3.12 Performance Measures

The Performance Measures is important to evaluate models, there are five values that can be used to measure the performance of the network for a particular data set.

3.12.1 Mean Square Error (MSE):

According to Principe et al., (2010) mean square error measures the average of the squares of the "errors". The error is the amount of value difference between the network output and the desired output. The formula for the mean squared error is:

$$MSE = \frac{\sum_{j=0}^{P}\sum_{i=0}^{N}\left(d_{ij}-y_{ij}\right)^2}{NP}$$ Eq. (3.1)

Where: P= number of output PEs.
N= number of exemplars in the data set.
y_{ij}= network output for exemplar i at PE j.
d_{ij}= desired output for exemplar i at PE j.

3.12.2 Normalized Mean Square Error (NMSE):

According to Principe et al., (2010) the normalized mean squared error is defined by the following formula:

$$NMSE = \frac{P \times N \times MSE}{\sum_{j=0}^{P}\left(\frac{\left(N\sum_{i=0}^{N}\left(d_{ij}^{2}\right)-\left(\sum_{i=0}^{N} d_{ij}\right)^2\right)}{N}\right)}$$ Eq. (3.2)

Where: P= number of output PEs.
N= number of exemplars in the data set.
MSE= mean square error.
d_{ij}= desired output for exemplar i at PE j.

3.12.3 Correlation Coefficient (r):

According to Principe et al., (2010) the size of the mean square error (MSE) can be used to determine how well the network output fits the desired output, but it doesn't necessarily reflect whether the two sets of data move in the same direction. For instance, by simply scaling the network output, we can change the MSE without changing the directionality of the data. The correlation coefficient (*r*) solves this problem. By definition, the correlation coefficient between a network output *x* and a desired output *d* is:

$$r = \frac{\frac{\sum_i (x_i-\bar{x})(d_i-\bar{d})}{N}}{\sqrt{\frac{\sum_i (d_i-\bar{d})^2}{N}}\sqrt{\frac{\sum_i (x_i-\bar{x})^2}{N}}}$$ Eq. (3.3)

The correlation coefficient is confined to the range [-1,1]. When *r* =1 there is a perfect positive linear correlation between *x* and *d*, that is mean *x* and *d* vary by the same amount. When *r*=-1, there is a perfectly linear negative correlation between *x* and *d*, that means they vary in opposite ways (when *x* increases, *d* decreases by the same amount). When *r* =0 there is no correlation between *x* and *d*, i.e. the variables are called uncorrelated. Intermediate values describe partial correlations. For example a correlation coefficient of 0.88 means that the fit of the model to the data is reasonably good (Principe, Lefebvre, Lynn, & Wooten, NeuroSolutions - Documentation, 2010).

3.12.4 Mean Absolute Error (MAE):

According to Willmott and Matsuura, (2005) the MAE is defined by the following formula:

$$MAE = \frac{\sum_{j=0}^{P}\sum_{i=0}^{N}\left|dy_{ij}-dd_{ij}\right|}{N\,P} \qquad \text{Eq. (3.4)}$$

Where: P= number of output PEs.
N= number of exemplars in the data set.
dy_{ij}= denormalized network output for exemplar i at PE j.
dd_{ij}= denormalized desired output for exemplar i at PE j.

3.12.5 Mean Absolute Percentage Error (MAPE):

According to Principe et al., (2010) The MAPE is defined by the following formula:

$$MAPE = \frac{100}{N\,P}\sum_{j=0}^{P}\sum_{i=0}^{N}\frac{\left|dy_{ij}-dd_{ij}\right|}{dd_{ij}} \qquad \text{Eq. (3.5)}$$

Where: P= number of output PEs.
N= number of exemplars in the data set.
dy_{ij}= denormalized network output for exemplar i at PE j.
dd_{ij}= denormalized desired output for exemplar i at PE j.

Note that this value can easily be misleading. For example, say that your output data is in the range of 0 to 100. For one exemplar your desired output is 0.1 and your actual output is 0.2. Even though the two values are quite close, the percent error for this exemplar is 100 (Principe, Lefebvre, Lynn, & Wooten, NeuroSolutions - Documentation, 2010).

After several studies were reviewed, then this research considered Hegazy and Ayed, (1998) methdology in determinig the total MAPE. Training phase were represented fifty percent of the total MAPE likewise the test set is equal the remaining fifty percent. Total Accuracy Performance (TAP) can be calculated by the following formula:

$$\textbf{Total MAPE} = \frac{(MAPE_{Tr}\times N_{Tr}+MAPE_{C.V}\times N_{C.V})/(N_{Tr}+N_{C.V})+MAPE_{Test}}{2} \qquad \text{Eq. (3.6)}$$

Where:

$MAPE_{Tr}$ = Mean absolute percentage error for training data set.
N_{Tr} = number of exemplars in the training data set.
$MAPE_{C.V}$ = Mean absolute percentage error for cross validation data set.
N_{Tr} = number of exemplars in the cross validation training data set.
$MAPE_{Test}$ = Mean absolute percentage error for test data set.

3.12.6 Accuracy Performance (AP):

According to Wilmot and Mei, (2005) Accuracy performance is defined as (100−MAPE) %. Total Accuracy Performance (TAP) can be calculated by the following formula:

$$TAP = 100 - Total\ MAPE \qquad \text{Eq. (3.7)}$$

4 CHAPTER 4: RESULTS AND ANALYSIS

4.1 Introduction

This chapter discusses the results that have been deduced from a field survey of seventy questionnaires. Section one presents the contractor profiles and all necessary information about the respondents. Section two was designed to investigate the degree of importance of each factor on cost estimation that affecting on cost estimate of construction project in Gaza Strip. A Delphi technique was used to validate these factors by conducting interviews with expertise. The main objective for this research is to develop a model to forecast cost estimate using SVM. This model was built based on data collected from local projects.

4.2 Factors affecting cost estimate in building projects

In fact, one of the most significant keys in building the SVM model is identifying the factors that have real impact on the construction cost for building projects. Depending on this great importance of selecting these factors, a questionnaire survey, was conducted to identify these factors for building projects in Gaza Strip. This chapter describes the results that have been obtained from the field study. Analysis of the questionnaire was conducted using Microsoft excel.

4.3 Questionnaire Analysis

Seventy questionnaires were distributed to three categories of contracting companies, where, fifty-seven questionnaires, as a response rate 81% of the total number of questionnaires, were correctly answered. More details and analysis are discussed in this section for the questionnaire results.

4.4 Part One: General Information

This section is mainly designed to provide general information about the respondents in terms of the major type of work involved, position and experience of respondent.

4.4.1 Classification of contracting companies according to PCU

As shown in Table 4.1, three classes of contracting companies are surveyed, noted that (57 %) of the investigated contracting companies are classified as first class.

Table 4.1, shows the frequency and percent of classification of contracting companies for projects.

Table 4-1: Classification of contracting companies

Classification	Frequency	Percent %
First class	40	57%
Second class	17	24%
Third class	13	19%
Total	70	100%

4.4.2 The position of officer who fills the questionnaire

As shown in Table 4.2, most of the respondents (44%) are site engineers.

This indicates the high cooperation of those engineers in this study.

Table 4.2, shows the frequency and percent of position of respondent for projects

Table 4-2: Position of respondent

Position of respondent	Frequency	Percent %
Company manger	8	11%
Projects manger	20	29%
Site engineer	31	44%
Others	11	16%
Total	70	100%

4.4.3 Number of company's employees

As shown in Table 4.3, most of the companies (72%) have less than 30 employees

Table 4.3, shows the frequency and percent of number of company's employees for projects.

Table 4-3: Number of company's employees

No. of employees	Frequency	Percent %
Less than 10	15	22%
From 11 to 30	35	50%
From 31 to 50	12	17%
More than 50	8	11%
Total	70	100%

4.4.4 Number of projects executed in the last five years

As shown in Table 4.4, (36 %) of the companies' volume of work is less than 10 projects in the last five years. Table 4.4, shows the frequency and percent of number of projects executed in the last five years.

Table 4-4: Number of executed projects

No. of executed projects	Frequency	Percent %
Less than 10	25	36%
From 11 to 20	24	34%
From 21 to 30	15	21%
More than 30	6	9%
Total	70	100%

4.4.5 The value of projects executed in the last five years

As shown in Table 4.5, it is noticed that (39%) of the companies have executed a volume of work with a value from more than 2 million. Table 4.5, shows the frequency and percent of the value of projects executed in the last five years.

Table 4-5: Value of executed projects

Value of executed projects	Frequency	Percent %
Less than 0.5 million	12	17%
From 0.51 to 1 million	12	17%
From 1.1 to 2 million	19	27%
More than 2 million	27	39%
Total	70	100%

4.4.6 The type of implemented projects

As shown in Table 4.6, it is noticed that (51.9%) of the companies have executed a volume of work with a value from 0.51 to 2 million. Table 4.6, shows the frequency and percent of the type of implemented projects.

Table 4-6: Type of executed projects

Type of implemented projects	Frequency	Percent %
Residential	11	16%
Commercial	6	9%

Residential & commercial	19	27%
Institutional	34	49%
Total	70	100%

4.5 Part two: Factors affecting on cost estimate for construction project in Gaza Strip

The questionnaire included 33 factors, which derived from previous studies as mentioned in chapter two, and those factors recommended by local contracting companies in the Gaza Strip. The factors were distributed into three groups. Factors related to structural (skeleton) group, external factors group and finishes group.

4.5.1 Factors related to structural (skeleton) group

Table 4.7 includes 10 skeleton factors. Most of respondents see that the number of floors in the building, type of used foundation in the building and the area of typical floor are the most influential factors on building cost. While area of retaining walls in project, number of elevators in the building, type of slab and number of staircases in the building have a moderate influence. The three remaining parameters as number of columns, length of span between columns and number of rooms have lower influence on the project cost. It is observed from Table 4.7 that all parameters have considerable effect where all of these have a rate more than 60%. This indicates that the selection of parameters was logical and realistic in its impact on building cost. This further will help to provide more acceptable results when building the cost model.

Table 4-7: Influence of skeleton factors on building cost

No	Group	Factors	RII	Rank
1	Factors related to structural construction	Type of used foundation in the building	0.87	2
2		Area of typical floor	0.84	3
3		Number of floors in the building	0.88	1
4		Number of columns	0.64	8
5		Number of rooms	0.55	10
6		Number of elevators in the building	0.76	5
7		Type of slab (Solid, Ribbed …)	0.73	6
8		Number of staircases in the building	0.73	6
9		Length of spans between columns	0.57	9

No	Group	Factors	RII	Rank
10		Area of retaining walls in project	0.77	4

4.5.2 *Factors related to external group*

Results indicate that Clarity of quantities and drawings schedule is the most important factors in the external group as shown in Table 4.8. Also size of the project is rated second while staff of supervision rated third in this group. On the other hand, location of project and type of contract are lowest factors affecting on building cost in this group.

