نموذج رقم (1)

إقـــــرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Development of Awarding System for Construction Contractors in Gaza Strip Using Artificial Neural Network (ANN)

إعداد نظام لترسية العطاءات على مقاولي التشييد

في قطاع غزة باستخدام طريقة الشبكة العصبية

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The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification

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الجامعة الإسلامية – غزة
عمادة الدراسات العليا
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Development of Awarding System for Construction Contractors in Gaza Strip Using Artificial Neural Network (ANN)

إعداد نظام لترسية العطاءات على مقاولي التشييد في قطاع غزة باستخدام طريقة الشبكة العصبية

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بناءً على موافقة شئون البحث العلمي والدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحث/ **يوسف جميل حسن أبوحجر** لنيل درجة الماجستير في **كلية *الهندسة*** قسم الهندسة المدنية- إدارة المشروعات الهندسية وموضوعها:

إعداد نظام لترسية العطاءات على مقاولي التشييد في قطاع غزة باستخدام طريقة الشبكة العصبية

Development of awarding system for construction contractors in Gaza strip using artificial neural network (ann)

وبعد المناقشة العلنية التي تمت اليوم السبت 05 ربيع أول 1436هـ، الموافق 2014/12/27م الساعة العاشرة والنصف صباحاً بمبنى القدس، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

والله ولي التوفيق،،،

مساعد نائب الرئيس للبحث العلمي وللدراسات العليا

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بسم الله الرحمن الرحيم

﴿قل إن صلاتي ونسكي ومحياي ومماتي لله رب العالمين ۞ لا

شريك له وبذلك أمرت وأنا أول المسلمين ۞﴾ الأنعام (162-163)

Dedication

❖ *Our parents to whom we owe too much.*

❖ *Every teacher who pays efforts to enrich our knowledge along all the studying period.*

❖ *Our martyrs' souls, who offered themselves for the liberation of Palestine.*

❖ *Every person who offers a useful science, a good deal, for the sake of the Islamic nation.*

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- *Special thanks for the engineers in the Palestinian institutions, authorities, consultants firms, international organizations, and municipalities who helped me in gathering necessary data and to the ones who professionally responded to the field study questionnaire.*

- *Grateful thanks to Gaza Contractor Union and all contracting companies for their participation in fulfilling the wanted data for re-evaluation process.*

- *Finally I would like to give my special thanks to my parents and family whose patience and love, enabled me to complete this work.*

ABSTRACT

Selection of the best contractor to implement a project on time, within a reasonable cost and with an acceptable level of quality is a key factors for project success. The most appropriate solution to avoid contractor failure is to integrate technical and financial factors to select appropriate contractor.

The most dominant way of awarding contracts in construction projects in Gaza strip is the lowest bid method. This methodolgy has made many problems in the implementation of construction projects between parties and that affected the efficiency & quality of works.

This study aims at improving the awarding policies in construction projects in the Gaza Strip by using the Artificial Neural Network (ANN) to develop a model for selecting the best contractor.

This research has been conducted through literature review of the topics related to contractors selection methods and criteria, followed by a field survey. Fifty four engineers were asked to fill a questionnaire that covers topics related to the selection of contractors methods practiced in Gaza Strip to identify the importance of these factors for the contractor selection.

The weights of factors affecting selection of contractors indicated that the price of the bid is 50%, the experience is 13.26%, the technical ability is 12.92%, the financial stability is 12.08%, and the management capabilities is 11.74%. The results shows that, the dominant part of respondents (91%) confirmed that the current awarding method "the lowest bid price" is considered one of the major problems of the construction sector.

Ninety-one tenders were used to train and test the ANN model. Neurosolution software was used to train the models. The results of the trained models indicated that neural network reasonably succeeded in selection the best contractor with 95.96% accuracy. The performed sensitivity analysis showed that the profitability and capital of company are the most influential parameters in selection contractors, so the contractor has higher profitability and capital, the chance of winning the tender is greater.

The results of this resarch recommended that there is a need to develop and modify the current low bid awarding system and to set up a new awarding system that set a balance between technical and financial criteria. All parties involved in construction industry are encourged to pay more attention for developing ANN in selection of the best contractor.

ملخص البحث

إن اختيار المقاول الأفضل بغرض تنفيذ المشروع ضمن الفترة المحددة وبسعر مناسب وذلك بمستوى مقبول من جودة العمل هو بالتأكيد المفتاح الأساسي لنجاح المشروع، وبالتالي فإن الحل الأنسب لتجنب فشل المقاول هو اقتراح نموذج يدمج بين العوامل الفنية والمالية لتحديد المقاول الأنسب لترسية العطاء عليه.
الطريقة الأكثر شيوعا في الترسية في مشاريع البناء في قطاع غزة هي أقل الأسعار، هناك العديد من المشاكل سواء في التنفيذ، أو العلاقة بين الطرفين وكفاءة وجودة الأعمال.

تهدف هذه الدراسة إلى تحسين سياسات الترسية في مشاريع البناء في قطاع غزة من خلال وضع معايير الاختيار، وتطبيق الشبكات العصبية الاصطناعية (ANN) لتطوير نموذج لاختيار أفضل مقاول.

تم إنجاز هذا البحث من خلال مراجعة الأدبيات السابقة في المواضيع المتصلة بأساليب ومعايير ختيار المقاولين، تبع ذلك بحث ميداني حيث تم التوجه إلى 54 شخصاً من المدراء و الخبراء والمهندسين من أصحاب العلاقة المباشرة باختيار المقاولين في مختلف المؤسسات العاملة في قطاع غزة، وذلك لتحديد أهمية كل عامل من هذه العوامل على عملية الاختيار .

بعد تحليل الاستبانة تبين أن عامل سعر العطاء قد حصل على 50% من درجات التقييم و عامل الخبرة حصل على 13.26% والقدرات الفنية حصل على 12.92% والاستقرار المالي للشركة قد حصل على 12.08% والقدرات الإدارية حصلت على 11.74% من درجات التقييم .وأظهرت نتائج تحليل الاستبيان وجود العديد من المشاكل في قطاع الإنشاءات وقد قرر % 91 من المشاركين في البحث الميداني بان نظام إحالة العطاءات المستخدم حاليا أي بمعنى أخر إن نظام الإحالة على اقل الأسعار هو من ابرز مشاكل قطاع الإنشاءات المحلي.

واحد وتسعون عطاء (مقاول) تم عمل تدريب واختبار لهم بطريقة الشبكة العصبية وذلك من خلال استخدام برنامج (Neurosolution) لتدريب نماذج الشبكات، حيث أشارت النتائج المخرجة من عملية التدريب بأن الشبكة العصبية نجحت بشكل ملحوظ في تحديد المقاول الأنسب ليتم ترسية المشروع عليه بدقة 95.96%، وأظهر تحليل الحساسية للنتائج بأن ربحية الشركة ورأس مال الشركة هما العاملان الأكثر تأثيرا على عملية اختيار المقاول، وبالتالي فإن المقاول صاحب التقييم الأعلى في ربحية المشاريع ورأس المال فإنه صاحب الفرصة الأكبر للفوزبالعطاء والترسية عليه.

إن أهم التوصيات التي قدمها هذا البحث هي ضرورة إعداد نظام جديد لإحالة العطاء على المقاولين في قطاع غزة بحيث يوازن بين العوامل الفنية والعوامل المالية ، وتشجيع جميع الأطراف المشاركة في صناعة البناء والتشييد إلى إعطاء المزيد من الاهتمام لتطوير استخدام الشبكات العصبية في تحديد المقاول الأنسب لتنفيذ المشروع .

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List of Abbreviations

ANN	Artificial Neural Network
PE	Processing Elements
MLP	Multi-Layer Preceptron
GFF	General FeedForward
RNN	Recurrent Neural Network
MSE	Mean Square Error
r	Correlation factor
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error
AP	Accuracy Performance
UNRWA	United Nations Relief and Works Agency
C.V	Cross Validation
NN	Neural Network
PCU	Palestinian Contractors Union
UNDP	United Nations Development Programme
MDLF	Municipal Development & Lending Fund
MOLG	Ministry of Local Government
ABV	Average Bid Value
NA	New Average
NH	New Highest offer
NL	New Lowest offer
NA	New Average

CHAPTER 1
INTROUDUCTION

1.1 Background

The local procurement in general, and particularly in the Gaza strip, has many problems. The aggressive competition and low prices may be considered as the main causes of these problems. The construction industry and awarding authorities, have begun to explore ways to improve the process of selecting general contractors. It is important for the concerning authorities or agencies to improve the lowest bid award contracting method by considering other factors in the evaluation process and selection suitable contractor, other than the lowest bid. 'Right' selection of suitable contractor is critical for achieving good project performance and overall success in construction projects (Lam and Palaneeswaran, 2008).

Project owners in the public sector put out to tender construction projects of buildings, roads, drainage, and waterworks as well as formation of sites. Contractors play a major role in such projects, which is why contractor selection constitutes a critical decision for project owners. The selection process should embrace investigation of contractors' potential to deliver a service of acceptable standard, on time, and within budget (Topcu, 2003).

The selection based on the low price basis can be one of the reasons for project completion delays, poor quality and/or financial losses, etc. An offered bid price is undoubtedly an important factor in choosing a contractor, but there are many other important issues playing a vital role in project implementation that have to be incorporated in the contractor's evaluation process (Darvish and Saeedi, 2009).

Emphasis directed towards encouraging lowest bid price should be redirected towards establishing contractor's ability for achieving project owner's satisfaction by supplying high project performance (time) and high quality of completed product. The outcome of a construction project can be measured in terms of cost, time, and quality achieved, hence they can be regarded as the three main concepts for contractor selection procedure. Based on these main concepts, a list of criteria can be generated. These criteria are utilized at contractor's prequalification, that is another frequently used procedure of selecting contractors (Topcu, 2003).

1.2 Problem Statement

The selection of contractors often encounters problems, such as the selection of inappropriate contractors, difficulty in the management of contractor and out-of control of quality, time, budget, and safety (Holt et al., 1998).

Due to lowest bid contracts award methodology, the following problems have arise in the last few years (Jesen and Donald, 2001):

- Low profit margins in high-risk industry.

- Reduction of trained craftspeople in the subcontracting area.

- Performance issues.

- Dispute issues.

The competitive bidding process in Gaza Strip is the most importance of its kind in the construction industry than in other sectors. It is more closely a pure competition. The most dominant way of awarding contracts in construction projects in Gaza strip is the lowest bid method. There was many problems in implementation as for the relationship between parties of projects and the efficiency & quality of works.

Therefore, it is important to investigate the awarding policies and practices in projects in the Gaza Strip to select of suitable contractor for achieving good project performance and overall success in construction projects.

1.3 Research Aim and Objectives

The aim of this research is to improve the awarding policies in construction projects in the Gaza Strip. The general aim in this research is achieved throughout the following objectives:

To review the current method of contract awarding systems in construction projects.

To investigate the contractor selection criteria used in Gaza strip.

To identify the importance of selection criteria through creating weights to all criteria, and evaluate the impact of criteria to the contractor's selection and its relationship to the price of tender.

To develop of awarding system for construction contractors in Gaza strip using Artificial Neural Network (ANN).

1.4 Research Methodology

This research is designed to develop awarding system for construction contractors in Gaza strip using Artificial Neural Network (ANN). A field survey study is planned to investigate the awarding policies in construction projects in the Gaza Strip. The research was conducted in following main stages.

1. Identifying and defining the problems and establishment of the aim & objectives of the study and development of research plan.

2. literature review of awarding systems in construction projects.

3. A field survey to identify most significant factors that should be considered during the awarding process.

4. Evaluation of the questionnaire design, through the pilot study, where experts from local clients and consultants were contacted. The purpose of the pilot study was to prove that the questionnaire questions are clear to be answered in a way that help to achieve the objectives of the study.

5. Questionnaire distribution to local clients and consultants who participated in projects in Gaza Strip.

6. Data analysis and discussion.

7.Collection of case studies from previous projects to establish relevant data to build the ANN model.

8. Propose a model for awarding process of projects in the Gaza Strip.

1.5 Tentative Table of Contents of The Thesis

Chapter 1: Introduction

An introductory chapter defines the problem statement, the objectives of this study, the methodology and an overview of this study.

Chapter 2: Literature review

Presents a literature review of traditional and present efforts that are related to the selection of contractor, and application of Artificial Neural Network (ANN) model in related field with its characteristics and structures.

Chapter 3: Methodology including (Field survey, Pilot study)

The adopted methodology in this research was presented in this chapter including the data-acquisition process of influential factors that relate to selection of contractor that necessary for the proposed model.

Chapter 4: Questionnaire, results and discussions

Presents statistical analysis for questionnaire surveying. It also presents the adopted influential factors in this study and the encoded data for model implementation.

Chapter 5: Model Building

Presents the selected application software and type of model chosen and displays the model implementation, training and validation. As well, the results of the best model with a view of influence evaluation of the trained ANN model are showen.