Table 4-8: Influence of external factors on building cost

No	Group	Factors	RII	Rank
1	External factors	Type of contract (Ls, unit)	0.61	5
2		Location of project	0.63	4
3		Staff of supervision (local or international)	0.64	3
4		Size of the project	0.66	2
5		Clarity of quantities and drawings schedule	0.77	1

4.5.3 *Factors related to finishing group*

Table 4.9 shows the respondents' views for the influence of 18 finishing parameters on total building cost. It is found that the type of external plastering is rated first (RII= 0.83) in the finishing factors group while area of marble works is rated second (RII = 0.79) in this group. Also volume of HVAC works is rated third (RII = 0.78), type of electrical works is rated fourth (RII = 0.77) and area of curtain walls is rated fifth in this group (RII = 0.76). These results reveal how convergence exists between most of parameters, and there is no dominant parameter existing among them. However, as illustrated in table below about the indication of this convergence, but all of these parameters was subjected to evaluate by relevant experts who presented their views and suggestion in next section. On the other hand, type of carpentry works, quantity of carpentry works, number of windows has less impact than above factors on building cost.

Table 4-9: Influence of finishing factors on building cost

No	Group	Factors	RII	Rank
1	Factors related to	Type of external plastering	0.83	1
2		Type of painting	0.74	9
3		Type of tiling	0.75	7

No	Group	Factors	RII	Rank
4	finishing of building	Area of marble works	0.79	2
5		Area of curtain walls	0.76	5
6		Number of internal doors	0.57	18
7		Quantity of metal works for protection and decoration	0.61	17
8		Type of water and sanitary works	0.69	13
9		Quantity of water and sanitary works	0.71	12
10		Firefighting and alarm works	0.75	7
12		Volume of HVAC works	0.78	3
13		Quantity of electrical works	0.76	6
14		Type of electrical works	0.77	4
15		Area of gypsum board and false ceiling	0.72	10
16		Type of carpentry works	0.65	15
17		Quantity of carpentry works	0.66	14
18		Number of windows	0.63	16

4.6 Overall ranking of factors affecting on total building cost

As indicated in Table 4.10 the important factors affecting on total building cost where investigated. The relative important index (RII) for each factor were identified and presented in a second questionnaire for expert contractors to determine the most important factors that affecting on building cost and to be sure from the high effect of these factor for cost of construction projects in Gaza Strip. The most effective factors are number of floors in the building, type of used foundation in the building, area of typical floor, type of external plastering, area of marble works, volume of HVAC works, area of retaining walls in project, clarity of quantities and drawings schedule, area of curtain walls, quantity of electrical works, number of elevators in the building, type of tiling. Also results indicate that lowest factors which have small effect on building cost are staff of supervision, number of windows, location of project, type of contract, quantity of metal works for protection and decoration, number of internal doors, length of spans between columns, number of rooms.

Table 4-10: Overall ranking of factors affecting on total building cost

NO.	**Factors**	**RII**	**Rank**
1	Number of floors in the building	0.911	1
2	Area of typical floor	0.886	2
3	Type of used foundation in the building	0.882	3
4	Type of external plastering	0.839	4
5	Volume of HVAC works.	0.796	5
6	Area of marble works	0.793	6
7	Area of retaining walls in project	0.786	7
8	Quantity of electrical works	0.782	8
9	Type of electrical works	0.779	9

NO.	Factors	RII	Rank
10	Area of curtain walls	0.768	10
11	Firefighting and alarm works.	0.768	10
12	Number of elevators in the building	0.764	12
13	Clarity of quantities and drawings schedule	0.764	12
14	Type of painting	0.754	14
15	Type of tiling	0.754	14
16	Number of staircases in the building	0.743	16
17	Area of gypsum board and false ceiling	0.732	17
18	Type of slab (Solid, Ribbed …)	0.721	18
19	Type of Aluminum works	0.711	19
20	Type of water and sanitary works	0.707	20
21	Quantity of water and sanitary works	0.707	20
22	Type of carpentry works	0.657	22
23	Number of columns	0.650	23
24	Quantity of carpentry works	0.643	24
25	Number of windows	0.629	25
26	Size of the project	0.621	26
27	Staff of supervision (local or international)	0.618	27
28	Location of project	0.611	28
29	Quantity of metal works for protection and decoration	0.596	29
30	Type of contract (Ls, unit)	0.575	30
31	Number of internal doors	0.575	30
32	Number of rooms	0.546	32
33	Length of spans between columns	0.546	32

4.7 Ranking of groups for factors affecting on total building cost

Survey results indicated that structural (skeleton) factors group was ranked the most important among all groups of factors (Table.4.11). On the other hand, finishes group was ranked second important. External factors group was ranked third. Also this results indicate that most important factors are from the first and third group.

Table 4-11: Ranking factors affecting on total building cost among groups

Groups	RII	Rank
Structural (skeleton) group	0.73	1
Finishes group.	0.72	2
External factors	0.66	3

4.8 Delphi Technique

Another technique has been used to determine the effective factors on building project cost. This technique relies on the concept of Delphi technique, which aimed to achieve a convergence of opinion on factors affecting the cost of the project. It provides feedback from the experts opinions. Then, they are asked to revise their opinions in light of the information contained in the feedback. This sequence of questionnaire and revision is repeated until no further significant opinion changes are expected (Creedy et al., 2006).

For Delphi process, several rounds should be conducted where first round begins with a questionnaire. The questionnaire serves as the cornerstone of soliciting specific information about a content area from the Delphi subjects, then after receiving the responses, the researcher converts the collected information into a well-structured questionnaire to be used as the survey instrument for the second round of data collection. In the second round, each Delphi participant receives a second questionnaire and is asked to review the items summarized by the investigators based on the information provided in the first round, where in this round areas of disagreement and agreement are identified. However, in third round Delphi panelist are asked to revise his/her judgments or to specify the reasons for remaining outside the consensus. In the fourth and often final round, the list of remaining items, their ratings, minority opinions, and items achieving consensus are distributed to the panelists. This round provides a final opportunity for participants to revise their judgments. Accordingly, the number of Delphi iterations depends largely on the degree of consensus sought by the investigators and can vary from three to five (Hsu, 2007). Five experts in construction field were selected to reach a consensus about specifying the key cost parameters. The results with those five experts were significantly close to the questionnaire results, and only three rounds were conducted due to largely degree of consensus. They proposed to exclude clarity of quantities and drawing schedule, area of retaining wall, area of marble work and area of curtain walls from these factors because of their rarity in Gaza"s projects, In addition, for the two factors; type of slab and length of span, they recommended to combine them with one factor that contains slab with drop beams. Moreover, they suggested merging area of gypsum board with HVAC (Heating Ventilation and Air-conditioning) to avoid existing dependent parameters in input factors because gypsum boards are installed in case of installing central air-conditioning and recommended to merge type of electrical work with quantity of electrical work to get homogeneous factors in the model.

4.9 Influential factors adopted in the research

Literature studies was the first process in determining the key parameters, then the questionnaire that was designed according to these literatures as long as specialists opinions, and finally Delphi technique that acquired a final identification of most influential factors on building projects cost.

According to previous techniques, it is obvious that there is a substantial convergence in identifying factors affecting on cost of building projects in Gaza Strip. Therefore, the most influential factors are adopted (skeleton and finishing factors). Table 4.12 shows the most influential factors that were adopted in this study and were used in building the models as input parameters. It contains five skeleton factors and four finishing factors.

Table 4-12: Influential Factors of building project Cost adopted in this research

NO.	Factors	Range
1	Number of floors	Number
2	Type of used foundation	None-Isolated-Strap-Piles-Mat
3	Area of typical floor	Number
4	Type of external finishing	None-Normal plaster- Marmarina- Natural stone
5	Volume of HVAC works & false ceiling	None -Central conditioning-Split units
6	Type & quantity of electrical & mechanical works	(Basic -Luxury)
7	Number of elevators & staircases	Number
8	Type of tile	(Ceramic –Terrazzo -Porcelain)
9	Type of slab	(Solid- Ribbed - Drop beams)

4.10 Real building projects in Gaza Strip (projects case studies)

This section is very important section because the model building and validation needs a real data. The projects data were collected from ministries, consultants, municipalities, NGO's and international organizations. The total number of collected projects were 88 projects. These projects were divided as the first type is residential buildings which classified according to the municipalities classification. The second is institutions buildings which can include public buildings and commercial building as shown in Table 4.13.

Table 4-13: Factors of collected real projects

Cost $	Area m2	Building type	Floors No.	Footing type	Slab type	Elevator No.	External finish	HAVA C	Tilling type	Electric al	Mechanical
20250	65	residenti al	2	Mat	H	0	T.P	no	Ter.	normal	normal
20510	75	residenti al	1	Mat	H	0	T.P	no	Ter.	normal	normal
21300	76	residenti al	1	isolated	H	0	no	no	Ter.	normal	normal

Cost $	Area m2	Building type	Floors No.	Footing type	Slab type	Elevator No.	External finish	HAVAC	Tilling type	Electrical	Mechanical
21520	79	residential	1	Mat	H	0	T.P	no	Ter.	normal	normal
21760	80	residential	1	Mat	H	0	T.P	no	Ter.	normal	normal
22780	80	residential	1	isolated	H	0	no	no	Ter.	normal	normal
22954	82	residential	1	isolated	H	0	T.P	no	Cer.	normal	normal
23200	84	residential	1	isolated	H	0	T.P	no	Cer.	normal	normal
23700	85	residential	1	isolated	H	0	no	no	Ter.	normal	normal
24300	85	residential	1	isolated	H	0	no	no	Ter.	normal	normal
24971	86	residential	1	isolated	H	0	T.P	no	Cer.	normal	normal
25276	87	residential	1	isolated	H	0	T.P	no	Cer.	normal	normal
26740	89	residential	1	isolated	H	0	T.P	no	Cer.	normal	normal
28065	95	residential	2	Piles	S	0	Oi	no	Por.	normal	normal
29499	100	residential	1	isolated	H	0	T.P	no	Cer.	normal	normal
32075	111	residential	1	isolated	H	0	T.P	no	Ter.	normal	normal
33050	117	residential	1	isolated	H	0	T.P	no	Ter.	normal	normal
34710	118	residential	1	isolated	H	0	T.P	no	Ter.	normal	normal
35710	125	residential	1	isolated	H	0	T.P	no	Ter.	normal	normal
56550	130	residential	1	isolated	H	0	T.P	no	Ter.	normal	normal
77700	135	residential	1	isolated	H	0	T.P	no	Ter.	normal	normal
94464	140	residential	1	isolated	H	0	T.P	no	Ter.	normal	normal
111612	150	residential	4	Piles	H	1	N. S	no	Cer.	normal	normal
114980	165	residential	4	Piles	H	1	N. S	no	Cer.	normal	normal
157100	180	residential	4	Piles	H	1	N. S	no	Cer.	normal	normal
178000	195	residential	3	isolated	S	0	T.P	no	Ter.	normal	normal
189150	220	residential	4	isolated	H	0	T.P	no	Cer.	normal	normal
190205	250	residential	5	isolated	H	1	N. S	no	Por.	excellent	normal

Cost $	Area m2	Building type	Floors No.	Footing type	Slab type	Elevator No.	External finish	HAVAC	Tilling type	Electrical	Mechanical
196898	255	residential	4	isolated	H	0	Oi	no	Por.	normal	normal
213750	270	residential	3	isolated	H	0	Oi	no	Cer.	normal	normal
222350	279	residential	4	isolated	H	1	N. S	no	Por.	excellent	normal
223542	280	residential	5	isolated	H	1	N. S	no	Por.	excellent	normal
252000	340	residential	8	isolated	H	0	T.P	no	Cer.	normal	normal
257000	350	residential	8	Mat	H	0	Oi	no	Cer.	normal	normal
273200	360	residential	8	isolated	H	0	Oi	no	Cer.	normal	normal
273241	370	residential	6	Piles	H	0	Oi	no	Cer.	normal	normal
305000	390	residential	8	Piles	H	0	Oi	no	Cer.	normal	normal
320000	410	residential	8	isolated	H	0	Oi	no	Cer.	normal	normal
340000	425	residential	4	isolated	H	0	N. S	no	Por.	normal	normal
433000	465	residential	3	Piles	H	0	T.P	no	Cer.	normal	normal
465900	500	residential	7	isolated	H	0	Oi	no	Cer.	normal	normal
520806.3	580	residential	7	isolated	H	0	Oi	no	Cer.	normal	normal
579630	600	residential	8	isolated	H	0	Oi	no	Cer.	normal	normal
700000	620	residential	8	Mat	H	0	Oi	no	Cer.	normal	normal
813945	670	residential	5	isolated	H	1	N. S	no	Por.	normal	normal
820000	700	residential	4	isolated	H	0	Oi	no	Cer.	normal	normal
1036080	960	residential	2	isolated	S	1	T.P	no	Cer.	excellent	normal
1343000	1070	residential	3	Piles	S	0	Oi	no	Ter.	normal	normal
1578000	1150	residential	4	isolated	S	0	Oi	no	Cer.	normal	normal
1681290	1200	residential	3	Mat	S	1	N. S	no	Por.	normal	normal
2031200	1200	residential	3	Mat	S	1	N. S	no	Por.	normal	normal
29963	105	institution	3	isolated	H	0	T.P	no	Cer.	normal	normal
38350	130	institution	2	isolated	H	0	Oi	no	Ter.	normal	normal

Cost $	Area m2	Building type	Floors No.	Footing type	Slab type	Elevator No.	External finish	HAVA C	Tilling type	Electric al	Mechanical
104608	150	institutio n	3	isolated	H	0	N. S	no	Cer.	normal	normal
155420	175	institutio n	3	isolated	H	0	N. S	no	Cer.	normal	normal
173100	190	institutio n	4	Piles	H	0	Oi	central	3	excelle nt	normal
190000	225	institutio n	3	isolated	H	0	N. S	no	Cer.	normal	normal
211200	269	institutio n	2	no	H	0	Oi	no	Ter.	normal	normal
221756	270	institutio n	2	isolated	H	0	Oi	no	Ter.	normal	normal
224788	295	institutio n	2	isolated	D.B.	0	Oi	no	Por.	normal	normal
228137 .3	320	institutio n	3	isolated	D.B.	0	Oi	no	Por.	normal	normal
267100	360	institutio n	3	isolated	D.B.	0	T.P	no	Cer.	normal	normal
275520	370	institutio n	2	no	H	0	T.P	no	Ter.	normal	normal
279000	370	institutio n	2	isolated	D.B.	0	T.P	no	Cer.	normal	normal
329993 .6	420	institutio n	2	Strap	H	0	Oi	no	Por.	normal	normal
335881	420	institutio n	2	Strap	H	0	Oi	no	Por.	normal	normal
336700	420	institutio n	2	Strap	H	0	Oi	no	Por.	normal	normal
358000	450	institutio n	1	isolated	D.B.	0	Oi	no	Ter.	excelle nt	normal
441600	480	institutio n	2	isolated	H	0	Oi	no	Por.	normal	normal
491250	540	institutio n	3	isolated	D.B.	0	N. S	no	Cer.	normal	excellent
554050	580	institutio n	4	isolated	D.B.	0	N. S	no	Cer.	normal	excellent
565685	590	institutio n	3	isolated	H	0	T.P	no	Ter.	excelle nt	normal
621600	600	institutio n	1	isolated	D.B.	0	T.P	no	Ter.	normal	excellent
644000	600	institutio n	1	Piles	D.B.	0	T.P	no	Ter.	normal	normal
782460	630	institutio n	1	no	D.B.	0	T.P	no	Ter.	normal	normal
785700	630	institutio n	4	isolated	H	0	T.P	no	Por.	normal	normal
802235	670	institutio n	3	isolated	H	0	Oi	no	Cer.	excelle nt	normal
833490	700	institutio n	4	isolated	H	0	Oi	no	Cer.	excelle nt	normal

Cost $	Area m2	Building type	Floors No.	Footing type	Slab type	Elevator No.	External finish	HAVAC	Tilling type	Electrical	Mechanical
835395	710	institution	4	isolated	H	0	Oi	no	Cer.	excellent	normal
997000	870	institution	6	isolated	D.B.	0	Oi	central	Por.	excellent	excellent
1157901	1000	institution	7	Mat	H	0	T.P	no	Ter.	excellent	excellent
1388800	1100	institution	5	Mat	H	0	Oi	isolated	Cer.	excellent	excellent
1610000	1180	institution	3	isolated	D.B.	0	N. S	isolated	Por.	excellent	excellent
2030400	1200	institution	4	Mat	H	0	Oi	isolated	Cer.	excellent	excellent
2305000	1200	institution	4	Mat	H	0	Oi	isolated	Cer.	excellent	excellent

(D.B. = Hollow slab with drop beam; H = Hollow slab; S= Solid slab; N. S = normal stone; T.P= Tryloon plastering; Oi = oixus plastering; Cer. = ceramic tiles; Ter. = terrazzo tiles; Por. = porcelain tiles).

5 CHAPTER 5: MODEL DEVELOPMENT

5.1 Introduction

The case study being dealt with in this search is the developing of a parametric cost estimation system for building projects. A structured methodology for developing the Support Vector Machine model has been used to solve the problem at hand. This methodology incorporates five main phases: 1) Select application 2) Model limitations 3) Model implementation 4) Training and testing 5) Discussion of results.

5.2 Select Application

This stage involves the study of the existing situation with a view to formulating a feasibility assessment for selecting and validating the proposed application. The following heuristic rules are used for selecting successful the applications (Boussabaine, 1996):

- Conventional statistical and mathematical methods are inadequate.
- The problem requires qualitative or complex quantitative reasoning.
- Solutions are derived from highly interdependent parameters that have no precise quantification.
- Data is multivariate and intrinsically noisy or error prone.

In this research, the cost data did not enable fitting a commonly chosen model, or did not allow the analyst to discern the appropriate cost estimating relationships; the problem of model commitment became more complex as the dimensionality of the independent variables set grew. Therefore, lack of a cost estimation model utilizing SVM for early design stage of building projects motivated the author and the following model is developed.

There are several types of SVM software's are used to predict the future values based on the past data like SPSS, MATLAB, NeuroSolution …etc. Many researchers used NeuroSolution application in building the SVM model, as it achieved good performance.

The developed model in this research based on NeuroSolution 5.07 for Excel program. It was selected for its ease of use, speed of training, flexibility of building and executing the SVM model, and it has multiple criteria for training and testing the model.

In NeuroSolutions, Support Vector Machines (SVMs) are implemented using the kernel Adatron algorithm. The kernel Adatron maps inputs to a high-dimensional feature space, and then optimally separates data into their respective classes by isolating those inputs that fall close to the data boundaries. Therefore, the kernel Adatron is especially effective in separating sets of data that share complex boundaries.

5.3 Model Limitations

In spite of great accuracy of using SVM in cost estimation, it has a considerable defect, as it depends mainly on historical data; this dependency has several disadvantages as the following;

- Diversity of variables for effective factors is limited to what available in collected data.
- Data should contain sufficient projects for each variable.
- New variables which was not included in adopted model will not be handled.

Therefore, in this model most of construction variables used in Gaza Strip were included except those that have not enough frequency. After analyzing the collected data, it was found that some limitations on input parameters should be assigned to give the best output.

5.4 Model Implementation

The implementation phase starts with knowledge acquisition and data preparation when there is a clear idea about feasible structures and the information needed to be elicited (Hegazy et al., 1994). The following figure clarifying the of the model implementation as shown in Figure (5.1)

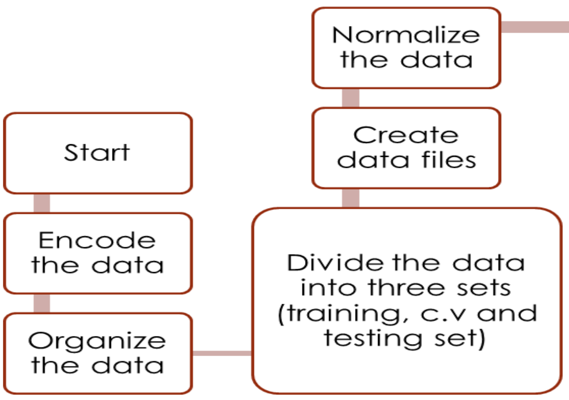

Figure (5.1): Model Flow Chart.

1) Data Encoding

There are many ways to encode the data into a numeric format, and this may be challenging because there are many ways to do it, and unfortunately some are better than others for neural network learning (Principe et al., 2010). Support vector machines as artificial neural network only deal with numeric input data. Therefore, the raw data should be converted from the external environment (Kshirsagar, 2012). Therefore, the data has been re-written according to the encoding described in the following Table 5.2

Table 5-1: Encoding of data

No.	Input Factors	Code
	Floor Area	in m^2
	Number of floors	In numbers
No.	Output Parameter	Code
1	Project budget	in dollar's

2) Data Organization

Initially, the first step in implementing the SVM model in NeuroSolution application is to organize the Neurosolution excel spreadsheet. Then, specifying the input factors that have been already encoded, which consist of 11 factors; Type of project, area of typical floor, number of floors, type of foundation, type of slab, number of elevators, type of external finishing, type of air-conditioning, type of tilling, type of electricity, and type of sanitary. The desired parameter (output) which is (total cost of the project). Figures (5.2) and (5.3) show the procedure of selecting the input and output factors in the application program.

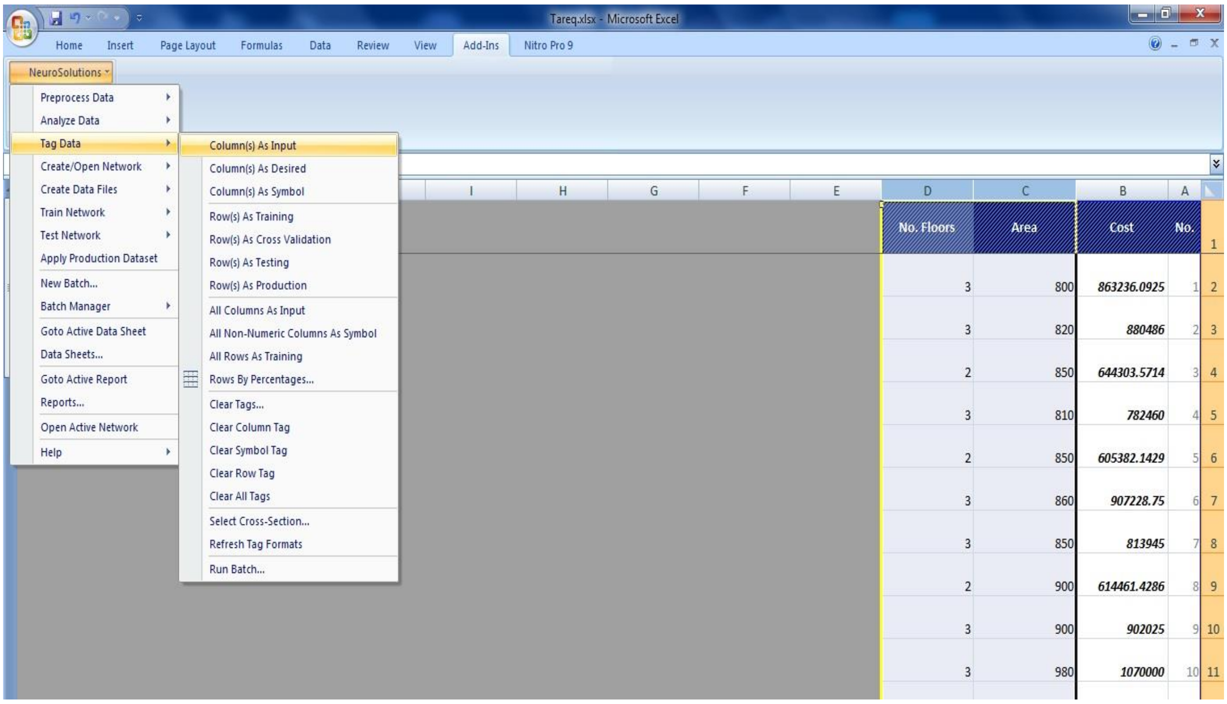

Figure 5-2: Select input data

Similarly, Figure 11.2 shows how the desired column was tagged that was represented by nodes at the output layer.