Chapter 6: Conclusion and Recommendations

Presents conclusion and recommendations outlines for future work.

CHAPTER 2
LITERATURE REVIEW

This chapter focuses on subjects that are available in literature and related to the awarding process in construction projects. The main topics that are included in the chapter are contractors selection process, selection criteria, selection models, artificial neural network (ANN) method and awarding System In Gaza Strip.

2.1 Contractor Selection Process

Construction industry is the main indicator of the economic growth of the country throughout the world. Construction industry is the significant contributor in the economic growth of any country. In developed countries, the construction industry incorporates the GDP growth of 7-10% whereas in developing countries the percentage is only 3-6% (Muqeem and Idrus, 2011).

The construction industry plays an important role in providing employment opportunities and enhancing economic development, especially in developing countries. However, the industry has a poor record for project success in terms of cost, time, quality, etc. Construction contractors are responsible for the actual production work involved (cost management, schedule management, quality management, etc.) in projects and so their performance is critical to the success of projects. Furthermore, replacing a contractor with another during project execution is very costly. It is therefore important to understand the factors influencing contractor selection (Skitmore et al., 2013).

Tender evaluation and contractor selection continues to be an area of significant importance and interest to organizations responsible for delivering project outcomes, it is perhaps one of the most critical undertakings performed by clients, the effectiveness of which is directly related to project success (Watt et al., 2010).

Project owners in the public sector put out to tender construction projects of buildings, roads, drainage, and waterworks as well as formation of sites. Contractors play a major role in such projects, which is why contractor selection constitutes a critical decision for project owners. The selection process should embrace investigation of contractors'

potential to deliver a service of acceptable standard, on time, and within budget (Topcu, 2003).

'Right' selection of suitable contractors is critical for achieving good project performance and overall success in construction projects In general, selecting eligible bidders/proponents is regarded as a vital safeguard for construction clients, especially in major/high value projects. The generic benefits of contractor selection process include healthy competitions, minimized risks, and improved quality potentials. (Lam and Palaneeswaran, 2008).

Contractor evaluation and selection is a difficult and challenging task plagued with many uncertainties. It is a complex multi-attribute decision problem that requires individuals to make judgments and trade-offs between competing objectives and limited resources (Watt et al., 2009).

The fundamental rationale behind competitive tendering is free market competition, i.e. genuine competition should achieve best value for money for the client, this has been the underlying philosophy of contractor selection for hundreds of years. However, it is often implemented to the extreme-some client organizations are obligated to accept lowest bid whether from a competent operator or not (Holt and Harris, 2001).

2.2 Risks of the Lowest Price and Contractors Selection Deficiencies

The practices and procedures for selecting contractors and awarding contracts in the construction industry are based on those used in the public sector and have remained relatively unchanged since the 1940s, These involve systems of bid evaluation dominated by the principle of acceptance of the lowest price. Many now believe that the public sector system of bid evaluation, concentrating as it does solely on bid price, is one of the major causes of project delivery problems, Contractors, when faced with a shortage of work, are more likely to enter low bids simply to stay in business in the short term and in the hope of somehow raising additional income through "claims" or cutting costs to compensate. This implies also that the automatic selection of the lowest bidding contractor is also risky a fact that is seldom appreciated by construction clients. Changing this process, however, is not easy (Hatush and Skitmore, 2000).

The selection based on the low price basis can be one of the reasons for project completion delays, poor quality and/or financial losses, etc. An offered bid price is undoubtedly an important factor in choosing a contractor, but there are many other important issues playing a vital role in project implementation that have to be incorporated in the contractor's evaluation process (Darvish and Saeedi, 2008).

Most clients, especially those in the public sector, necessarily have to be accountable for their decisions and this becomes more difficult when selecting bidders other than the lowest. This has led researchers to look for techniques for contractor selection which utilise information concerning client objectives and contractor capabilities as well bid price as objectively and transparently as possible as a means of achieving the best value for money (Hatush and Skitmore, 2000).

Improper selection of contractors might lead to many problems during work progress. These include bad quality of work, and delay in project duration. The main objectives of the contractor selection process are to reduce project risk, maximize the quality and maintain strong relationships between project parties, Some owners regard the cost as the most important criteria to base the contractor selection process on; however, research recommends that a multi-criteria selection process should be further taken into consideration (Marzouk et al., 2013).

The contractor selection procedure also suffers from two other deficiencies. First, the selection process does not attach any importance to the past work performance of contractors. Having won a contract, a contractor, with a poor record of past work performance, is very likely to deliver work with poor standard. For example, found the contractors to be unreliable when their past work performance was not considered in the selection process. Second, a contractor can bid for any number of projects at the same time. Because procurement auctions take place in a decentralized manner in government departments, it is quite possible that a contractor wins the award of multiple projects. Such a contractor often fails to handle all the projects satisfactorily due to his limited resources and exceeds the planned schedule and cost and, consequently, compromises on quality (Padhi et al., 2009).

2.3 General Contractor Selection Process Around the World

Today's growing numbers of contractor selection methodologies reflect the increasing awareness of the construction industry for improving its procurement process and performance researchers and practitioners have realized that lowest-price is not the promising approach to attain the overall lowest project cost upon project completion، multi-criteria selection becomes more popular (Darvish and Saeedi, 2008).

Different countries use different procedures to select the contractor. All these procedures are aimed at selecting a qualified contractor on a competitive basis, but in reality a decision is usually based on a single criterion for instance. In Australia contractor selection is based on different criteria and the process is implemented in two stages: first, the contractor's experience is evaluated and then comes bargaining for a price. In Saudi Arabia, the lowest bidder is selected provided that the bid is not less than 70% of the owner's cost estimate. In Turkey, a two stage procedure is used, but at the end, the lowest price determines the selection. In Canada and the USA, especially in the public sector, the ''lowest bidder" is selected, but a bid bond in an amount equal to 10% of the bid price also has to be provided. In Lithuania, the ''lowest bidder" is selected as in Canada and the USA. In Iran, the ''lowest bidder" is selected but the selection is based on different criteria and two stage process, first the pre-qualification of all contractors is evaluated and then the lowest price mechanism works. Hence, it may be concluded that price criterion is decisive in contractor selection. Lately the ''lowest bid" selection practice has been criticized because it involves high-risk exposure of the client (Darvish and Saeedi, 2008).

Marzouk et al.(2013) illustrate the different approaches for contractor's selection in different countries as shown in Table 2.1.

Table 2.1: Approaches for contractor's selection (Marzouk et al., 2013)

No.	Country	Decision making approach
1	Denmark	Rejecting the highest two and the lowest two and selecting the contractor that offers a price closest to the average
2	Italy, Portugal, South-Korea	Rejecting the highest one and the lowest one and selecting the contractor that offers a price closest to the average
3	France	Rejecting the contractor that offers an abnormally low price
4	Australia	The process is implemented in two stages: first, evaluating the contractor's experience; second, bargaining for a price then occurs
5	Saudi-Arabia	The lowest bidder is selected provided that the bid is not less than 70 percent of the owner's cost estimate
6	Turkey	The lowest price determines the selection
7	Canada, USA	The lowest bidder is selected
8	Lithuania	The lowest bidder is selected
9	Iran	The lowest bidder is selected. The process occurs in two stages: first, the contractor's pre-qualification is evaluated; second, the lowest price mechanism works

2.4 Awarding Procedures

Government departments in India follows a three-stage procedure to award a work contract. In the first stage, the applicants are evaluated on the basis of their registration details. Registration details indicate the class to which a contractor belongs. Normally, a contractor is registered with the government as B-, A-, special-, or super-class contractor on the basis of physical resources, qualified manpower, and past experiences available. A B-class contractor is eligible to bid for small projects costing less than or equal to Indian rupees of five million, whereas a super-class contractor can bid for projects of all sizes. In the second stage, the department evaluates the applicants and scores them with respect to three main pre-qualification

attributes of their technical bids: (1) Quantum of similar work done in the past, (2) Availability of physical resources, and (3) Financial status (liquid assets) of the contractor. The department shortlists the three highest scoring bid participants for the second stage of evaluation. In the third stage, the contractor, quoting the lowest bid price, is declared as the winner (Padhi et al., 2009).

The correct choice of construction contractor(s) is a critical function of either the client or the client's consultant/ project manager, that usually has a significant impact on the success or otherwise of a project, Figure 2.1 illustrates the commonly pursued alternative routes to contractor selection (Kumaraswamy, 2003).

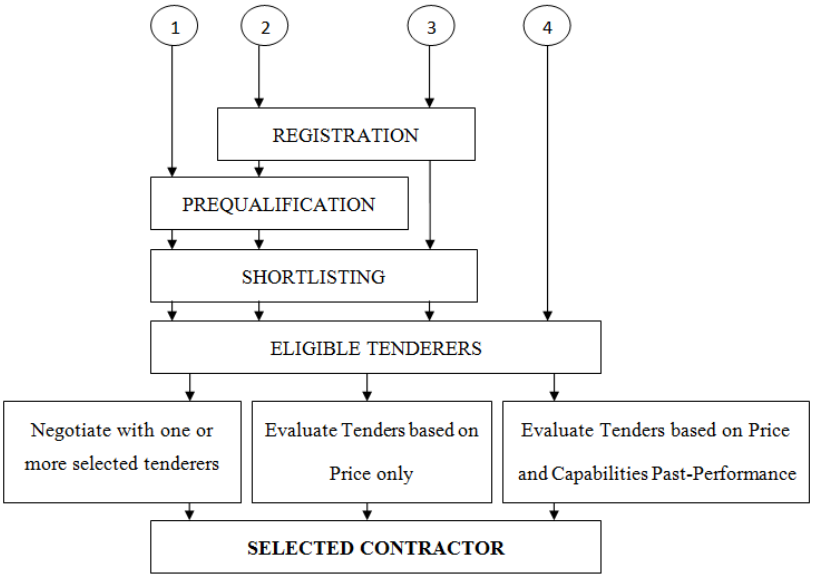

Figure 2.1: Routes to contractor selection (Kumaraswamy, 2003)

In the last two decades, there has been a steady increase in the range of methods used for the procurement of construction work. Despite this, however, there has been no commensurate improvement in the "success" rate of construction projects. Instead, there have been extensive delays in the planned schedule, cost overruns, serious problems in quality and an increased number of claims and litigation. To improve this situation, still further methods are being sought to improve current tendering procedures and contractor selection (Hatush and Skitmore, 2000).

Medoukh (2008), summarized some of the used awarding methods in construction projects based on wide study of the previous research in this regard as follows:

- **Nearest to the Average of All Bids Received**

In this system, once the owner has received all offers, he or she performs a simple mathematical calculation to find the Average Bid Value (ABV): all of the participants' offers are summed and divided by the total number of bids received.

ABV = (SUM of offers / number of bids). To award the contracts, the owner looks for the nearest offer to ABV and selects this bid.

- **The Danish System**

A simple formula to select the most reasonable offer from the competitive bids received. It rejects the two extreme offers (highest and lowest); a new highest and lowest offer, and consequently a New Average (NA), thus exist. The remaining offers are considered in relation to the New Highest offer (NH). The New Lowest offer (NL) and the Average (A) of all of the offers are calculated. The new average (NA), which helps in selecting the successful bidder, is calculated as follows:

NA= (NL+4A+NH) / 6

The offer that is ranked first above this new average is then treated as realistic and acceptable.

- **A Negotiated Offer**

When an owner negotiates a contract with a pre-selected contractor or group of contractors, the competitive process is eliminated entirely, and the contractor is chosen on the basis of reputation and overall qualifications to do the job.

Negotiated contracts are normally limited to privately financed work because competitive bidding is a legal requirement for most public projects except under extraordinary or unusual application of negotiated contracts across the board in the private sector. This can only be interpreted as a sign that owners are increasingly finding that such arrangements are in their best interest.

2.5 Selection Criteria

Awarding a construction contract to the lowest bidder without considering other factors can result in problems such as fraud, cost over-runs, delays, and poor performance. Therefore, contractors are often evaluated with multiple criteria including past quality performance, safety, cost, schedule, and relationship with owners (Gaojun and Yan, 2006).

Given the complexities and underlying issues surrounding contractor selection, and the variety of criteria available, how then do clients choose suppliers and what is the relationship between the criteria used in an evaluation? Which criteria influence choice? Is price a more important criterion than experience, capability, expertise, or performance? Does the relative importance vary as a function of industry, position, experience or project complexity? These questions form the basis of our continuing research to investigate which factors influence the actual choice of a contractor for major projects and the relative importance of the criteria used. Despite its importance, this aspect of contractor selection remains largely unexplored, as evidenced by the very few studies reported (Watt et al., 2010).

Where clients have an identified single criterion, such as a fixed price or fixed completion date, several criteria relating to contractors' likely performance (such as technical experience, structure of the organisation, financial stability, past performance and safety records) need to be considered in selecting contractors (Hatush and Skitmore, 2000).