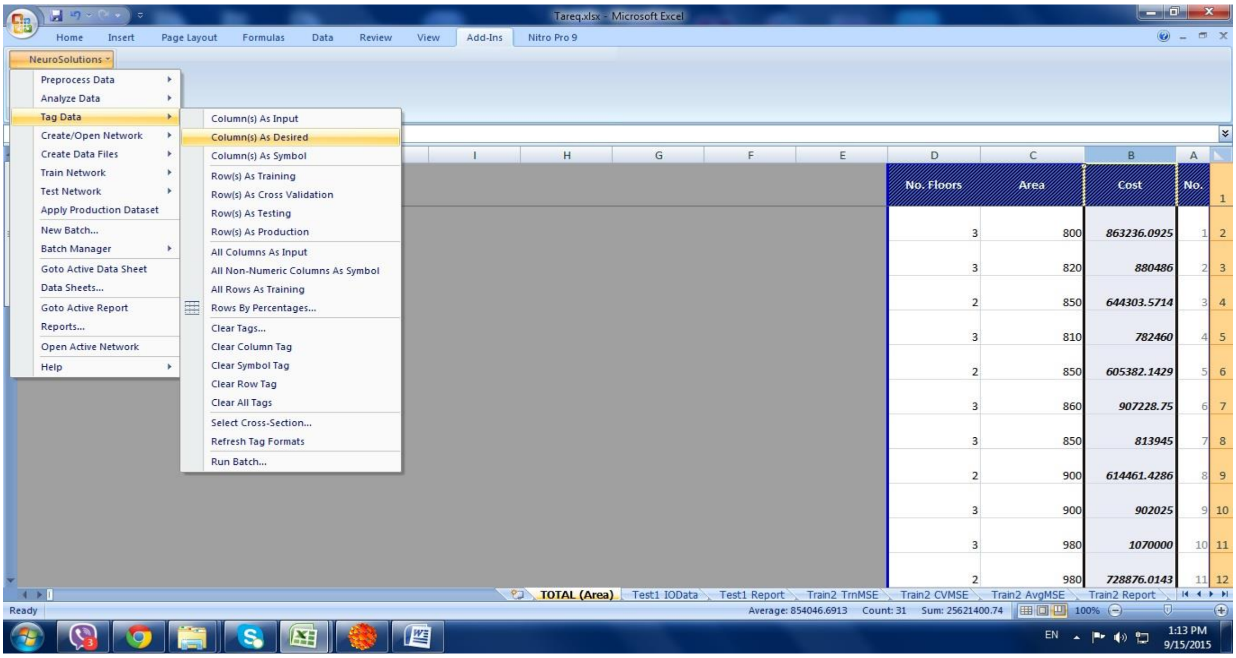

Figure 5-3: Tag column of data as desired parameter

3) Data Set

The available data were divided into three sets namely; training set, cross-validation set and test set. Training and cross validation sets are used in learning the model through utilizing training set. However, the test set does not enter in the training process and it has not any effect on the training process, where it is used for measuring the generalization ability of the network, and evaluated network performance (Arafa & Alqedra, 2011).

In the present study, the total available data is 30 exemplars that were divided logical randomly, according to previous literatures in section (2.9.4), into three sets with the following ratio:

- Training set (includes 18 exemplars ≈ 60%).
- Cross validation set (includes 5 exemplars ≈ 17%).
- Test set (includes 7 exemplars ≈ 23%).

As shown in Figure (5.4), assigning the three sets of model building using tag option in Neurosolution program.

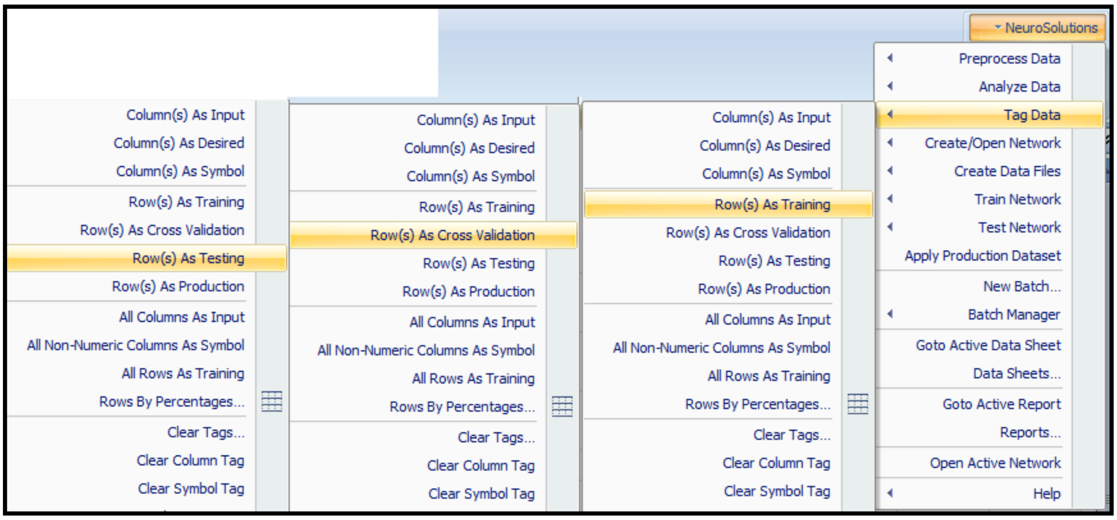

Figure 5-4: Sets of model building

4) Model Building

Once all data were prepared, then the subsequent step is building the SVM. A supervised learning control was checked to specify the maximum number of epochs and the termination limits. Figure (5.5) describes the first place in creating the model from add-ins tool in Excel.

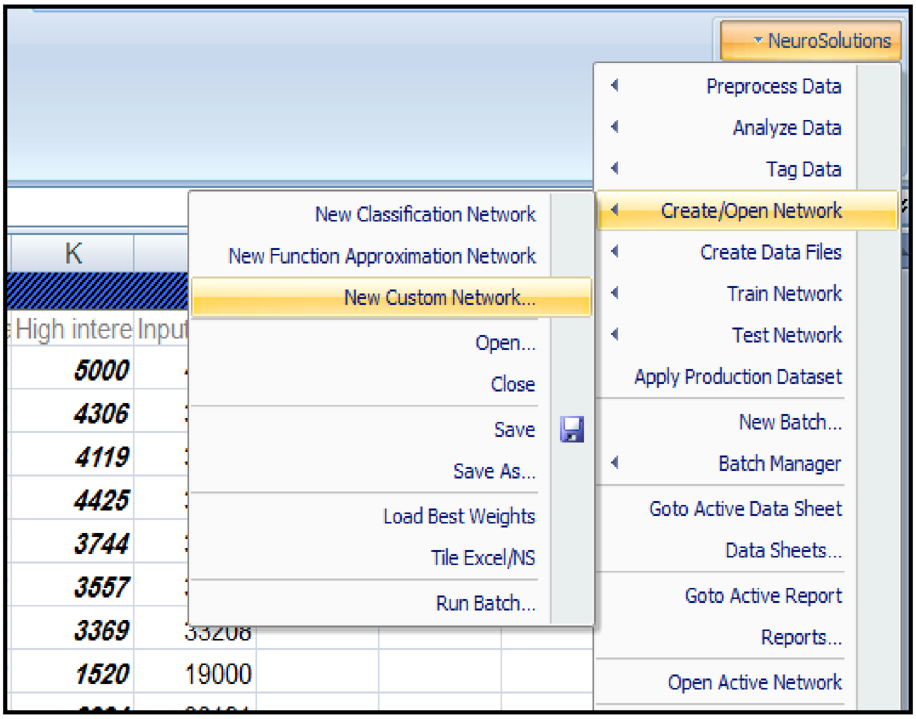

Figure 5-5: Building initial network

The support vector machine was built by selecting the type of network, number of epochs. Figure (5.6) presents the initial network of support vector machine (SVM) network.

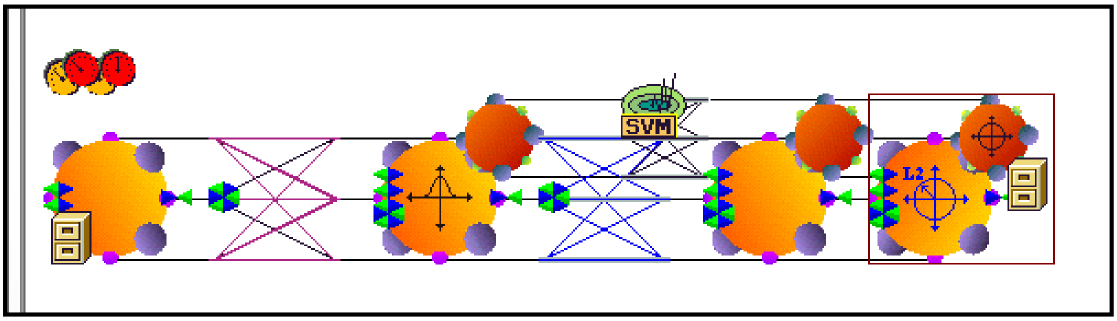

Figure 5-6: Support vector machine (SVM) network

Before starting the training phase, the normalization of training data is recognized to improve the performance of trained networks by Neurosolution program as shown in Figure (5.7) which ranging from (0 to 1).

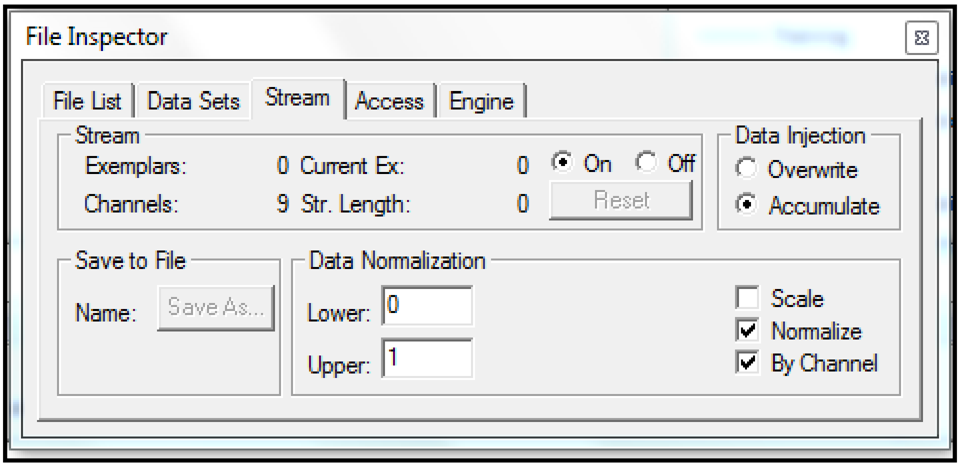

Figure 5-7: Selecting the normalization limits of data

5.5 Training Models and Testing

SVM is able to generalize solutions to problems by learning from pairs of input patterns and their associated output pattern, where the objective of training a SVM is to adjust the weights of the model to bring its output closer to the desired output, where the weights after training contain meaningful information, whereas before training, they are random and have no meaning.

This process of changing or adapting the connection weights in some orderly fashion using a suitable learning method is referred to as the learning rule of the network (Dogan, 2005).

The model training starts with selecting the (SVM) network type also a hundred epochs and several runs were limited, where a run is a complete presentation of 500 epochs, each epoch is a one complete presentation of all of the data (Principe *et al.*, 2010).. Figure (5.8) clarifies training variables for one trial.

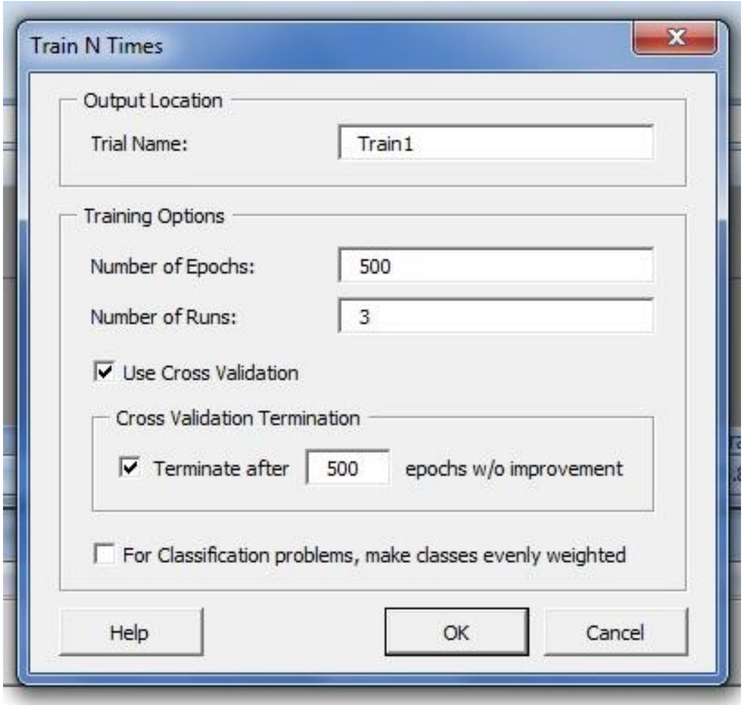

Figure 5-8: Training options in Neurosolution

However, in each run, new weights were applied in the first epoch and then the weights were adjusted to minimize the percentage of error in other epochs.

To avoid overtraining for the network during the training process, an option of using cross-validation was selected, which computes the error in a cross validation set at the same time that the network is being trained with the training set.

5.6 Model cross-validation and testing

The cross-validation data is used during the training but for monitoring not to train the network, instead to check the learning of the network during the training; and the testing data is used to validate the training network after finishing training process (Edara, 2003).

Cross validation uses its own data set to monitor the SVM ability to produce generalized cost estimates; this is done by training many networks on a training set and comparing the errors of the networks on the validation set. The networks that performed best on the validation data set are then selected (Dindar, 2004).

The testing data is totally a different set of data that the network is unaware of; after finishing the training process testing data is used for validation and generalization of the trained network. If the network is able to generalize rather precisely the output for this testing data, then it means that the SVM is able to predict the output correctly for new data and hence the network is validated. Moreover, the amount of data that is to be used for training and testing purposes is depending on the availability of the data, but in general the training data is 2/3rd of the full data and the remaining is used for testing purposes. The cross-validation data can be 1/10th of the training data (Edara, 2003).

5.7 Model Results

As mentioned above, the purpose of testing phase of SVM model is to ensure that the developed model was successfully trained and generalization is adequately achieved. The best model that provided more accurate payment delay risk estimation without being overly complex was structured of (SVM) includes two input factors; floor area and number of floors, and one output (Total cost).

The testing dataset was used for generalization that is to produce better output for unseen examples. Data from seven projects were used for testing purposes.

A Neurosolution test tool was used for testing the adopted model. Table 5. presents the results of these twenty-six projects with comparing the real cost of tested project with estimated cost from neural network model, and an absolute error with both price and percentage are also presented.

Table 5.3 Results of neural network model at testing phase

No.	Actual Cost ($)	Estimated Cost ($)	Absolute Error AE ($)	Absolute Percentage Error (%)
Project 1	834,236	831,920	2,316	0.3%
Project 2	851,395	847,475	3,920	0.5%
Project 3	820,000	814,397	5,603	0.7%
Project 4	919,208	866,959	52,249	6%
Project 5	699,218	674,843	24,374	4%
Project 6	952,194	935,969	16,225	2%
Project 7	907,000	867,855	39,145	4%
		Average	**20,547**	**2.37 %**

Figure (5.9) describes the actual cost comparing with estimated cost for the test set. It is noticed that there is a great convergence between the two lines which means the model had succeeded in estimating the cost of new school buildings with a high accuracy.

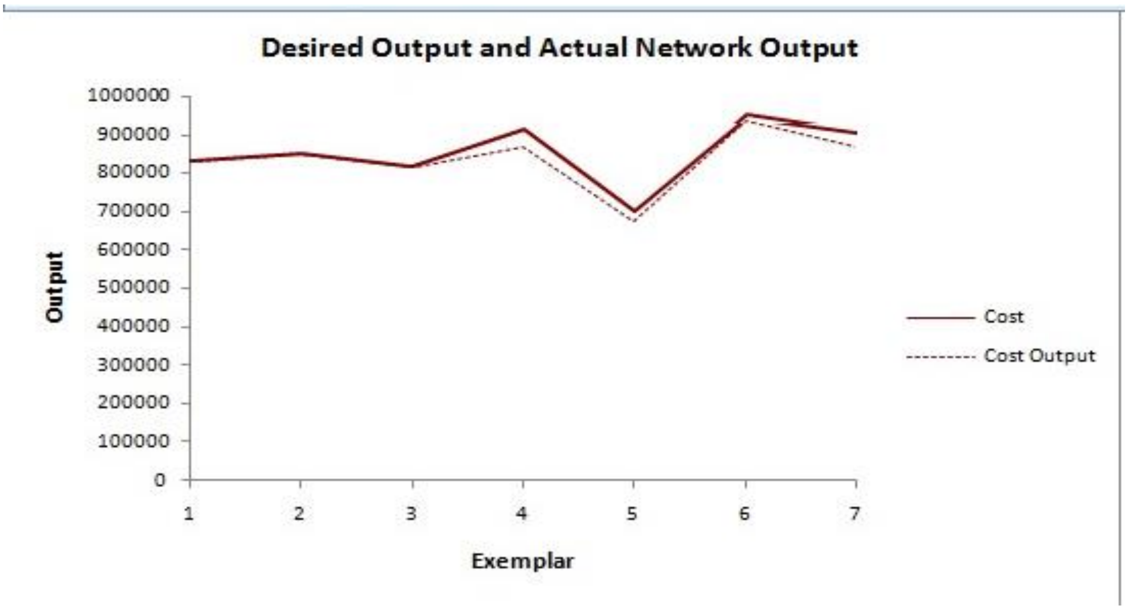

Figure 5-9: Comparison between actual and estimated payment delay risk for test set

➢ **Model evaluation**

The most common evaluation approaches have been utilized to determine the estimation accuracy in testing phase are:

- Mean Absolute Error (MAE).
- Mean Absolute Percentage Error (MAPE).
- Correlation Coefficient (r).

➢ **Mean Absolute Error (MAE)**

It is one of many ways to quantify the difference between an estimated and the actual value of the projects being estimated. According to Willmott and Matsuura (2005) the MAE is relatively simple; It involves summing the magnitudes (absolute values) of the errors to obtain the 'total error' and then dividing the total error by n, it can be defined by the following formula:

$$MAE = \frac{\sum_{j=0}^{P}\sum_{i=0}^{N}|dy_{ij}-dd_{ij}|}{N\,P} \qquad \text{Eq. (5.1)}$$

Where: P= number of output PEs.

N= number of exemplars in the data set.

dy_{ij}= denormalized network output for exemplar i at PE j.

dd_{ij}= denormalized desired output for exemplar i at PE j.

According to (Eq. 5.1), the mean absolute error (MAE) equals (US$ 20,547$), it is acceptable for projects worth just million dollars. However, it is not a significant indicator for the model performance because it proceeds in one direction for the hypothetical case study that supposed for this model, where the mentioned error may be small if the total cost of the project is over one million.

- **Mean Absolute Percentage Error**

The mean absolute Percentage error is a quantity used to measure how close forecasts or predictions are to the eventual outcomes, according to Principe *et al*., (2010) The MAPE is defined by the following formula:

$$\mathbf{MAPE} = \frac{100}{N\,P}\sum_{j=0}^{P}\sum_{i=0}^{N}\frac{|dy_{ij}-dd_{ij}|}{dd_{ij}} \qquad \text{Eq. (5.2)}$$

Where:

P= number of output PEs.

N= number of exemplars in the data set.

dy_{ij}= denormalized network output for exemplar i at PE j.

dd_{ij}= denormalized desired output for exemplar i at PE j.

Note that this value can easily be misleading. For example, say that your output data is in the range of 0 to 100. For one exemplar your desired output is 0.1 and your actual output is 0.2. Even though the two values are quite close, the percent error for this exemplar is 100 (Principe *et al*., 2010).

Referring to the (Eq.5.2), The mean absolute Percentage error (MAPE) for the test results equals (2.37%), this result can be expressed in another way by accuracy performance (AP) according to Wilmot and Mei (2005) which is defined as (100−MAPE) %.

AP= 100% - 2.3% = 97.7%

That means the accuracy of adopted model for payment delay risk in building projects is (97.7%). The result is acceptable for projects worth one million dollars.

➢ **Correlation Coefficient (R)**

Regression analysis was used to ascertain the relationship between the estimated cost and the actual cost.. The correlation coefficient (R) is 0.973, indicating that; there is a good linear correlation between the actual value and the estimated neural network cost at tested phase.

The results of performance measures according to the Neurosolution program are presented in Figure 5-10: where the correlation coefficient (R) = 0.973 and MAE = 20, 547 $ as calculated previously.

Performance	*Cost*
MSE	738826661.8
NMSE	0.122524554
MAE	20547.50633
Min Abs Error	2316.335411
Max Abs Error	52249.33584
r	0.973560813

Figure 5-10: Results of performance measurements according to the Neurosolution app

6 CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

Cost estimation done during the conceptual phase of the project cycle is usually calculated approximately, which leads to great inaccuracy (±20 % range). The reasons for that are due to the project details are not fixed as well as the lack of information. In such case, SVM could be a suitable tool for estimating project cost. Project managers in Gaza Strip, often need to estimate the cost of construction projects at early stage quickly and approximately to provide funding or to obtain the adoption of the budget from decision-makers. Therefore, it is important to find a way to know the cost of the construction projects in a short time with acceptable accuracy.