Selection criteria for contractor selection process are characterized by the co-existence of both quantitative and qualitative data. The qualitative data is non-linear, uncertain, and imprecise. In addition, subjectiveness and the lack of experience and knowledge within the process make the task challenging (El-Sawalhi et al., 2007).

Knowing the evaluation criteria is essential in the bid decisions. To have a good sense of what are the main criteria that owners/ clients tend to have in evaluating auctioneers, the preferred criteria for evaluating tenders are "past project performance, technical expertise and cost are the most important criteria in an actual choice of contractor with organizational experience, workload, and reputation being the least important." quality of product was the most important criterion of contractor selection. Notably, this

criterion was consistent in all industries. Based on their research, bidding price is not the main evaluation criterion. In fact, on average it is only around 15% important. So it is important to consider non-monetary criteria in making either one of the bidding decisions. They also observed that past project performance is the most important evaluating factor; about 30% of the relative importance of evaluating bids is assigned to it (Watt et al., 2010).

Criteria for selecting the best contractor are introduced such as: ‘‘history of reasonable bid price submissions’’; ‘‘a work history that indicates specialization and quality of workmanship in a particular construction skill; ‘‘contractor’s degree of quality control’’; ‘‘decorum, conduct and non-disruptiveness of contractor staff and subcontractors ‘‘coordination of operations that will cause noise, vibrations, dust, odors, safety concerns and other activities’’; ‘‘responsiveness to warranty issues’’; ‘‘Flexibility and cooperation when resolving delays’’; and ‘‘ability to meet project schedule’’. Abiding by such criteria, or on others depending on the situation, leads to the right selection of the best alternative, which has many benefits for all parties in the construction project; such as high quality finishing, meeting deadlines based on the estimated time, as well as abiding by the estimated cost (Marzouk et al., 2013).

To select the best contractor should taking into consideration the following criteria of selection: technology and equipment, management, experience and knowledge of the technical staff, financial stability, quality, being familiar with the area or being domestic, reputation, and creativity and innovation. Despite setting several contractor selection criteria, the final decision should consider both; the criteria set and the competitiveness of the price (Marzouk et al., 2013).

Four essential criteria for choosing a contractor; ‘‘price, technical know-how, quality and cooperation.’’ In order to determine the relative importance of each criterion, the mean, median and standard deviation were calculated. The four criteria are considered essential ones. Usually, maximizing profits and minimizing costs come as crucial objectives of a contractor. Consequently, setting price as one of the criteria of choosing a contractor is essential (Marzouk et al., 2013).

Investigated the perceived importance of criteria that influenced a client's choice of supplier. The conclusion drawn from that specific study found that criteria, such as, experience in projects of similar size and type, current workload, management qualifications, and time of year were considered important. Other studies suggested selection criteria that provide a measure of a supplier's capability in terms of organizational structure, management skills, banking arrangements, cash flow, management qualifications and experience, and past performance (Watt et al., 2009).

Investigated various contractor selection criteria to determine the importance of the ''lowest price" wins philosophy. The study showed that ''lowest price" is not necessarily the principal discriminator, and clients are tending toward broader evaluations that include more categories of criteria when selecting suppliers. That is, clients base evaluations and decisions on value rather than cost through the use of Multi-Criteria Selection (MCS), Specific reported categories of criteria include contractor organisation, financial considerations, management resources, past experience, past performance and a number of project specific criteria (Watt et al., 2009).

In a quest to identify a universal set of criteria suggested a suite of criteria to support contractor selection. These included managerial capability, financial soundness, technical personnel and their ability, past performance, experience, financial status, project management organization, and capacity to undertake or support the intended scope of work. In a subsequent article, Hatush and Skitmore reported a multi-criteria approach to contractor selection. Criteria included technical ability, health and safety, reputation, management capability, and bid amount (cost) (Watt et al., 2009).

Selection of contractors for construction projects in government departments (including those in India) is usually based on the consideration of a number of attributes. They are listed below (Padhi et al., 2009).

a. Bid price quoted by a contractor: It is the price quoted by a contractor to get the project work. The government prefers the contractor who quotes the lowest bid.

b. Financial status of the contractor: It is the minimum liquid assets that a contractor must have (30% of reserve price) to get the project work.

c. Total amount of similar work done by the contractor: The criterion of total amount of similar work done by the bidding contractors is important because it gives an idea to the government department about the contractor's experience in handling work of similar quality specifications and costs.

d. Physical resources available with the contractor: The government department asks the bid participants to submit the details of available physical resources that they can expend for the project.

In Turkish public sector, there is a two-stage process for the selection of contractors that have passed through mandatory requirements filter: contractor prequalification and determination of lowest bidder among prequalified applicants, at the first stage, applicants are evaluated and scored with respect to four main prequalification criteria: "ability to timely complete projects", "organizational expertise", "availability of experienced technical staff", "availability of resources such as machinery and equipment". Contractors having a score less than a threshold value (75 from 100 points) are screened out as illustrated in Table 2.2 . The average value of the scores of the remaining applicants are calculated. Contractors having a score greater than or equal to 95% of the average value prequalify for the second stage. At the second stage, bid prices are taken into account. The lowest bidder wins the contract. (Topcu, 2003).

Table 2.2: Selection criteria & their (point, weight) boundaries in Turkey (Topcu, 2003)

No	Main Criteria	Sub-Criteria	Weight (%)	Point
1	Ability to timely complete projects	Financial status	70	20- 40
		Workload	30	
2	Organizational expertise	Length of time in construction industry	10	40- 60
		Similar projects	80	
		Fraudulent activity & failed contract	10	
3	Availability of experienced technical staff			0-10
4	Availability of resources			0-10
Total				**100**

In Chinese public sector, the bid evaluation is made based on six important criteria: (1) Degree of response to the bid document; (2) Construction organization design; (3) Firm's honour and competence; (4) Bid prices and the amounts used of three materials (steel, cement and lumber); (5) Range for reducing cost; and (6) Comprehensive evaluation and examination. All the bidders should be evaluated by all the commissioners based on the above criteria as illustrated in Table 2.3. The bidder with the maximum points is awarded the construction project. Bids are opened, evaluated and selected under supervision of the Administration Office for Inviting and Submitting Bids for Construction Projects of Beijing (Lai and Wang, 2004).

Table 2.3: Selection criteria & their point boundaries in China (Lai and Wang, 2004)

No	Main Criteria	Sub-Criteria	Point
1	Degree of response to the bid document	Quality standard	50
		Time	50
2	Construction organization design	Construction scheme	45
		Quality guarantee system and its measures	20
		Safety measures	10
		Plans for labour force and the amounts used of main equipment and materials	10
		Construction scheduling plan and its guarantee measure	15
3	Firm's honour and competence	Level of qualification	30
		Honour title(s) for project(s) earned by the firm	20
		Level of qualification of project manager	15

Table 2.3: Cont.

3	Firm's honour and competence	Experience in similar projects	10
		Qualified and excellent percentage of projects in recent two years	15
		Percentage of keeping time promise	10
4	Bid prices and the amounts used of three materials	Bid price	90
		Amounts used of three materials	10
5	Range for reducing cost		3
6	Comprehensive evaluation and examination		5

In the Qatari Committee for the reconstruction of the Gaza Strip, the bid evaluation is made based on nine important criteria: (1) financial capacity; (2) technical capacity; (3) managerial capacity; (4) previous experience; (5) past performance; (6) the company's reputation; (7) health and safety; (8) claims; and (9) current workload . All the bidders should be evaluated by all the commissioners based on the above criteria as illustrated in Table 2.4, after calculating points for bidders introduce of these offers on a mathematical equation containing the value of bids, to bring out the best offers financial and technical for awarding. Bids are opened, evaluated and selected under supervision of the Qatari Committee Office for inviting and submitting bids for reconstruction projects of Gaza (Qatari Committee, 2013).

Table 2.4: Criteria of evaluation & their point boundaries in Qatari Committee (Qatari Committee, 2013)

No	Main Criteria	Sub-Criteria	Point
1	Financial capacity	Current Ratio	10
		Debt Ratio	2
		Profitability	2
		Capital	3
		Bank facilities	3
2	Technical capacity	Technical staff experience	8
		Number of crew technical	3
		Number, type and condition of the equipments	5
		Cash for equipments	2
3	Managerial capacity	The structure of the company	6
		Administrative staff qualifications	4
		System monitoring and follow-up	2
4	Previous experience	Number of similar projects	4
		Type of projects implemented	2
		Size of projects implemented	2
		Number of projects implemented	2
5	Past performance	Compliance with the contractual terms	5
		Compliance with specifications	4
		Record of company response	2

Table 2.4: Cont.

6	The company's reputation	Compliance with contractual duration	2
		The company's relationship with the current owner	5
		The company's relationship with the previous owners	2.5
		Rating company	2.5
7	Health and safety	Policy health and safety	3
		The company's history in the field of safety	1
		Safety training programs	2
8	Claims and disputes	Response to resolve claims and disputes	3
		Tendency to raise the claims	1.5
		Number of claims in previous projects	1.5
9	Current workload	Number of projects under implementation	2
		Size of projects under implementation	2

2.6 Selection Models

In practice, a contractor selection issue can be described as a two-stage process. First, a large number of contractors are invited to tender and then a short list of contractors is drawn based on a set of pre-determined criteria (prequalification stage). In the second stage, a contractor is selected from the short list to execute the project (final contractor selection stage) (Al Wahaidi, 2012). The methods used for selecting contractors in order to award public projects in the construction industry are generally based on the principle of acceptance of the lowest bid price. However, the evaluation on lowest price basis is one of the major causes of project delivery problems. On the other hand, as project owners in the public sector are held accountable for their decisions, explaining the

rationale of the selection is more difficult when they select a contractor other than the lowest bidder (Topcu, 2003).

By far the most frequently used method of selecting construction contractors is competitive bidding. Investigations into contractor selection and evaluation methods have more recently expanded. These methodologies include : multi-criteria decision-making (MCDM), bespoke approaches (BA), multi-attribute analysis (MAA), data envelopment analysis (DEA), multi-attribute utility theory (MAUT), multiple regression (MR), cluster analysis (CA), fuzzy set theory (FST), multivariate discriminate analysis (MDA), cash flow techniques, multi-parameters evaluation bidding system, qualifier-1 and qualifier-2 or contractor pre-qualification, highlight optimum legitimate tender (HOLT) selection techniques, program evaluation and review technique (PERT) approach, decision support systems for contractor pre-qualification – an artificial neural network approach (ANN), and analytic hierarchy process (AHP) (Darvish and Saeedi, 2008).

Many studies have recognized the importance of, and the associated difficulties in, multi-attribute scoring of contractors. Consideration of multiple attributes in procurement auction is important, but setting their priority in a bid evaluation process is difficult. To overcome these weaknesses and evaluate construction contractors in a multi-attribute procurement scenario in government sectors, a number of modeling approaches have been proposed in the literature, Table 2.5 shows a few selected modeling approaches and the contractor selection attributes used in these approaches. (Padhi et al., 2009).

Table 2.5: Modeling approaches and the contractor selection attributes (Padhi et al., 2009)

No.	Author	Country	Selection attributes used	Modeling approach
1	Kumaraswamy (1996)	Hong Kong	Financial status, technology offered, and experience in handling similar types of projects	Performanc e-based scoring

Table 2.5: Cont.

2	Holt (1998)	UK	Quoted cost, quality of work, and completion time	Cluster analysis
3	Hatush and Skitmore(1998)	UK	Quoted bid price, financial soundness, technical ability, management capabilities, safety performance, and reputation.	Multi-attribute utility theory
4	Deng (1999)	Australia	Quoted cost, technical capability, services and references of the government officials.	Fuzzy-AHP
5	Al-Harbi (2001)	UAE	Experience in handling similar types of projects, financial stability, quality performance, manpower resources, equipment resources, and current workload.	AHP
6	Topcu (2004)	Turkey	Quoted cost, quality of work, and completion time	AHP
7	Lai et al. (2004)	China	Contractor organization structure, firm honor and competence, quoted bid price, and amount of materials used.	Multi-attribute analysis
8	Missbauer and Hauber (2006)	Austria	Bid price	Integer programming

At cluster analysis (CA) method, the nature of the problem under consideration in this method involves a theoretically infinite range (set) of contractors, albeit this will be a function of tendering arrangement employed. The principal task therefore, is one of reducing this original set into a series of smaller, manageable sub-sets of like character. By analyzing these sub-sets, the quality (i.e. attributes) of contractors therein may be observed and the best subset(s) identified for subsequent tender invitation if prequalification is being performed. Alternatively, the characteristics of sub-set membership would help in assigning contractors to standing lists (e.g. specific work types or, project sizes) (Medoukh, 2008).