The main objective of this research is to develop SVM model to estimate the cost at early stage of construction projects in Gaza strip. To achieve this there is a need for identifying the factors that affect the cost of construction projects including subjective and risk-related factors that can be available at early stage.

Parametric cost estimating technique lead this research to study a lot of previous research and recognize the influential parameters in construction cost at early stage. Delphi technique was used to identify nine factors that affect cost of construction projects.

Many projects were collected from the Ministry of Public Works and Housing, contractors and consultants. Data collected were analyzed and the research problem identified

6.2 Conclusion

This study aimed at developing a new technique for early cost estimate of building projects in Gaza Strip, through developing a model that is able to help parties involved in construction projects (owner, contractors, and others) in obtaining the total cost information at the early stages of project with limited available information.

Several steps and procedures were conducted in order to achieve this aim as following:

1) A questionnaire survey, expert interviews and exploratory search of previous studies were used to identify the cost effective factors on building projects. nine key parameters were adopted as most influential factors on building costs which are use of building, area of typical floor, number of stories, type of the foundation, slab type, type of tilling, type of external finishing, number of elevators, Mechanical, Electrical.

2) Historical data of building projects were collected. The projects were executed between 2010 and 2014 in Gaza Strip, from government ministries, UNRWA, engineering institutions, contractors and consultants. The data was analyzed and some of data were excluded due to some basic conditions.

3) Developing SVM model passed through several steps started with selecting the application to be used in building the model. The SPSS and EXCEL program was selected for its efficiency in several previous researches in addition to its ease of use and extract results.

4) The accuracy performance of the adopted model recorded 97% where the model performed well and no significant difference was discerned between the estimated output and the actual budget value. The acceptable error rate in early stage of building projects as mentioned in researches and studies is ranging between (0.2-0.5%) while the average percentage error of this model is 2.37%.

5) In order to ensure the validity of the model in estimating the cost of new projects, many statistical performance measures were conducted i.e; Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Total Mean Absolute Percentage Error (Total MAPE), and Correlation Coefficient (r). The results of these performance measures were acceptable and reliable, where the mean percentage error of the model was 2.37%, and the total mean absolute percentage error was 0.973

6) The approach as presented is capable of providing accurate estimates of project cost by using nine parameters at the early design phase

7) Some assumption and limitation were assumed in the study according to available collected data. These limitations include the available choices of each factor as Area of typical floors for example, has limited area between 60 m2 to 1000 m2, as well as the other input factors.

6.3 Recommendations

The following recommendations are the most important ones that can be deduced by this research:

6.3.1 Recommendations to Owners & Consultants

1) As this study revealed that the vast majority of construction cost exceed the estimation cost, clients and consultant are advised to ensure that the pricing team is fully supported with the necessary tools and techniques to deal with this matter.
2) Clients and consultants should give more attention to cost estimating process in order to enhance productivity and accuracy. They should monitor the performance of their estimates in terms of accuracy and hire a qualified technical staff in order to obtain the accurate estimate.
3) A clear identification of the construction project requirements is essential before the start of the estimate. Care by clients should be taken to keep changes in the scope of work as minimum as possible.
4) Estimates based on updated price information should be considered in order to come up with accurate estimate and avoid any wrong estimation.
5) After the completion of each project, clients and consultants have to compare actual costs with projected costs to evaluate their cost estimating proficiency and improve their skill.
6) Clients and consultants are recommended to keep continuously records for all cost related data and built a historical database of finished project. This unique database should be the main source of information that will be used in estimating future projects.

6.3.2 Recommendations to Contractors

1) It is recommended that each contracting company continuously keeps records for all cost related data and built a historical database for the company. This unique database should be the main source of information that will be used in estimating future projects.
2) It is recommended that the estimators in contracting companies attend courses in using estimating software to improve their capabilities in this field.
3) The local contracting companies are invited to have an estimating software package and use it in estimating the works in order to get more accurate estimate, save time, minimize error, and hopefully to have better chance to win bids.

6.3.3 Recommendations to Government, Contractors' Union and Association of Engineers

1) It is recommended to conduct training courses in computer applications in estimating. This training and seminars aim to improve the local practice in cost estimating and increases the capabilities of estimators in using estimating software packages.
2) The construction projects information should be organized in a computerized system to improve the accuracy of cost estimation practice in Gaza Strip. It is recommended if there is center for construction data.

6.3.4 Recommendations for Further Studies

1) The survey was conducted in Gaza Strip in a period where the construction business was deteriorated or even paralyzed, which in turn was reflected on the results of the research. It is recommended to conduct another survey when the construction industry recovers and make a comparative analysis to the results.
2) It's recommended to make models for every type of building alone, to enable the researcher to write all rules to get general results that can be generalize to all projects.
3) The results are encouraging for further research of expanded data sets and give estimate for several outputs such as the networks costs, the project duration and others.

7 REFERENCES

Abdal-Hadi, M. (2010) *Factors Affecting Accuracy of Pre-tender Cost Estimate in Gaza Strip.* Unpublished M. Sc. thesis, Islamic University, Gaza, Palestine.

Abu Jamous, H. (2013) *Parametric Cost Estimation of Road Projects Using Artificial Neural Networks* Unpublished M. Sc. thesis, Islamic University, Gaza, Palestine.

Adeli, H. and Jiang, X. (2003) Neuro-Fuzzy Logic Model for Freeway Work Zone Capacity Estimation. *Journal of Transportation Engineering*, Vol. 129, No. 5, pp 484–493.

Ahuja, H., Dozzi, S. and Abou Rizk, S. (1994) *Project management techniques in planning and controlling construction projects*, 2nd ed., John Wiley and Sons Inc., New York.

Akintoye, A. (2000) Analysis of factors influencing project cost estimating practice. *Construction Management and Economics*, Vol.18, No. 1, pp. 77-89.

Al.Hamidi, I. and Mohammed, M. (2009) Quality Control of Cost Estimation Process in Construction Organizations. *Eng.& Tech. Journal*, Vol.27, No.4.

Aljarosha, Z. (2008) *Impact of conditions of contract for construction (FIDIC 99).* Unpublished M. Sc. thesis, Islamic University, Gaza, Palestine.

Al-Najjar, J. (2008) *Factors influencing time and cost overruns on construction projects in the Gaza Strip.* Unpublished M. Sc. thesis, Islamic University, Gaza, Palestine.

Al-Shanti, Y. (2003) *A Cost Estimate System for Gaza Strip Construction Contractors.* Unpublished M. Sc. thesis, Islamic University, Gaza, Palestine.

Arafa, M. and Alqedra, M. (2011) Early stage cost estimation of building construction projects using artificial neural networks. *Journal Of Artifical Intelligence*, Vol. 4, No.1, pp. 63-75.

Barrie, D. and Paulson, B. (1993) *Professional construction management*. 3rd edition. UK :Mc Grow-Hill.

Beheshti, M. and Lollar, J. (2008) Fuzzy logic and performance evaluation: discussion and application, *International Journal of Productivity and Performance Management,* Vol. 57 Iss: 3 pp. 237 – 246.

Bell, J. (2005) *Doing your Research Project*. 4th Edition, McGraw-Hill Education, Maidenhead, England.

Bhatnagar, R. and Ghose, M. (2012) Comparing Soft Computing Techniques For Early Stage Software Development Effort Estimations. *International Journal of Software Engineering & Applications (IJSEA)*, Vol.3, No.2.

Bo, X. and Albert, C. (2011) Measuring complexity for building projects : a Delphi study. *Engineering, Construction and Architectural Management*, Queensland University of Technology(QUT), Australia. Vol. 19 No.1, pp. 7-24.

Cavalieri, S., Maccarrone, P., Pinto, R., (2004). Parametric vs. neural networkmodels for the estimation of production costs: A case study in the automotive industry. *Int. J. Production Economics VOL. 91, PP.165–177.*

Cheng M., Tsai H., Sudjono E., (2010). Conceptual cost estimates using evolutionary fuzzy hybrid neural network for projects in construction industry. *Expert Systems with Applications VOL. 37 , PP. 4224–4231.*

Cheng, M., Tsai H., and Sudjono, E. (2010) Conceptual cost estimates using evolutionary fuzzy hybrid neural network for projects in construction industry. *Expert Systems with Applications Journal,* Vol. 37, pp. 4224-4231.

Construction Projects Using Evolutionary Fuzzy Neural Inference Model. Automation in Construction Journal, Vol.18, No.2, pp. 164–172

Dysert, L. R. (2005) So you think you're an estimator?. *AACE International Transactions,* EST.01. West Virginia.

Dysert, L. R. (2006) Is "estimate accuracy" an oxymoron?. *AACE International Transactions* EST.01: EST01.1 - 01.5.

ElSawy, I., Hosny, H., and Abdel Razek, M. (2011) A Neural Network Model for Construction Projects Site Overhead Cost Estimating in Egypt. *IJCSI International Journal of Computer Science Issues*, Vol. 8, Issue 3, No. 1.

Enshassi, A. Mohamed, S. and Madi. I. (2007) Contractors' Perspectives towards Factors Affecting Cost Estimation in Palestine. *Jordan Journal of Civil Engineering*, Volume 1, No. 2.

Enshassi, A., Mohamed, S. and Madi, I. (2005) Factors affecting accuracy of cost estimation of building contracts in the Gaza Strip, *Journal of Financial Management of Property and Construction*, Vol. 10 Iss: 2 pp. 115 – 125.

Eriksson, P. (2003) *Long-term relationships between parties in construction projects - Away to increase competitive advantage*. 17th Nordic Conference on Business Studies, Reykjavik, Iceland, 2003.

Fellows, R. and Liu, A. (2008) *Research methods for construction. 3rd* edition. United Kingdom, Blackwell Publishing Ltd.

Feng, W., Zhu, W. and Zhou, Y. (2010) The Application of Genetic Algorithm and Neural Network in Construction Cost Estimate. *The Third International Symposium on*

Electronic Commerce and Security Workshops(ISECS '10) Guangzhou, P. R. China, pp. 151-155.

Gandhinathan, R., Raviswaran, N. and Suthakar, M. (2004) QFD- and VE-enabled target costing: a fuzzy approach. *International Journal of Quality & Reliability Management,* Vol. 21 Iss: 9 pp. 1003 – 1011.

Ganiyu, B. and Zubairu, I. (2010) Project Cost Prediction Model Using Principle Component Regression For Public Building Projects In Nigeria. *Journal of Building Performance,* Volume 1, Issue 1.

GAO. (2009) "*Cost estimating and assessment guide*". United States Government Accountability Office , GAO-09-3SP .Washington.

Gunaydın M., Dogan Z., (2004). A neural network approach for early cost estimation of structural systems of buildings, *International Journal of Project Management VOL. 22 PP. 595–602.*

Hajek, P. (1998) Metamathematics of Fuzzy Logic. *Kluwer Academic Publishers, Dordrecht.*

Han, K. J., Lee, H. S., Park, M. and Ji, H.S. (2008) Cost Estimating Methodology Using Database Layer In Construction Projects. *The 25th International Symposium on Automation and Robotics in Construction*, pp 470-475,Vilnius, Lithuania.

Hendrickson, C. (2000) *Project management for construction*. 2nd edition. Pittsburgh.

Henry, R., McCray, G., Purvis ,R. and Roberts, T. (2002) Exploiting organizational knowledge in developing IS project cost and schedule estimates: An empirical study. *Information & Management*. Vol. 44, pp 598–612.

Holm L., Schaufelberger J. E., Griffin D. and Cole T. (2005) Construction Cost Estimating: Process and Practices. Upper Saddle River, N. J.: Prentice Hall.

Idri, A. , Abran, A. and Khoshgoftaar, k. (2001) Fuzzy Case-Based Reasoning Models for Software Cost Estimation. *In Proceedings of the 11th International*

Idri, A. and Abran, A. (2001) Towards a fuzzy logic based measures for software projects similarlity. *7th International Symposium on Software Metrics*, pp. 85-96, England, UK.

Jamkhaneh, E. and Gildeh, B. (2011) Chain Sampling Using Fuzzy Probability Theory. *Journal of Applied Sciences*. Vol. 11 Iss: 24, pp. 3830 – 3838.

Jantzen, J. (1998) *Tutorial On Fuzzy Logic*. Tech. report no 98-E 868. Technical University of Denmark, Department of Automation, Denmark.

Jantzen, J. (2007) *Foundations of Fuzzy Control*. Chichester, England. John Wiley & Sons Ltd. *Journal*, Vol. 115, No. 4.

Jrade, A. and Alkass, S. (2007) Computer-Integrated System for Estimating the Costs of Building Projects. *Journal of Architectural Engineering*. Vol. 13, No.4.

Kern, A. and Formoso, C. (2006) A model for integrating cost management and production planning and control in construction. *Journal of Financial Management of Property and Construction*, Vol. 11 Iss: 2, pp. 75 – 90.

Kumar, S., Mandala, A., Chaitanya, V. and Prasad, V. (2011) Fuzzy logic for Software Effort Estimation Using Polynomial Regression as Firing Interval. *International Journal of Computer Technology and Applications(IJCTA)*, Vol. 2, No.6, pp1843-1847.

Langford, D., Hancock, M., Fellows, R. and Gale, W. (2000) "*Human resources management in construction*".4th edition. Edinburg Gate England: Person Education Limited.

Madi, I. (2003) *Essential factors affecting accuracy of cost estimation of building contractors.* Unpublished M. Sc. thesis, Islamic University, Gaza, Palestine.

Math works, (2010) Fuzzy Logic Toolbox User's Guide. MATLAB 6.0, Math works, Inc.,2010.

Memon, A., Abdul Rahman, I., Abdullah, M. and Abdu Azis, A. (2010) Factors Affecting Construction Cost in Mara Large Construction Project: Perspective of Project Management Consultant. *International Journal of Sustainable Construction Engineering & Technology*. Vol. 1, No 2.

Metaxiotis, K., Psarras, J. and Samouilidis, E., (2003) Integrating fuzzy logic into decision support systems: current research and future prospects. *Information Management & Computer Security*, Vol. 11 Iss: 2 pp. 53 – 59.

Mittal, H. and Bhatia, P. (2007) Optimization Criteria for Effort Estimation using Fuzzy Technique. *Clei Electronic Journal*, Volume 10, No1, p 2.

Multiple Regression Techniques, *Journal of Construction Engineering and Management, 132-7, p.750-758.*

Naoum, S. (2007) *Dissertation Research and Writing for Construction Students*. 2nd Edition ed. London: Elsevier Ltd.

Nguyen, H., Prasad, N., Walker, c. and Walker, A., (2003) *A first course in fuzzy and neural control.* Chapman & Hall/CRC, A CRC Press Company Boca Raton London, New York, Washington, D.C.

Odeyinka, H. and Lowe, J., (2002) Factor Approach To The Analysis Of Risks Influencing Construction Cost Flow Forecast. *RICS Construction and Building Research (COBRA) Conference*. Nottingham, UK. pp 120 -131.

on the Gaza Strip contractor's cost estimation. Unpublished M. Sc. thesis, Islamic University, Gaza, Palestine.

Ordoobadi, S. (2008) Fuzzy logic and evaluation of advanced technologies. *Industrial Management & Data Systems,* Vol. 108 Iss: 7 pp. 928 – 946.

Ordoobadi, S. (2009) Development of a supplier selection model using fuzzy logic. *Supply Chain Management: An International Journal,* Vol. 14 Iss: 4 pp. 314 – 327.

Popescu, C., Phaobunjong, K. and Ovararin, N. (2003) Esti*mating Building Costs*.1st edition. Marcel Dekker, Inc. New York, USA.

Ray, A., Sarkar, B. and Sanyal, S. (2010) Process cost prediction: a soft computing approach. *International Journal of Intelligent Computing and Cybernetics,* Vol. 3 Iss: 3 pp. 431 – 448.

Reddy, P., Sudha, R. and Sree, R. (2011) Application of Fuzzy Logic Approach to Software Effort Estimation. *International Journal of Advanced Computer Science and Applications,* Vol. 2, No. 5.

Sachdeva, K., Hanmandlu, M. and Kumar, A. (2012) Real Life Applications of Fuzzy Decision Tree. *International Journal of Computer Applications*. Volume 42– No.10, pp24-28.

Shehatto, O. (2013) F*actors Cost estimation for building construction projects in Gaza Strip using Artificial Neural Network (ANN)*.Unpublished M. Sc. thesis, Islamic University, Gaza, Palestine.

Sheikh, N. (2013) *COST ESTIMATION OF CONSTRUCTION PROJECTS AT GAZA STRIP* USING FUZZY LOGIC Unpublished M. Sc. thesis, Islamic University, Gaza, Palestine.

Simon, D. (2003) *Introduction to fuzzy control*. Courtesy of Embedded Systems Programming. http://www.embedded.com/showArticle.jhtml?articleID=10700619.

Sivanandam, S., Sumathi, S. and Deepa, S. (2007) Introduction to Fuzzy Logic using MATLAB. Springer-Verlag Berlin Heidelberg.

Smith A.E., Mason A.K. (1997), Cost estimation predictive modeling: Regression versus neural network; *The Engineering Economist 42(2); 137–161.*

Sonmez, R. (2004). Conceptual cost estimation of building projects with regression analysis and neural networks. *Canadian Journal of Civil Engineering, 31(4), 677 – 683.*

Steward, Rodney D. (1991) Cost Estimating, 2nd ed., John Wiley & Sons, Inc., New York.

Surmann, H. and Selenschtschikow, A. (2002) Automatic generation of fuzzy logic rule bases: Examples I. *First International ICSC Conference On Neuro-Fuzzy Technologies*, PP 75-81, Cuba.

Tan, Y. and Shen, L. (2010) A fuzzy competence requirement (FCR) model for competitive bidding strategy. *Construction Innovation: Information, Process, Management*, Vol. 10 Iss: 1, pp. 75 – 88.

Teodorovic, D. (1999) Fuzzy Logic Systems For Transportation Engineering: The State Of The Art. *Elsevier Science*, Transportation Research Part A 33, pp337-364.

Trost, S. M., and Oberlender, G. D. (2003). Predicting Accuracy of Early Cost Estimates Using Factor Analysis and Multivariate Regression, *Journal of Construction Engineering and Management, Vol. 129, No. 2, pp. 198–204.*

Turochy, R. Hoel, L. and Doty, R. (2001) *Highway Project Cost Estimating Methods Used In The Planning Of Project Development.* Technical Assistance Report, Virginia Transportation Research Council, VTRC 02-TAR3.

Uppal, K.B. (1997) *Estimating? Past, Present and 21st Century.* Transaction of the AACE 41st Annual Meeting, July 1997, pp.Est.01.1-EST 01.4.

Verma, A. (1997) Construction of offender profiles using fuzzy logic. *Policing: An International Journal of Police Strategies & Management*, Vol. 20 Iss: 2, pp. 408 – 418.

Willmott, C. & Matsuura, K. (2005) Advantages of the mean absolute error (MAE) over the root mean square error (RMSE) in assessing average model performance. *Climate Research*, Volume 30, p. 79–82.

Zadeh, L.A. (1965) Fuzzy Set. Information and Control, vol. 8, pp. 338-353.

Zheng, X. and Guang, M. (2012) On the Estimate Method of Construction Engineering Cost Based on the RS-GA-NNA Model". Research Journal of Applied Sciences, Engineering and Technology. Vol.4.No13, pp2003-2008.

بسم الله الرحمن الرحيم

الجامعة الإسلامية

عمادة الدراسات العليا

كلية الهندسة ـ قسم الهندسة المدنية

اسـتـبــانة

Influential factors on prices of building projects in Gaza Strip

العوامل المؤثرة علي عملية التسعير في المشاريع الإنشائية في قطاع غزة

وذلك كجزء من البحث التكميلي لنيل درجة الماجستير في إدارة التشييد

الباحث

م.طارق ريان

إشراف

الدكتور/ نبيل الصوالحي

غزة ـ فلسطين

2015

استبانة تهدف إلي دراسة العوامل المؤثرة علي عملية التسعير في المشاريع الإنشائية للمباني

في قطاع غزة من وجهة نظر المقاولين

السيد المقاول/المهندس: السلام عليكم ورحمة الله وبركاته

بداية أتقدم لكم بجزيل الشكر والتقدير لمساهمتكم بجزء من وقتكم وجهدكم في تعبئة هذه الاستبانة.
تعتبر عملية التسعير من الأنشطة الأساسية والمهمة في المشاريع الإنشائية وقطاع التشييد والبناء لذلك فان هذه الاستبانة تهدف إلي دراسة العوامل المؤثرة علي عملية التسعير في المشاريع الإنشائية للمباني في قطاع غزة, وهي جزء من البحث التكميلي لنيل درجة الماجستير في إدارة التشييد في الجامعة الإسلامية بغزة.

مكونات الاستبانة:

الجزء الأول: التعريف بالجهة المعنية
الجزء الثاني: العوامل التي تؤثر علي عملية التسعير في مشاريع إنشاء المباني في قطاع غزة ويتكون من قسمين:

- **العوامل المتعلقة بعملية الإنشاء الأساسية للمباني (البناء الهيكلي)**
- **العوامل المتعلقة بعملية تشطيب المبني.**

المعلومات الواردة في الاستبانة:-

إن كافة المعلومات الواردة في هذا الاستبيان سوف يتم استخدامها لأغراض البحث العلمي مع الالتزام التام بالمحافظة علي سرية المعلومات الخاصة بكم.

أرجو أن تكون طريقة الإجابة على الاستبانة كالأتي:

أ- تقييم العوامل الكيفية و ذلك بإعطاء كل عامل الدرجة المناسبة (1 – 5).
1- يؤثر بدرجة قليلة 2 - يؤثر بعض الشيء 3 - يؤثر بدرجة متوسطة
4- يؤثر بدرجة كبيرة 5- يؤثر بدرجة كبيرة جدا

ب - وضع العلامة (X) لبعض العوامل الأخرى.