El-Sawalhi et al. (2007) summarized all the used models in the contractor selection process based on wide study of the previous research in this regard as follows:

- **Dimensional weighting aggregation (DWA)**

This model adopted by Russell and Skibniewski (1990), it is considered simple to apply do not need special knowledge to understand, but it has some of disadvantages, it depends on the subjective judgment of the decision makers, a low score in one section can be compensated by a high score in another, did not consider the risks associated with the inconsistency of contractor data, the risks inherent with different decision maker's opinion are not considered and cannot accommodate different criteria with dissimilar units of measurements.

In (DWA) a contractor's aggregate rating is calculated as the weighted sum of rating the overall decision parameters. Decision makers are asked to evaluate contractors on a 1 to 10 scale, 1 being unsatisfactory and 10 being satisfactory. Then, a contractor's score is calculated as a weighted sum of ratings over all decision criteria, (i.e., scores x weights).

- **Knowledge based system (KBS)**

Adopted by Russell et al. (1990), it gives a chance for heuristic decision rules to be used for better expectations, but it has some of disadvantages, the limitation encountered in the model is the implicit treatment of the uncertainties inherent with heuristic knowledge.

QUALIFIER-2, this program was based on an aggregated weighing for each contractor obtained through the input rating for each decision criterion, it is a Knowledge based

system in which the decision of selection is made by the model user using the decision rules, not the calculated scores. The model is a compilation of engineering judgment and experience. The owner evaluates the input data using heuristic decision rules that suggests selection decision (If . . . then) rules.

- **Multi-attribute analysis (MAA)**

Adopted by Holt et al. (1994), MAA is a simple scoring model. Because of its simplicity, it is frequently used by decision makers, but it has some of disadvantages, the input variable is often a very subjective measure used by practitioners, the model fails to incorporate systematic checks on the consistency of judgment, it does not consider the non-linearity between the decision criteria and contractors attributes and the uncertainty of the contractor data is not taken into consideration.

MAA is a quantitative approach which facilitates the consideration of multiple attributes. Options being evaluated may be rated against the client's objectives. Preferences may be incorporated by assigning weights which then combined to yield the highest score indicating the optimal.

- **Fuzzy set (FST)**

Adopted by Nguyen (1985), it Can deal with qualitative and quantitative data Work with group membership Deals with uncertain data, but it has some of disadvantages, difficulties associated with the formulation of the membership functions for selection criteria and the number of parameters and the complexity of the framework, and the user should acquire extensive mathematical background to understand and run the analysis.

(FST) theory resembles human reasoning in its use of approximate information and uncertainty to generate decisions. It was specifically designed to mathematically represent uncertainty and vagueness and provide formalized tools for dealing with the imprecision intrinsic to many problems. Since knowledge can be expressed in a more natural by using fuzzy sets, many engineering and decision problems can be greatly simplified. Fuzzy set theory implements classes or groupings of data with boundaries that are not sharply defined (i.e., fuzzy).

- **Program Evaluation and Review Technique (PERT)**

Adopted by Hatush and Skitmore (1997), it incorporates multiple ratings permitting the uncertainty in contractor data to be evaluated, but it has some of disadvantages, the subjective nature of judgment on the aspiration levels, the technique is not able to handle the inherent non-linear relationship between contractor's attributes and their corresponding selection decisions.

PERT is a planning method which takes the probability of the criteria into account. It was used to assess and evaluate contractor data against client goals, namely time, cost, and quality.

- **Analytical hierarchy process (AHP)**

Adopted by Munaif (1995), Al-Harbi (2001), Mahdi (2002), Topcu (2004), it's advantages are: allows group decision-making It transfers subjective judgment into meaningful weights and ratios on which to base decisions, diverse judgments by decision makers can be accommodated by this technique which synthesizes that judgment into a representative outcome and pinpoints inconsistencies made in the Judgments, but it has some of disadvantages, subjective nature of letting the decision maker decide on the weight which will effect the final decision, the scale used is not apparent , there is the possibility of rank reversal occurrence and the comparison between two criteria is represented by two different scales .

AHP design problem by breaking it down into a hierarchy of interrelated decision elements, decision criteria and sub criteria; After the decision problem is modeled in a hierarchical fashion, the decision maker must develop a set of comparison matrices that numerically define the relative preference of each decision alternative with respect to each criterion and also the relative importance of each criterion.

- **Multi-attribute utility (MAU)**

Adopted by Hatush and Skitmore (1998), it's advantages are: permits different types of contractor capabilities to be evaluated and deals with uncertain data Incorporates the risk of the decision maker, but it has some of disadvantages, it is hard to retrieve the public client's preference via utility function, it require to provide exact probability values so that the utility function can be derived, the decision making process takes a

long time and becomes tedious if there are numerous criteria, needs very good knowledge of probability theory and no ability to deal with multiple decision makers

Simultaneously.

In (MAU) all decisions involve choosing one, from several, alternatives. Typically, each alternative is assessed for desirability on a number of scored criteria. What connects the criteria scores with desirability is the utility function. The most common formulation of a multi-criteria utility function is the additive model.

- **Case-based reasoning (CBR)**

Adopted by Ng (2001), it's advantages are: a practical solution can be produced even when knowledge about a particular selection system is weak and the solutions obtained from previous cases can be modified to meet the current situation through the adaptation functions provided in the system, but it has some of disadvantages, the model needs input of large a number of cases when initially operated which may be difficult to achieve in practice, in cases where there is no similar or approximate solution, the system will give a negative solution, and the system is not an adaptive one that can learn and predict new solutions.

CBR is an artificial intelligence technology that solves new problems by adapting solutions that were used to solve old problems. Reasoning by reusing or modifying experience is a frequently applied paradigm for human problem solving. This is particularly the case when the domains are not completely understood or when the concept is open-ended.

2.7 Artificial Neural Network (ANN)

An Artificial Neural Network (ANN) is a computational model that is inspired by the structure and functional aspect of biological neural network. The feature that makes the neural network more flexible and powerful is its ability to learn by example. The neural network has multi-disciplinary applications which include neurobiology, philosophy, economics, finances, engineering, mathematics and computer science, etc.. The first artificial neuron was produced in 1943 by the neurophysiologist Warren McCulloch and the logician Walter Pits. But the technology available at that time did not allow them to do too much (Kumar et al., 2014).

An artificial neural network (ANN) is a system derived from neurophysiological models. In general, this type of model consists of a collection of simple, nonlinear computing elements, whose inputs and outputs are linked to form a network . However, one disadvantage of ANNs, which is an impediment to their more widespread acceptance, is the absence of any capability to inform the user as to how the network arrives at a particular decision, in a form that is easily comprehensible. These networks are also unable to give details of the knowledge that is encoded within the black box (Kuo et al., 2014)

Artificial neural network (ANN) is a computational structure with artificial neurons performing a nonlinear function of their inputs. It has the advantage of modeling complex data by means of a training algorithm without priori assumption, and has the ability to handle multivariable problems, learn highly non- linear relationship and approach any nonlinear systems and adjust the models dynamically by altering the net-work weights when new training data were put in. The advantages of using ANN are that they could be fitted to any kind of data set and did not require model assumptions (Dong and Zhao, 2014).

Since neural networks (NNs) were first proposed by McCulloch and Pittsin1943, they have been successfully applied to different areas. Multilayer feed forward NNs are theoretically universal approximates. Due to the strong approximation capacity and learning ability, NNs are suitable for prediction and regression problems, There are numerous applications, such examples include, transportation systems and financial price forecasting (Quan et al., 2014).

Artificial neural networks consist of a large number of artificial neurons that are arranged into a sequence of layers with random connections between the layers. it can be arranged in different layers: input, hidden, and output. The hidden layer has no connections to the outside world because they are connected only to the input and output layers. Due to strong adaptive learning and fault tolerance capabilities many researchers have used neural network as prediction model in the field of construction management (Muqeem and Idrus, 2011).

Artificial neural networks (ANN), Adopted by Taha (1994), Khosrowshahi (1999), and Lam et al.(2000), it's advantages are: data-driven self-adaptive methods in that there are

few a-priori assumptions about the models for problems under study, the statistical distribution of the data need not be known, non-convergence in the data is implicitly accounted for by the internal structure of the ANNs, suitable for analyzing the non-linear relationship between the output variables, ANNs results can be generalized capable of making both calculations and inferences on a complex combination of the quantitative and qualitative data, and uncertainties and inaccuracies were reduced to the lowest level, but it has some of disadvantages, it is hard for a neural network model to give an explanation as to why a candidate contractor was qualified or disqualified, the ANN are often criticized for exhibiting a low degree of comprehensibility, the ANN model suffers from the difficulties in the acquisition of training pairs for the private client's projects, and the ANN requires a large amount of historical data for training (El-Sawalhi et al., 2007).

2.7.1 Basics of ANN

ANNs are data-driven self-adaptive methods in that there are few a-priori assumptions about the models for problems under study. It is a massively parallel processor made up of simple processing units, which has a natural propensity for storing experiential knowledge and making it available for use. The procedure used to perform the learning process is called the learning algorithm. It has a large number of nodes and connections. Each connection points from one node to another and is associated with a weight (El-Sawalhi et al., 2007).

2.7.2 Structuring of ANN

Neural network structure plays a significant role in model accuracy, generalization and over fitting is directly related to the architecture used in the neural network to model the data, since training iterations and the number of hidden units are key elements during the training of the network, and adjusting these elements could lead to great improvements in the networks modeling capability (Dindar, 2004).

Bouabaz & Hamami (2008), demonstrated that there is a number of factors for selecting the neural network structure and rules, such as the nature of the problem, data characteristics, complexity of data and the number of sample data. The network architecture refers to the number of hidden layers and the number of nodes within each hidden layer. As a matter of fact, there are two questions in designing a neural network

that have no specific answers because they are mainly depend on application; the first is the required data to train a network, and the best number of hidden layers and nodes to be used. Generally, the more data and the fewer hidden layers and hidden nodes that can be used, is the better. There is a subtle relationship between the number of facts and the number of hidden layers/nodes. Having too few facts or too many hidden layers/nodes can cause the network to "Memorize". When this happens, it performs well during training but tests poorly (ElSawy et al., 2011).

The main building elements of ANNs are neurons or nodes and the links connecting between them. Each link has a weight parameter associated with it. These nodes or neurons are assorted into three categories, which are input, output, and hidden neurons. Each neuron receives stimulus from the neighboring neurons connected to it, processes the information and produces an output. There are different ways in which information can be processed by a neuron, and different ways of connecting the neurons to one another. In general, different neural network structures can be constructed by using different neurons or nodes and by the specific manner in which they are connected (Cengiz et al., 2005).

The ANN structure consists of three layers are illustrated in Figure 2.2 , an input layer which receives data; an output layer which sends computed information; and one or more hidden layers to link input and output layer, All or a fraction of the neurons in a layer are connected with all or a part of neurons of the previous and the next layer (Cengiz et al., 2005).

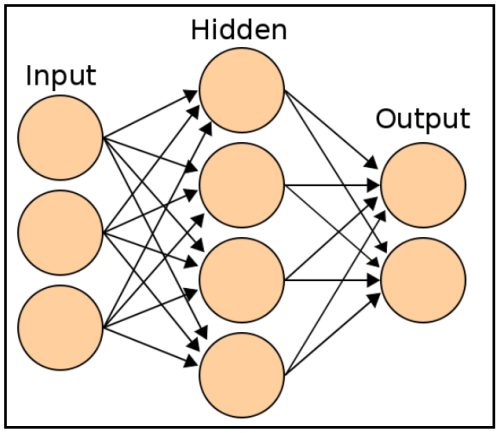

Figure 2.2: Layers of ANN (Cengiz et al., 2005)

2.7.3 Architecture of neural networks

- **Feed-forward networks**

Feed-forward ANNs allow signals to travel one way only, from input to output. There is no feedback (loops) i.e. the output of any layer does not affect that same layer. Feed-forward ANNs tend to be straight forward networks that associate inputs with outputs. They are extensively used in pattern recognition. This type of organisation is also referred to as bottom-up or top-down (Chen et al., 2014).

- **Feedback networks**

Feedback networks can have signals travelling in both directions by introducing loops in the network. Feedback networks are very powerful and can get extremely complicated. Feedback networks are dynamic; their 'state' is changing continuously until they reach an equilibrium point. They remain at the equilibrium point until the input changes and a new equilibrium needs to be found. Feedback architectures are also referred to as interactive or recurrent, although the latter term is often used to denote feedback connections in single-layer organizations (Chen et al., 2014).