الجزء الأول:

1-تصنيف الشركة حسب تصنيف اتحاد المقاولين:

درجة أولى ☐ درجة ثانية ☐ درجة ثالثة ☐

2-الوظيفة الإدارية لمن يقوم بتعبئة الاستبانة:

☐ صاحب / مدير الشركة ☐ مدير المشاريع ☐ مهندس الموقع ☐ غير ذلك

3- عدد الموظفين الإداريين والفنيين في الشركة:

☐ اقل من 10 ☐ 30-10 ☐ 50-31 ☐ أكثر من 50

4-عدد المشاريع المنفذة خلال السنوات الخمس الماضية في مجال المباني:

☐ اقل من 10 ☐ 20-10 ☐ 30-21 ☐ أكثر من 30

5-متوسط حجم أعمال الشركة خلال السنوات الخمس الماضية في مجال المباني (مليون دولار).

☐ اقل من 0.5 ☐ 1-0.51 ☐ 2-1.1 ☐ أكثر من 2

6-نوع المشاريع المنفذة:

☐ سكني ☐ تجاري ☐ سكني تجاري ☐ مؤسسي

الجزء الثاني:

العوامل المؤثرة علي التسعير:

في الجدول التالي عدد من العوامل التي تؤثر علي عملية التسعير في صناعة التشييد في مشاريع البناء يرجي تحديد درجة تأثير هذه العوامل علي التسعير مع الأخذ بعين الاعتبار الرموز التالية

الرمز	درجة التأثير
1	يؤثر بدرجة قليلة
2	يؤثر بعض الشيء
3	يؤثر بدرجة متوسطة
4	يؤثر بدرجة كبيرة
5	يؤثر بدرجة كبيرة جدا

first part:

1. Classification of the company / according to Contractors Union:

☐ First Class ☐ Second Class ☐ Third Class

2. The position of officer who fills the questionnaire:

☐ Company Manger ☐ Projects Manger ☐ Site Engineer ☐ Other

3. Number of company's employees:

☐ ☐ ☐ ☐

Less than 10 10– 30 31 – 50 More than 50

4. Number of executed projects during the last five years:

☐ Less than 10 ☐ 10 – 20 ☐ 21 – 30 ☐ More than 30

5. Average value per year of executed projects during the last five years (in million dollars):

☐ Less than 0.5 ☐ 0.51 - 1 ☐ 1.1 – 2 ☐ More than 2

6. Type of implemented projects:

☐ Residential ☐ commercial ☐ Residential & commercial ☐ institutional

Second Part:

Factors affecting the pricing process in the construction of buildings

In the table below there are numbers of factors affecting in building projects cost. Please define the degree of importance of these factors in pricing process in the construction of buildings.

Numbers between (1-5) determine the weight of parameter on the total cost of building cost. Where:

1: Very Low **2: Low** **3: Medium** **4: High** **5: Very High**

أولا : العوامل المتعلقة بعملية الإنشاء الأساسية للمبني (البناء الهيكلي)

1. يؤثر بدرجة قليلة **2. يؤثر بعض الشيء** **3. يؤثر بدرجة متوسطة** **4. يؤثر بدرجة كبيرة** **5. يؤثر بدرجة كبيرة جدا**

درجة التأثير					العوامل المؤثرة(Factors)	الرقم
5	4	3	2	1	نوع القواعد المستخدمة في المبني Type of used foundation in the building	1.
5	4	3	2	1	مساحة الطابق المتكرر للمبني Area of typical floor	2.
5	4	3	2	1	عدد الطوابق في المبني Number of floors in the building	3.
5	4	3	2	1	عدد الأعمدة في المبني Number of columns	4.

5	4	3	2	1	عدد الغرف في المبنى Number of rooms	.5
5	4	3	2	1	عدد المصاعد في المبنى Number of elevators in the building	.6
5	4	3	2	1	نوع السقف للمبنى (مصمت , مفرغ, ...) Type of slab (Solid, Ribbed …)	.7
5	4	3	2	1	عدد الأدراج في المبنى Number of staircases in the building	.8
5	4	3	2	1	المسافات بين الأعمدة Length of spans between columns	.9
5	4	3	2	1	مساحة الجدران الاستناديه لتنفيذ المبنى Area of retaining walls in project	.10

ثانيا : العوامل الخارجية

درجة التأثير					العوامل المؤثرة	الرقم
5	4	3	2	1	نوع العقد Type of contract (Ls, unit)	.1
5	4	3	2	1	موقع إنشاء المبنى Location of project	.2
5	4	3	2	1	طبيعة الجهة المشرفة (محلية أو دولية) Staff of supervision (local or international)	.3
5	4	3	2	1	حجم المشروع Size of the project	.4
5	4	3	2	1	وضوح جدول الكميات والمخططات Clarity of quantities and drawings schedule	.5

ثالثا:العوامل المتعلقة بعملية تشطيب المبنى

درجة التأثير					العوامل المؤثرة	الرقم
5	4	3	2	1	نوع الكسوة الخارجية Type of external plastering	.1
5	4	3	2	1	نوع الدهان Type of painting	.2
5	4	3	2	1	نوع البلاط Type of tiling	.3
5	4	3	2	1	كمية أعمال الرخام Area of marble works	.4
5	4	3	2	1	مساحة الواجهات الزجاجية Area of curtain walls	.5

5	4	3	2	1	عدد الأبواب الداخلية Number of internal doors	.6
5	4	3	2	1	كمية الحديد المستخدم للحماية والديكور Quantity of metal works for protection and decoration	.7
5	4	3	2	1	نوع الأعمال الصحية المستخدمة Type of water and sanitary works	.8
5	4	3	2	1	كمية الأعمال الصحية المستخدمة Quantity of water and sanitary works	.9
5	4	3	2	1	وجود أعمال إنذار وإطفاء حريق Firefighting and alarm works.	.10
5	4	3	2	1	حجم أعمال التكييف Volume of HVAC works.	.11
5	4	3	2	1	كمية الأعمال الكهربائية Quantity of electrical works	.12
5	4	3	2	1	نوع الأعمال الكهربائية Type of electrical works	.13
5	4	3	2	1	مساحة أعمال الجبس والأسقف المستعارة Area of gypsum board and false ceiling	.14
5	4	3	2	1	نوع أعمال النجارة Type of carpentry works	.15
5	4	3	2	1	كمية أعمال النجارة Quantity of carpentry works	.16
5	4	3	2	1	عدد الشبابيك Number of windows	.17
5	4	3	2	1	نوع الألمنيوم المستخدم Type of Aluminum works	.18

يرجي كتابة أي عوامل مؤثرة لم تذكر سابقا:

Please, write any effective factors do not mentioned in the above table:

....

....

شكرا جزيلا على وقتك الثمين والجهد المبذول في هذا الاستبيان

Thank you very much for your valuable time and effort in this questionnaire

بسم الله الرحمن الرحيم

الجامعة الإسلامية

عمادة الدراسات العليا

كلية الهندسة - قسم الهندسة المدنية

استبيان رقم 02

دراسة العوامل المؤثرة علي عملية التسعير في المشاريع الإنشائية للمباني

في قطاع غزة من وجهة نظر المقاولين

وذلك كجزءٍ من البحث التكميلي لنيل درجة الماجستير في إدارة التشييد

الباحث

م.طارق ريان

إشراف

الدكتور/ نبيل الصوالحي

غزة - فلسطين

2015

استبيان يهدف إلي دراسة العوامل المؤثرة علي عملية التسعير في المشاريع الإنشائية للمباني

في قطاع غزة من وجهة نظر المقاولين

السيد المقاول/المهندس: السلام عليكم ورحمة الله وبركاته

بداية أتقدم لكم بجزيل الشكر والتقدير لمساهمتكم بجزء من وقتكم وجهدكم في تعبئة هذا الاستبيان.

تعتبر عملية التسعير من الأنشطة الأساسية والمهمة في المشاريع الإنشائية وقطاع التشييد والبناء لذلك فان هذه الاستبانة تهدف إلي دراسة العوامل المؤثرة علي عملية التسعير في المشاريع الإنشائية للمباني في قطاع غزة, وهي جزء من البحث التكميلي لنيل درجة الماجستير في إدارة التشييد في الجامعة الإسلامية بغزة.

الجزء الأول:

1-تصنيف الشركة حسب تصنيف اتحاد المقاولين:

☐ درجة أولى ☐ درجة ثانية ☐ درجة ثالثة

2-الوظيفة الإدارية لمن يقوم بتعبئة الاستبانة:

☐ صاحب الشركة ☐ مدير المشاريع ☐ مهندس الموقع ☐ غير ذلك

3- عدد الموظفين الإداريين والفنيين في الشركة:

☐ اقل من 10 ☐ 30-11 ☐ 50-31 ☐ أكثر من 50

4-عدد المشاريع المنفذة خلال السنوات الخمس الماضية في مجال المباني:

☐ اقل من 10 ☐ 20-11 ☐ 30-21 ☐ أكثر من 30

5-متوسط حجم أعمال الشركة خلال السنوات الخمس الماضية في مجال المباني (مليون دولار).

☐ اقل من 0.5 ☐ 1-0.51 ☐ 2-1.1 ☐ أكثر من 2

6-نوع المشاريع المنفذة:

☐ سكني ☐ تجاري ☐ سكني تجاري ☐ مؤسسي

الاخوة الخبراء الرجاء ترتيب اهم العوامل الؤثرة في عملية التسعير من وجهة نظركم بما لا يقل عن 15 عامل مؤثر بشكل كبير مع العلم بان الترتيب والنسب المرفقة كانت نتائج الاستبيان رقم (01) من وجهة نظر المهندسين الذين يعملون في مجال المقاولات.

#	Factors	Total	RII	Rank	Rank	Remarks
1.	Number of floors in the building	70	0.883	1		
2.	Type of used foundation in the building	70	0.869	2		
3.	Area of typical floor	70	0.843	3		
4.	Type of external plastering	70	0.829	4		
5.	Area of marble works	70	0.789	5		
6.	Volume of HVAC works.	70	0.789	5		
7.	Area of retaining walls in project	70	0.771	7		
8.	Clarity of quantities and drawings schedule	70	0.769	8		
9.	Type of electrical works	70	0.766	9		
10.	Area of curtain walls	70	0.763	10		
11.	Quantity of electrical works	70	0.760	11		
12.	Number of elevators in the building	70	0.757	12		
13.	Type of tiling	70	0.754	13		
14.	Firefighting and alarm works.	70	0.754	13		
15.	Type of painting	70	0.737	15		
16.	Type of slab (Solid, Ribbed …)	70	0.726	16		
17.	Number of staircases in the building	70	0.726	16		
18.	Area of gypsum board and false ceiling	70	0.723	18		
19.	Type of Aluminum works	70	0.720	19		
20.	Quantity of water and sanitary works	70	0.706	20		
21.	Type of water and sanitary works	70	0.694	21		
22.	Size of the project	70	0.663	22		
23.	Quantity of carpentry works	70	0.657	23		
24.	Type of carpentry works	70	0.649	24		
25.	Number of columns	70	0.643	25		
26.	Staff of supervision (local or international)	70	0.640	26		
27.	Number of windows	70	0.634	27		
28.	Location of project	70	0.629	28		
29.	Type of contract (Ls, unit)	70	0.614	29		
30.	Quantity of metal works for protection &decoration	70	0.609	30		
31.	Length of spans between columns	70	0.569	31		
32.	Number of internal doors	70	0.569	31		
33.	Number of rooms	70	0.551	33		

يرجي كتابة أي عوامل مؤثرة لم تذكر سابقا:

……………………………………………………………………………………………

شكرا جزيلا على وقتك الثمين والجهد المبذول في هذا الاستبيان