Chen et al., (2014) summarized the structure and mathematical model for ANN, the ANN structures can be grouped into two major categories; feed forward and feedback (recurrent) network. In the feed forward network no loops are formed by the network connections which are strictly in one direction from one layer to another. One or more loops may exist in feedback networks. Furthermore, multilayer perception (MLP) are the most common type of feed forward networks and the back propagation algorithm, a gradient descent algorithm is the most commonly adopted algorithm for training the multilayer perception. The hidden layer neurons are the processing unit. The activation function of the processing unit acts as a squashing function such that the output of a neuron in a neural network is between certain values usually 0 and 1 or -1 and 1, mathematically, From this model the interval activity of the neuron can be shown to be:

$$V_k = \sum_{J=1}^{P} W_{kj} X_j \quad \text{..(1)}$$

The output of the neuron, yk, would therefore be the outcome of some activation function on the value of vk. This process is described in the Figure 2.3.

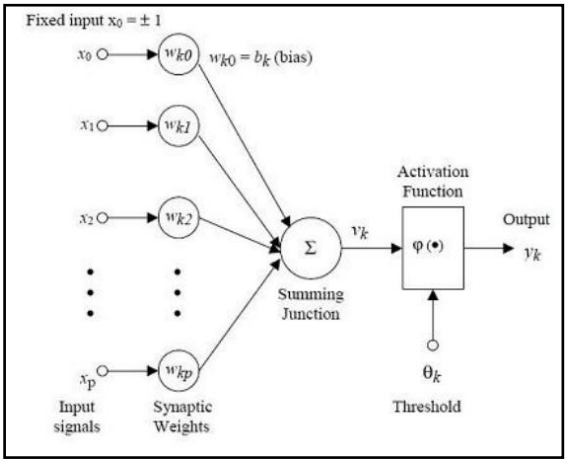

Figure 2.3: Structure and mathematical model for ANN (Chen et al., 2014).

2.7.4 Activation functions

Nygren (2004), demonstrated that the activation function performs a mathematical operation on the signal output. Depending upon the type of input data and the output required. Over the years, the researchers tried several functions to convert the input into output, various mathematical functions have been used as activation functions, These functions can take many forms: Linear, Logistic, and tangent, etc. Most commonly used are threshold function, sigmoid function, tanh function, and Bias function, etc.

As mentioned previously, the activation function acts as a squashing function, such that the output of a neuron in a neural network is between certain values (usually 0 and 1, or -1 and 1). In general, there are three types of activation functions, denoted by Φ(V) . First, there is the Threshold Function which takes on a value of 0 if the summed input is less than a certain threshold value (v), and the value 1 if the summed input is greater than or equal to the threshold value.

$$\varphi(V) = \begin{cases} 1 & if\ V \geq 0 \\ 0 & if\ V < 0 \end{cases} \quad \text{.....(2)}$$

Secondly, there is the Piecewise-Linear function. This function again can take on the values of 0 or 1, but can also take on values between that depending on the amplification factor in a certain region of linear operation.

$$\varphi(V) = \begin{cases} 1 & V \geq 0.5 \\ V & -0.5 > V > 0.5 \\ 0 & V \leq 0 \end{cases} \quad \text{.....(3)}$$

Thirdly, there is the sigmoid function. This function can range between 0 and 1, but it is also sometimes useful to use the -1 to 1 range. An example of the sigmoid function is the hyperbolic tangent function.

$$\varphi(V) = \tanh\left(\frac{V}{2}\right) = \frac{1 - e^{-V}}{1 + e^{-V}} \quad \text{.....(4)}$$

Attal (2010), the ability of ANNs to adapt different types of problems based on activation functions represents a critical flexibility. These functions experimentally change based on the placed independent variables in model and expected outputs. The mathematical activation functions used in ANNs to interpret the data between layers and input-output placed in Table 2.6.

Table 2.6: Common activation functions in ANNs (Attal, 2010)

Activation Functions	Definitions	Range
Linear	x	$(-\infty, +\infty)$
Sigmoid	$\frac{1}{(1-e^{-x})}$	(0, 1)
Hyperbolic	$\frac{e^{x}-e^{-x}}{(e^{x}+e^{-x})}$	(-1, 1)
Exponential	e^{-x}	$(0, \infty)$
Softmax	$\frac{e^{-x}}{\sum_i x_i}$	(0, 1)
Unit Sum	$\frac{x}{\sum_i x_i}$	(0, 1)
Square root	$\sqrt{x}$	$(0, \infty)$
Sine	Sin(x)	(0, 1)
Ramp	$\begin{cases} 1, x \leq -1 \\ x, -1 < x < 1 \\ 1, x \geq 1 \end{cases}$	(-1, 1)
Step	$\begin{cases} 0, x < 0 \\ 1, x \geq 0 \end{cases}$	(0, 1)

2.7.5 Types of Artificial Neural Networks

There are several types of ANNs which can be classified according to their connection geometries or by the algorithms used in the training process, such as Feed forward network, Radial basis function networks (RFB), self-organizing map (SOM),.. etc. (Cengiz et al., 2005). The following paragraph classifies the most common ANN types, which are:

- **Single-Layer Feed Forward Networks**

It is the simplest form of a layered network, which consists of a single layer of weights, where the inputs are directly connected to the outputs by series of weights. Such a network is called a single-layer network, with the designation "single layer" referring to the output layer of computation nodes (neurons). The input layer of source nodes is not counted because no computation is performed there (Al-Najjar, 2005), figure 2.4 shows the single layer feed forward network.

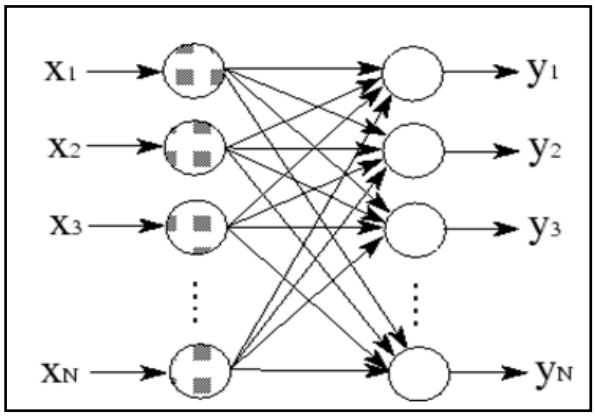

Figure 2.4: Single layer feed forward network (Al-Najjar, 2005)

- **Multilayer Perceptron (MLP)**

The most popular type of neural network in use currently is multilayer perceptron (MLP) which is commonly used in regression and classification problems. They are capable of modeling many functions but require a large amount of time, epochs, and nodes (Weckman et al., 2010).

In (MLP), neurons are organized in several layers: the first is the input layer (fed by a pattern of data), while the last is the output layer (which provides the answer to the

presented pattern). Between input and output layers there is one or more hidden layers which are comprised of the nodes chosen in the design phase. Each node of these takes the input values, associated weights, and runs them through the chosen function. The chosen function affects how and how well the network is able to learn. The node then uses a transfer function to produce a weight-associated output. The hidden node values and weights are run through the output node (layer) algorithm, and a final output value is calculated (Dowler, 2008). Figure 2.5 shows (MLP) network.

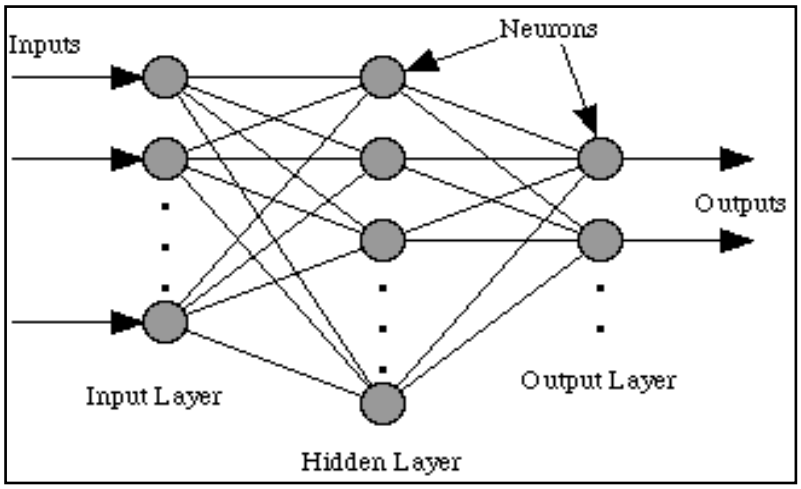

Figure 2.5: Multilayer Perceptron (Christian et al., 2000)

▪ **General Feed Forward (GFF)**

GFF networks are a special case of MLP such that connections can jump over one or more layers, The GFF networks often solve the problem much more efficiently. A classic example of this is the two-spiral problem. Without describing the problem, it suffices to say that a standard MLP requires hundreds of times more epochs of training than the generalized feed forward (for the same size network) (Principe et al., 2010). See Figure 2.6

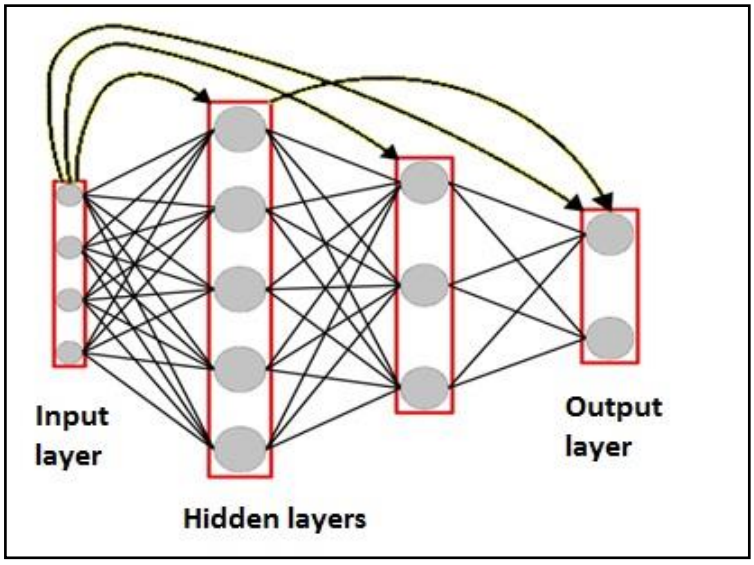

Figure 2.6 : General Feed Forward networks structure (Principe et al., 2010)

- **Recurrent Networks**

A recurrent neural network distinguishes itself from a feed forward neural network in that it has at least one feedback loop. Recurrent neural networks (RNN) have a closed loop in the network topology. They are developed to deal with the time varying or time-lagged patterns and are usable for the problems where the dynamics of the considered process is complex and the measured data is noisy (Al-Najjar, 2005).

2.7.6 Why ANN?

Contractor selection process often involves much inexact, uncertain and incomplete information therefore it is very difficult to measure, especially, the judgments and preferences of decision makers. The uncertainty is due mainly to the fuzziness and randomness associated with contractor performance, decision-maker experience, selection criteria and the qualitative judgments. These substantial uncertainties and subjectivities have hampered the applicability of many methods which have been used widely in selection process problems and require high quality data (Morote, 2012).

El-Sawalhi et al., (2007) said that the model that gives the best results should be able to meet the specific characteristic of the selection problem. The critical characteristics of the selection process are:

- selection process is a multi-criteria problem. The proposed model should do analysis of the criteria on a simultaneous basis.

- selection process contains risks inherited from different decision maker's opinion.
- selection process includes noisy and uncertain date given by different contractors.
- selection process contain subjective judgment made by decision makers.
- selection process include non-linear relationships between contractor's attributes and their bid pricing with selection decisions.
- The model should be able to adapt the results to suite changes associated between different contractors.
- It should be able to deal with qualitative as well as quantitative data.

To investigate the suitability of the published models to meet these characteristics, the specific abilities of historical models used for contractors selection are illustrated in Table 2.7.

After extensive investigation of the published selection models, it is found that the Neural Network (ANN) is the most relevant model to cope with the above mentioned characteristics, also it can perform tasks that a linear program cannot. When an element of the neural network fails, it can continue without any problem by their parallel nature. A neural network learns and does not need to be reprogrammed. It can be implemented in any application. It can be implemented without any problem. Due to all above reasons, this study select a neural network method to develop a model for awarding system for construction projects in the Gaza Strip.

Table 2.7: Comparisons between the published models abilities (El-Sawalhi et al., 2007)

NO.	Models / critical characteristics	(DWA)	(KBS)	(MAA)	(FST)	PERT	(AHP)	(MAU)	(CBR)	(ANN)
1	Group decision	-----	-----	-----	-----	-----	T	-----	T	T
2	Deal with subjective judgment	-----	-----	-----	T	-----	-----	T	T	T
3	Non-linear behavior	-----	-----	-----	T	-----	-----	-----	T	T
4	Uncertainty and risks considered	-----	-----	-----	T	T	-----	T	T	T
5	No needs training of the system	T	T	T	T	T	T	T	-----	-----
6	Ability to interpret the results	T	T	T	T	T	T	T	-----	-----
7	Understanding the mathematical behavior	T	T	T	T	T	T	T	-----	-----
8	Adaptive model	-----	-----	-----	-----	-----	-----	-----	T	T
9	Multiple criteria simultaneously	-----	-----	-----	T	T	T	T	T	T
10	Not acquire high knowledge to implement	T	T	T	-----	-----	T	-----	-----	T
11	Qualitative and quantitative data	-----	-----	-----	T	T	T	T	T	T

2.8 The Bid Awarding System in Gaza Strip

The owners and implementing agencies in Gaza Strip performed their bidding process more or less through similar or comparable steps, the investigation about the process used in many implementing agencies, donors, and local public institutes such as : Palestinian Economic Council for Construction and Development (PECDAR), Kreditanstalt Für Wiederaufbau (KFW), Ministry of Health (MOH), Ministry of Local Government (MOLG), United Nation Relief and Works Agency (UNRWA) and others organization lead to the following finding (Medoukh, 2008) :

1. All bidders are informed through at least one public announcements in the local newspaper, or through a private invitation in the case of limited bidding.

2. At least three classified contractors in the required class are invited to submit their bids.

3. The classification of the Palestinian Contractors Union (PCU) is required and acceptable to all agencies and owners.

4. The time between invitation and bid submission is variable from 10 days to 30 days depend on the nature and size the project.

5. The offers are opened on the date announced by the envelope-opening committee.

6. All offers must be checked by the bids opening committee. A record of bid opening, identifying all the bids received, the bid prices including alternative bids if any, and the presence or absence of the requisite bid security, read out at the public opening of bids, and should be formally prepared. All discounts offered, modifications, and withdrawals should also be recorded. All members of the bid opening committee or persons responsible for bid opening should sign the record of the bid opening.

7. All offers must be evaluated by the bids evaluation committee, and then awards the contract to the lowest bidder who satisfies the contract conditions and specifications.

8. The implementing agency should always ensure that the bidder whose bid has been evaluated as the lowest evaluated substantially responsive bid has the financial and technical capability to execute the contract satisfactorily. If this is determined as

positive, the contract shall be awarded to the bidder which submitted the lowest evaluated substantially responsive bid.

Emphasis directed towards encouraging lowest bid price should be redirected towards establishing contractor's ability for achieving project owner's satisfaction by supplying high project performance (time) and high quality of completed product. The outcome of a construction project can be measured in terms of cost, time, and quality achieved (Topcu, 2003).

2.9 Summary

According to previous studies, the following is a summary of the most important results:

1. Contractor selection is a process to evaluate candidate contractors' ability to complete a contract satisfactorily before awarding process.

2. The selection based on the low price basis can be one of the reasons for project completion delays, poor quality and/or financial losses, etc.

3. A large number of contractor selection models and criteria were identified.

4. A brief overview of the contractor selection practices worldwide was taken to illustrate the different systems of contractor selection being used.

5. Detailed explanation of ANN as decision-making tool indicating its importance in contractor selection process.

6. Today's growing numbers of contractor selection methodologies with different criteria reflect the increasing awareness of the construction industry for improving its contractor selection process, So Institutions operating in the Gaza Strip must develop methods of selection of contractors.

CHAPTER 3
Research Methodology

This chapter discusses the methodology used in this research. The adopted methodology to accomplish this study used historical data analysis as the base of providing a relation between the factors affecting on contractor selection process.

It provides the information about the research strategy, population and sample size, questionnaire design and contents, pilot study, process of data analysis, case studies to establish relevant data to build the model, and developing and evaluating of the model validity are presented

3.1 Research Strategy

Research strategy in general means a plan of action by which the research objectives can be questioned. This research is concerned about finding a more accurate and suitable technique to choose the most competent bidder to execute a project through selection process. To achieve this, the researcher adopted a strategy that consists of five phases as shown below:

Phase 1: Topic selection and thesis proposal phase

Selection of the topic, problems are defined, objectives are established, and research plan is developed.

Phase 2: Literature review phase

A summary of literature review regarding the criteria used in the selection process and summary of used models were reviewed.

Phase 3: Data collection and questionnaire design phase

Data was collected quantitatively by the study survey instrument which was the prepared and piloted questionnaire. Collection of data from the study population sample in the field took about fifteen days. The average time for filling a questionnaire was about 15 minutes.

The researcher found that ANN technique is applicable and adaptable model among other used models in the selection process. The researcher determined the criteria of the selection process and its relevant factors that used in the design of the questionnaire. The questionnaire focused on two parts. The first part was general questions and the second part was regarding the main criteria and the relevant factors that affect the contractor selection. In this questionnaire, the most important factors were determined based on the relative importance index. Then based on the results of the questionnaire, the weights of the selection criteria are determined.

A structured questionnaire was used in this research to identify the main parameters affecting awarding process in construction projects in Gaza Strip. For the need of many data to develop the neural network model, many historical projects that were done between 2010 and 2012 in Gaza Strip were collected from municipalities, government ministries, engineering institutions, contractors and consultants in this period especially due to resumption of implementing construction projects in those years after several interruption years because of the Israeli blockade.

It is to be noted that the questionnaire is prepared in "Arabic Language" in order to avoid any misunderstanding of its topics. A copy of the English questionnaire and an Arabic version of it are attached in Annex 1 and Annex 2 respectively. As most of the studied population can not use English, a translator carried out the translation. An academic expert also reviewed the Arabic version in order to achieve accuracy as much as possible.

Phase 4: Developing and evaluating the model

Developed simple model based on ANN approach that can be used in the selection of the contractors in Gaza Strip. This model is flexible and the user can enter any criteria that fit his requirements. The model was developed by using NeuroSolution 5.07. Accordingly, the best model was tested and the sensitivity analysis have been assessed by variation in the cost of projects.

Phase 5: Conclusion and recommendation phase

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

recommendations. Figure 3.1 shows the methodology flowchart, which leads to achieve the research.

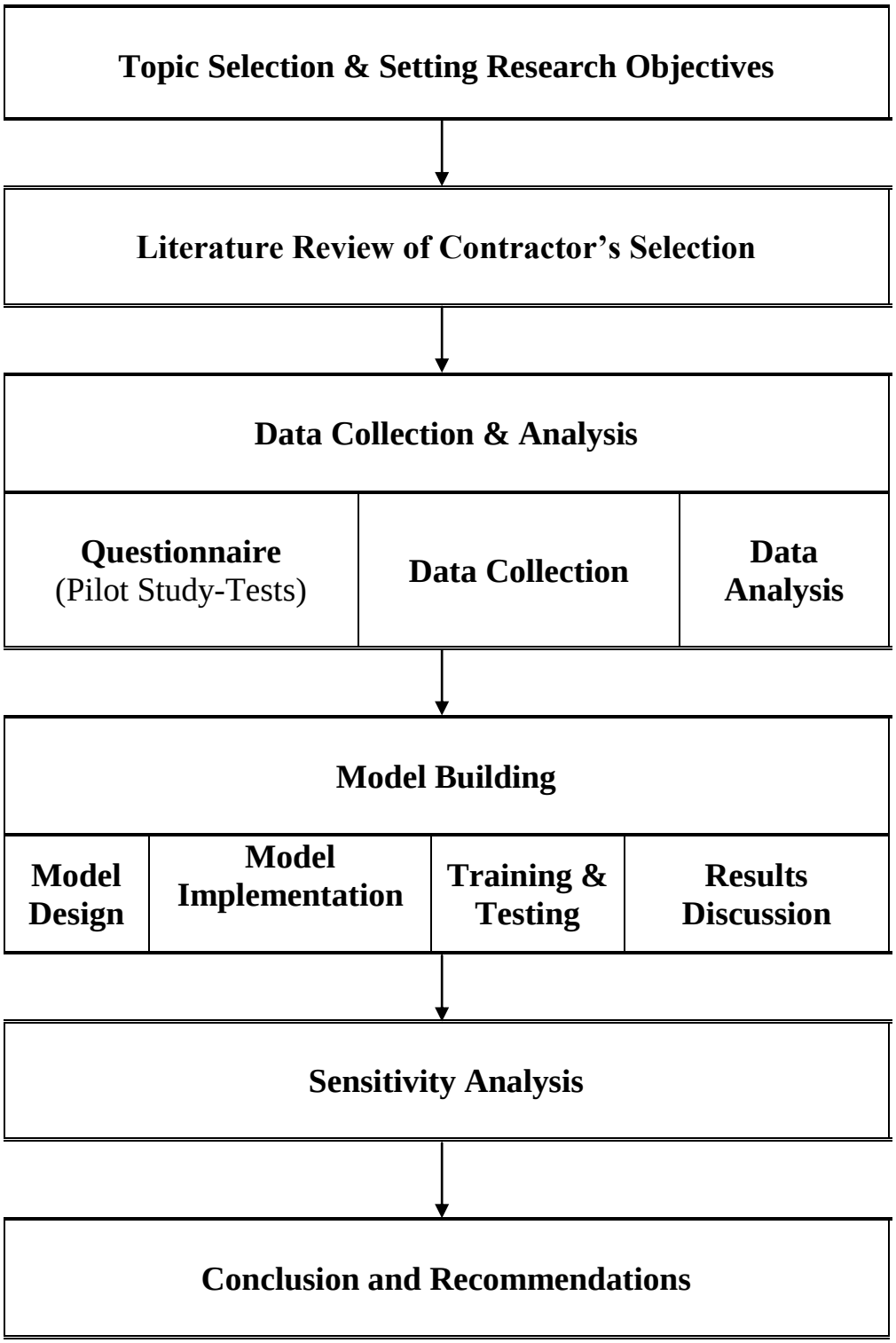

Figure 3.1: The methodology flow chart

3.2 Questionnaire content validity

The researcher assessed the content validity and reliability of the questionnaire by two ways are as follows:

A) Arbitrating the questionnaire

Distributing the questionnaire to a group of arbitrators containing three experts who have wide experience in subject of the research. The researcher has modified, deleted, and added the necessary parts of the questionnaire in response to the group's suggestions.

B) Pilot study

After the preliminary testing, a pilot study was conducted to evaluate the questionnaire, the researcher distributed the questionnaire to a sample of 10 persons which considered as experts in their organizations and with more than 15 years expert in the evaluation of contractor's bids, most of them are members of officials evaluation committees, project managers, donors representatives, or professional consultants. Generally speaking, it appeared that respondents had no difficulty in understanding the items or the instructions to complete the questionnaire. Based on the comments of the experts some modifications in the text of the questionnaire are performed. The modifications are discussed with the supervisor and then the questionnaire is finalized. The researcher has tested the internal concurrence of the questionnaires by calculating the correlation coefficients between each item and the related items of the field.

3.2.1 Questionnaire statistical validity

In order to ensure the validity of the questionnaire and to be sure that the objective of each paragraph is to achieve the main aim of the questionnaire , two statistical tests should be applied :

A) Criterion- related validity

Internal consistency of the questionnaire has been checked through measuring the correlation coefficients between each section and the whole questionnaire.

Statistical Package for Social Science (SPSS) software has been used to find Pearson correlation coefficient. If significance level (P-value) for statment within a group is

found to be less than (0.01-0.05), this means the correlation coefficient is significant at x = 0.05 and then the statment is consistent and valid to measure what is set for. On the other hand, if P-value is less than or equals 0.01, this means the correlation coefficient is significant at x = 0.01 and the paragraph is valid to measure its objective. The following table shows such computations :

Table 3.1 : Correlation coefficients between items and their related section

Main Factor	**Sub Factor**	**Pearson Correlation**	**Significance level**
Financial stability	Capital of the Company	0.799	0.00**
	Liquidity	0.833	0.00**
	Debt Volume	0.819	0.00**
	Banking Facilities	0.842	0.00**
	Profitability	0.746	0.00**
Management capabilities	Organizational Structure	0.857	0.00**
	Policy of health and safety	0.847	0.00**
	Experience of the managerial staff	0.908	0.00**
	Availability of training system	0.909	0.00**
	Use of computerized systems	0.916	0.00**
	Availability of monitoring, tracking, and evaluation system	0.862	0.00**

Table 3.1 : Cont.

Experience	Number of projects implemented from 3 years	0.929**	0.00**
	Amount of projects implemented from 3 years	0.925	0.00**
	The amount of similar projects implemented from 3 years	0.946	0.00**
	The adherence to the contractual period from 3 years	0.887	0.00**
Technical ability	Volume of equipment and machinery	0.908	0.00**
	Number of the technical staff	0.956	0.00**
	Experience of the technical staff	0.941	0.00**
	Technological means used	0.855	0.00**
	Classification of company	0.796	0.00**

**Correlation is significant at the 0.01 level.

B) Structure validity

Structure validity is the second statistical test that used to test the validity of the questionnaire structure by testing the validity of each field and the validity of the whole questionnaire. It measures the correlation coefficients between the field (a field is part

of group and consists of many paragraphs) and the whole fields of the questionnaire that have the same level of likert scale. Table 3.2 shows the Structure Validity.

Table 3.2 : Validity of each field and the validity of the whole questionnaire

Main Factor	Pearson Correlation	Significance level
Financial stability	0.914	0.00
Management capabilities	0.932	0.00
Management capabilities	0.946	0.00
Technical ability	0.941	0.00

3.3 Questionnaire reliability

Reliability means the capacity to repeat a result, and is a measure of the instrument used in the research. A research instrument is anything that produces information, from a tape measure to a questionnaire. Reliability is generally measured by means of statistics. A reliable research instrument is one that produces the same result, within reasonable boundaries. A questionnaire that produces substantially the same responses each time it is administered to a certain group of people is a reliable measuring instrument. The researcher conducted two tests on the pilot study sample to measure the questionnaire reliability, the two test are Split-Half Coefficient and Alpha- Cronbach's Method.

A) Split-Half Coefficient method

Significance levels of exploratory sample have been used to compute questionnaire reliability using Split-half model. The method randomly divides the measurement instrument into two halves. Each of the two sets of items is treated as a separate instrument form and is scored as such. The two sets of scores are correlated, and this is considered to be an estimate of the measure of reliability. Then, correcting the Pearson correlation coefficients can be done by using Spearman Brown correlation coefficient of correction. Table 3.3 shows that the questionnaire had a highly degree of validity.

Table 3.3 : Split-Half Coefficient method

Main Factor	Pearson Correlation	Spearman- Brown Coefficient
Financial stability	0.654	0.769
Management capabilities	0.853	0.921
Management capabilities	0.876	0.934
Technical ability	0.858	0.926
Total	0.895	0.944

B) Cronbach's Coefficient Alpha

Researcher has used another method to compute reliability of questionnaire where alpha coefficients value for each section and the total average of the questionnaire have been computed . The normal range of Cronbach's coefficient alpha value is between 0.0 and +1.0 where higher values reflect a higher degree of internal consistency.

Table 3.4 shows Alpha- Cronbach Coefficients, the results were ranged from 0.866 and 0.944, which means that there are significance and highly validity coefficients.

Table 3.4 : Reliability Cronbach's Alpha

Main Factor	Cronbach's Alpha
Financial stability	0.866
Management capabilities	0.944
Management capabilities	0.941
Technical ability	0.934
Total	0.937

3.4 Importance of factors

The factors that influence the awarding process in Gaza Strip were categorized into four groups; financial stability, management capabilities, experience, and technical ability.

The respondents were asked to provide their opinions on the identification of awarding criteria for contractors in the construction sector in Gaza Strip. Likert scale at scores from 1 to 5, where "1" represent very low and "5" the very high.

Analysis of questionnaire quantitative data was done by using relative importance index (RII) as a statistical tool. Relative importance indices were calculated using the following formmula:

$$\text{Relative importance index (RII)} = \frac{\sum w}{AN} = \frac{\sum_{i=1}^{i=5} i \times n_i}{5N} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where w is the weight given to each factor by the respondent, ranging from 1 to 5,

n5 = number of respondents for Very Important,

n4 = number of respondents for Important,

n3 = number of respondents for Medium Importance,

n2 = number of respondents for Low Importance,

n1 = number of respondents for No Importance.

A is the highest weight (i.e.5 in the study) and N is the total number of samples. The RII equals ranges from 0 to 1.

CHAPTER 4
Data Collection and Results

In fact, one of the most significant keys in building the neural network model is identifying the factors that have real impact on the awarding process. Depending on this great importance of selecting these factors, several techniques were adopted carefully to identify these factors in Gaza Strip construction projects; as reviewing literature studies, and a questionnaire survey.

In this chapter, the results of the field survey are presented and discussed. This chapter illustrates and discusses the characteristics of the study population. The factors affecting the bid awarding are presented.

4.1 Questionnaire analysis

Seventy questionnaires were distributed to various engineering institutions. Fifty four questionnaires, as a response rate 77% of the total number of questionnaires, have been correctly answered and submitted. These questionnaires were cleaned, and some of them were omitted due to incomplete data. More details and analysis are discussed in the following section.

4.1.1 Population characteristics

The characteristics of study population comprise of type of organization, types of implemented projects, value of implemented projects, job title, years of experience, contractors Union classification.

4.1.1.1 Description of respondent organization

Table 4.1 shows the type of organizations and the sample size for the study population. In addition, it shows number of valid respondents of each organization.

Table 4.1: Distribution of questionnaire according to organization type

No.	Description	Frequency	Percent (%)
1	Public Owner	18	33
2	Donor	3	6
3	NGOs	10	18
4	Implementing agency	8	15
5	Consultant	6	11
6	Other organizations	9	17
Total		**54**	**100**

As outlined in Table 4.1, the sample size respondents number consists of 33% as public owners, 6% as donors, 19% as NGOs, 15% as implementing agencies, 11% as consultants and 17% as other organizations. The majority of the respondents are involved in awarding process and this strengthens the results and recommendations.

4.1.1.2 Types of implemented projects

Table 4.2 shows that 15% of the implemented projects is housing, 24% is public buildings, 26% is roads, 7% is water and wastewater projects, 4% of the implemented projects is private buildings and 24% is others.

Table 4.2 : Types of implemented projects

No.	Description	Frequency	Percent (%)
1	Housing	8	15
2	Public buildings	13	24
3	Roads	14	26
4	Water and Wastewater	4	7
5	Private buildings	2	4
6	Others	13	24
Total		**54**	**100**

As outlined in Table 4.2, The participants in the questionnaire varied between several areas of expertise, and this gives added strength to the analysis of the questionnaire.

4.1.1.3 Value of implemented projects

Table 4.3 shows that 34% of the implemented projects got an average annual value (=>10) million dollars, 9% of the implemented projects value is between (=5 m to <10 M) dollars. As well 17% of the implemented projects values is between (=2 M to <5 M) dollars, 15% of implemented projects value is between (=1M to <2M) dollars, and 25% of implemented projects value is less than 1M dollars.

Table 4.3 : Average annual value of the implemented projects

No.	Item	Frequency	Percent (%)
1	=>10M	18	34
2	=5 M – <10M	5	9
3	=2 M – <5 M	9	17
4	=1M – <2M	8	15
5	< 1M	13	25
Total		**54**	**100**

As outlined in Table 4.3, over the past five years, 43 % of executed projects are over 5 million dollars. The results show that about half of the implemented projects by the respondents of value more than 5 M dollars, which means that the total value of the projects implemented is relatively high.

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4.1.1.4 Respondent's occupation

Table 4.4 shows that 17% of the respondents occupation in their organization is project manager, 24% of the respondents occupation is construction supervisor, 20% of the respondents occupation is other positions. In addition 20% of the respondents occupation is head of department, 11% of the respondents occupation is office engineers, and 8% of the respondents occupation is procurement specialists. The researcher is satisfied with the level of importance the respondents in general give to fill this questionnaire.

Table 4.4 : Respondent's occupation

No.	Item	Frequency	Percent (%)
1	Project Manager	9	17
2	Construction Supervisor	13	24
3	Head of Department	11	20
4	Office Engineer	11	20
5	Procurement Specialist	6	11
6	Others	4	8
Total		**54**	**100**

4.1.1.5 Respondent's experience

Table 4.5 shows that 17% of the respondents experiences is more than 15 years, 33%of the respondents experiences is between 10 to 15 years, 24% of the respondents experiences is between 5 to 10 years, and 26% of the respondents experiences is less than 5 years. The result shows that 50% of respondents have more than 10 years of experience, which gives the research more confidence in the results.

Table 4.5 : Respondent's experience

No.	Description	Frequency	Percent (%)
1	More than 15 years	9	17
2	10-15 years	18	33
3	5-10 years	13	24
4	Less than 5years	14	26
Total		**54**	**100**

4.1.1.6 Dependence on the Palestinian Contractors Union (PCU) classification

Table 4.6 shows that 24% of the respondents' organization always depends on PCU classification, 46% often depends on PCU classification, 9% sometime depends on PCU

classification, 8% rarely depends on PCU classification, while 13% never depends on PCU classification. These results indicate the significance of PCU classification.

Table 4.6 : Adopt of classifying of the contractors union

No.	Description	Frequency	Percent (%)
1	Always	13	24
2	Often	25	46
3	Sometimes	5	9
4	Rarely	4	8
5	Never	7	13
Total		**54**	**100**

4.1.1.7 Awarding to the lowest price

Table 4.7 shows that 32%of the responses is always bid are awarded to the lowest price, 48% of the responses is often, 11% of the responses is sometimes, 7% of the responses is rarely, and 2% of the responses is never .

Table 4.7 : Awarding to the lowest price

No.	Description	Frequency	Percent (%)
1	Always	17	32
2	Often	26	48
3	Sometimes	6	11
4	Rarely	4	7
5	Never	1	2
Total		**54**	**100**

The results shows that 32% of the respondents' organizations always awarding on the contractor with the lowest, and 48% often awarding on the contractor with the lowest. The results show high tendency toward awarding on the contractor with the lowest.

4.1.2 Factors influencing the awarding process in Gaza Strip

4.1.2.1 The factors related to the financial stability

Table 4.8 shows the respondents' opinion regarding the factors related to the financial stability of the company. The factors' relative importance index (RII) is as the following: "The liquidity of the company" with RII equals 0.83 and rank equals 1, "The capital of the company" with RII equals 0.77 and rank equals 2, "The banking facilities provided by the company" with RII equals 0.70 and rank equals 3, "The profitability" with RII equals 0.65 and rank equals 4, and "The debt volume of the company" with RII equals 0.64 and rank equals 5. The results indicate the extent of significance of the financial stability in the awarding process. The contractor's financial stability is an indication of his ability to execute the project and to meet financial obligations where it is considered as one of the most important criteria for evaluating the capability of general contractors.

The relative importance index of the liquidity of the company equals 0.83, which indicates its highest importance. Same thing is valid for the capital of the company and the banking facilities.

Table 4.8: The factors related to the financial stability of the company

Factor	RII	Rank
The liquidity of the company	0.83	1
The capital of the company	0.77	2
The banking facilities	0.70	3
The profitability	0.65	4
The debt volume of the company	0.64	5

4.1.2.2 The management capabilities

Table 4.9 shows the respondents' opinion regarding the factors related to the management capabilities of the company. The factors' RII is as the following: "The experience of the managerial staff of the company" with RII equals 0.79 and rank equals

1, "The existence of an appropriate organizational structure for the company" with RII equals 0.71 and rank equals 2, "The availability of monitoring, tracking, and evaluation system of the company" with RII equals 0.70 and rank equals 3, "The existence of policy for the company in the field of health and safety standards to control the work" with RII equals 0.69 and rank equals 4, "The availability of training system for managerial staff in the company" with RII equals 0.67 and rank equals 5, and "The use of computerized systems in the management" with RII equals 0.66 and rank equals 6. The existence of an appropriate experience of the managerial staff for the company and the organizational structure of the company are with high RII 0.79 and 0.71 respectively, which reflects their importance in the awarding process. The appropriate organizational structure shows how the information and decision-making processes move between different levels. The factors related use of computerized systems in the company has low RII compared with the other factors. The researcher refers that to the nature of most companies, which considered relatively small and locally competitive and rarely depends on computerized systems to develop its performance.

Table 4.9: Factors related to the management capabilities

Description	RII	Rank
Experience of the managerial staff	0.79	1
Organizational structure	0.71	2
Availability of monitoring, tracking, and evaluation system	0.70	3
Policy of health and safety	0.69	4
Availability of training system	0.67	5
Use of computerized systems	0.66	6

4.1.2.3 The Factors related to the experience

Table 4.10 shows the respondents' opinion regarding the factors related to the experience of the company. The factors' RII is as the following:

"The amount of projects implemented by the company from 3 years " with RII equals 0.80 and rank equals 1, " The amount of similar projects implemented by the company from 3 years " with RII equals 0.79 and rank equals 2, "The number of projects implemented by the company from 3 years" with RII equals 0.78 and rank equals 3, and "The adherence to the contractual period in the implementation of projects from 3 years " with RII equals 0.77 and rank equals 4.

The experience is an essential criterion to ensure that the contractors have the skills to implement the project in terms of time, quality, and cost. The amount of projects implemented by the company from 3 years has been ranked in the first position. This indicates the high tendency of the owners to select the contractors who have this volume of experience in order to guarantee the success of their projects.

Table 4.10: Factors related to the experience of the company

No.	Description	RII	Rank
1	Amount of projects implemented	0.80	1
2	The amount of similar projects implemented	0.79	2
3	Number of projects implemented	0.78	3
4	The adherence to the contractual period	0.77	4

4.1.2.4 Technical ability

Table 4.11 shows the respondents' opinion regarding the factors related to technical ability of the company. The factors' RII is as the following:

"The experience of the technical staff" with RII equals 0.81 and rank equals 1, "The volume of equipment and machinery" with RII equals 0.79 and rank equals 2, "The number of the technical staff" with RII equals 0.77 and rank equals 3, "The classification of company" with RII equals 0.76 and rank equals 4, and "The

technological means used by the company in the implementation of projects" with RII equals 0.70 and rank equals 5.

The results indicate the importance of the technical ability of the company to enable the contractors to demonstrate that it has the technical capacity to perform the work for which it is seeking selection for specific project. The first two factors related to "the experience of the technical staff" and "the volume of equipment and machinery" have high relative importance index, which show the importance of the experience of the technical staff as well as the availability of the equipments and machinery.

Table 4.11: The factors related to the technical ability

No.	Description	RII	Rank
1	Experience of the technical staff	0.81	1
2	Volume of equipment and machinery	0.79	2
3	Number of the technical staff	0.77	3
4	The classification of company	0.76	4
5	Technological means used	0.70	5

4.1.2.5 The main factors

Table 4.12 and Figure 4.12 show the respondents' opinion regarding the selection groups of the contractors. The groups' RII is as the following:

"Experience of the company" with RII equals 0.79 and rank equals 1, "Technical ability of the company" with RII equals 0.77 and rank equals 2, "Financial stability of the company" with RII equals 0.72 and rank equals 3, and "Management capabilities of the company" with RII equals 0.7 and rank equals 4.

Table 4.12: The main factors groups

No.	Description	RII	Rank
1	Financial stability	0.72	3
2	Management capabilities	0.70	4
3	Experience	0.79	1
4	Technical ability	0.77	2

4.1.3 Awarding Stage

4.1.3.1 Consideration of selection criteria in the bid awarding decision

Five alternatives about contractor's awarding methods are presented in this section in order to select the more appropriate one according to the respondents opinions. Table 4.13 shows that "consider the selection criteria as qualification criteria only, and then award the bid to the lowest evaluated bid price" obtained 17% of the respondents opinion, "consider the selection criteria as qualification criteria only, and then award the bid to the closest bid to average of evaluated bid price" represented 4% of the respondents opinion, "award the bid to the highest weight after combination of the technical and financial scores" represented 50% of the respondents opinion. Furthermore, "consider the technical criteria as a qualification criteria only, and award the bid to the closest bid to project estimation" got 13% of the respondents opinion, " provide score to technical criteria, and award the bid to whom with the high total score" composed 13% of the respondents opinion and 1% for others .

The opinion of majority of respondents considered the technical criteria in the selection of contractors, so this opinion eliminated the single effect of the price in awarding bids, this reflects relative interest considered by the evaluators to apply a new awarding system which balances between the technical criteria and the financial ones.

Table 4.13 : Consideration of selection criteria in the bid awarding decision

No.	Description	Frequency	Percent (%)
1	Consider the selection criteria as qualification criteria only, and then award the bid to the lowest evaluated bid price	9	17
2	Consider the selection criteria as qualification criteria only, and then award the bid to the closest bid to average of evaluated bid price	2	4
3	Award the bid to the highest weight after combination of the technical and financial scores	27	50
4	Consider the technical criteria as a qualification criteria only, and award the bid to the closest bid to project estimation	7	13
5	Provide score to technical criteria, and award the bid to whom with the high total score	8	15
6	Others	1	1
Total		**54**	**100%**

4.1.3.2 Award the bid to the highest weight after combination of the technical and financial scores

Table 4.14 shows that 6% of the responses is 80% technical and 20% financial, 29% of the responses is 70% technical and 30% financial, 20% of the responses is 60% technical and 40% financial, 33% of the responses is 50% technical and 50% financial, and 12% of the responses is others.

The result shows that, 33% of respondents believe that the importance of the price factor completely equal to the importance of other factors to select the best among applicants contractor

Table 4.14 : Combination of the technical and financial scores

No.	Description	Frequency	Percent (%)
1	80% technical and 20% financial	2	6
2	70% technical and 30% financial	8	29
3	60% technical and 40% financial	5	20
4	50% technical and 50% financial	9	33
5	Others	3	12
Total		**27**	**100**

4.1.3.3 Lowest price is one of the main problems plaguing the construction sector

Table 4.15 shows that 91% of the respondents' organization think that the method of award of tenders at the lowest price is one of the main problems plaguing the construction sector, while 9% think that the lowest price is not of the main problems plaguing the construction sector. The results indicated the existence of many problems in the local construction sectors, the dominant part of respondents confirmed that the current awarding method i.e. "the lowest bid price" considered as one of the major problems of the construction sector. This outcome indicated the trends and ability of construction clients and project owners to apply new awarding methods in order to overcome the encountered problems related to contractor's selection based only on consideration of financial criteria and negligence of other significant criteria. Therefore, it is necessary to convert to new ways of awarding process other than awarding depend on lowest price.

Table 4.15 : Lowest price is one of the main problems

No.	Description	Frequency	Percent (%)
1	Yes	49	91
2	No	5	9
Total		**54**	**100**

4.1.3.4 Awarded the tender to the lowest price and select the best contractor for the project implementation

Table 4.16 shows that 9% of the respondents' organization think that way awarded the tender to the lowest price able to identify the best contractor for the project implementation, 19% of the responses is often, 24% of the responses is rarely, and 48% of the responses is never.

The result got in Table 4.15, which shows that 91 % of the answers ensured that most of problems of the construction sector in Gaza Strip are awarding the bids to the lowest bid, confirmed also the result of Table 4.16. The output of Table 4.16 shows that 72% (48%, 24%) of the respondents assured that the current awarding methods are unable or rarely enable them to select the most suitable contractor, the results achieved demonstrated the importance of this research and enhance the necessity to apply a new multi-criteria awarding system in Gaza Strip.

Table 4.16 : Lowest price and select the best contractor

No.	Description	Frequency	Percent (%)
1	Yes	5	9
2	Often	10	19
3	Rarely	13	24
4	No	26	48
Total		**54**	**100**

4.1.3.5 Award committees and the estimated cost of the project

Table 4.17 shows that 31% of the respondents' organization think that Award committees take the estimated cost of the project in awarding process, 28% of the responses is often, 24% of the responses is rarely, and 17% of the responses is never.

To ensure that there is inaccuracy in the current awarding system, the results illustrated in Table 4.17 showed that 41% (24%, 17%) agreed that the bids awarding committees don't take or rarely take into consideration the cost estimate of the project when awarding the bids to the contractors.

Table 4.17 : Award committees and the estimated cost of the project

No.	Description	Frequency	Percent (%)
1	Yes	17	31
2	Often	15	28
3	Rarely	13	24
4	No	9	17
Total		**54**	**100**

4.1.3.6 Reasons for adopting lowest price awarding method

Table 4.18 shows that 35% of the responses is speed and ease of decision awarding, 9% of the responses is do not need a specialized team in the process of awarding, 26% of the responses is transparency and fairness in the process of awarding, and 30% of the responses is others such as (donor restrictions, desire of organization for saving cost, and to benefit from the grant from donor as much as possible).

The result shows that, 35% of respondents believe that Speed and ease of decision awarding Is the main reason for the adoption of awarding a lower price system, but the speed of the decision certainly does not mean that the decision is right and the project may be facing big problems, especially during the implementation.

Table 4.18: Reasons for adopting lowest price awarding method

No.	Description	Frequency	Percent (%)
1	Speed and ease of decision awarding.	19	35
2	Do not need a specialized team	5	9
3	Transparency and fairness	14	26
4	Others	16	30
Total		**54**	**100**

4.1.3.7 Impediments to the use of other methods in the process of awarding in the construction sector

Table 4.19 shows that 28% of the responses is Lack of awareness of the dangers of awarding a lower price, 19% of the responses is inability of institutions (technically and financially) to work on the development of the process of awarding a special form, 43% of the responses is considering the price factor is the most important factor in the awarding process, and 11% of the responses is others. The result shows that, the parties to the project should be further sensitized to the importance of other factors and to clarify the disadvantages of awarding the lowest prices.

Table 4.19: Impediments to the use of other awarding methods

No.	Description	Frequency	Percent (%)
1	Lack of awareness	15	28
2	Inability of institutions (technically and financially)	10	19
3	Factor is the most important factor	23	43
4	Others	6	11
Total		**54**	**100**

4.2 The criteria weights

The selection criteria and sub-criteria have been identified based on the statistical analysis results of the questionnaire to be the base for establishing the selection model in order to determine its weights by based on Relative Importance Index (RII), obtained here represent the opinion of professionals interviewed in this study. The weight for each factor was calculated using the following formula :

Weight for each factor = RII /SUM (RII).

4.2.1 The main factor weights for contractor's selection

Table 4.20 illustrates the weights assigned to the four main factors by used the previous formula and the rank of each main factor used in the selection of contractors during the bidding stage. The weight of the Experience equals 26.51% and occupied the first rank, the weight of the Technical ability equals 25.84% and occupied the second rank, and the weight of the Financial stability equals 24.16% and occupied the third rank. Finally, the weight of Management capabilities equals 23.49 % and occupied the last rank.

Table 4.20: Weights for main factors

No.	Description	Weight (%)	Rank
1	Financial stability	24.16	3
2	Management capabilities	23.49	4
3	Experience	26.51	1
4	Technical ability	25.84	2
Sum		**100**	

The results indicated that the major decision criteria include financial stability; technical ability; management capabilities; and experience. Thus, it is concluded that these four criteria-also the price of bid are important and should be applied when performing contractor selection practice. It could be argued that the participants have put the experience factor as a more influential factor among the technical factors they did not face financial problems with contractors and perhaps political projects in the Gaza Strip

enables contractors extract more from a financial payment, which provides for the contractor financial liquidity

It is also obvious from the findings that the financial stability obtained a reasonable

weight of 24.16% that nearly to some extent with previous studies conducted by Al Wahaidi(2012) with weight 33%, the difference between the results because of differ in some of sub criteria of the item.

The management capabilities has also considerable weight in this research reaches related 23.49% and that agreed with Wahaidi(2012) where its weight was 20% Hence, the management capabilities are considered as milestone criterion in the selection process. The technical ability of the contractor is also has weight equals 25.84% which indicates to the extent of its importance in the whole process and agreed also with Wahaidi(2012) where its weight was 30%. It is noticed that the experience has a satisfactory weight equals 26.51% that less than the results of Wahaidi(2012) where its weight was 17%. The researcher refers the relatively high weight of the experience to the necessity for performance of contractors in order to implement the projects and avoid all kinds of risk has negative impact on the success of the project.

Finally, these results represent the opinion of the professionals (procurement analysts, project managers, and consultants) who were interviewed in this study to calculate the weight used RII.

4.2.2 Weights for contractor's selection (Sub-Factors)

Table 4.21 illustrates the weights assigned to the 20 sub-factors used in the selection of contractors during the bidding stage according to the respondents opinions. Column 1 of Table 4.21 shows the weight of the main factors, column 2 shows the fractional weight of each factor within the same class, and column 3 shows the factor's weight, which was calculated by multiplying the results in column 1 and 2 by each other, the results in this column represent the weight of each factor within the whole factors. The weight associated to each factor reflects its importance in the selection of contractors during the evaluation stage.

Table 4.21: Weights for Sub- Factors

Class (Main criteria)	(1) Class's Weight (%)	Sub-Factors	(2) Fractional weight of Each factor in the class (%)	(3) 3=(1X2) Factor's weight (%)
Financial stability	12.08	The capital of the company	21.44	2.59
		The liquidity of the company	23.11	2.79
		The debt volume of the company	17.82	2.15
		The banking facilities	19.49	2.36
		The profitability	18.10	2.19
Management capabilities	11.74	Organizational structure	16.82	1.98
		Policy of health and safety	16.35	1.92
		Experience of the managerial staff	18.72	2.20
		Availability of training system	15.87	1.86
		Use of computerized systems	15.63	1.84
		Availability of monitoring, tracking, and evaluation system	16.58	1.95

Table 4.21: Cont.

Experience	13.26	Number of projects implemented	24.84	3.29
		Amount of projects implemented	25.47	3.38
		The amount of similar projects implemented	25.15	3.33
		The adherence to the contractual period	24.52	3.25
Technical ability	12.92	Volume of equipment and machinery	20.62	2.66
		Number of the technical staff	20.10	2.60
		Experience of the technical staff	21.14	2.73
Technical ability	12.92	Technological means used	18.27	2.36
		The classification of company	19.84	2.56
Total	**50**			**50**

4.3 Data Collection

In fact, the process of collecting information that is related to awarding process problems is a difficult task especially in Gaza Strip, because such information is the property of each organization. However, great effort and time were exposed to collect adequate account of projects to establish appropriate data for neural network model. The methodology for collecting these data was based on personal contacts with institutions across Gaza Strip.

4.4 Data Results and RE-evaluation

In this section, a detailed analysis of data and results is presented and elaborated by using frequency analysis. The data used in this study was collected from 91 bids (13 projects) from 2010-2012. A data sheet was prepared and used to extract all useful information from each project for all contractors. Table 4.22 presents the main sources of data and the number of projects that have been obtained from these sources and Table 4.23 presents the number of contractors based on classification of projects.

Table 4.22: Data resources

Data Resources	No. of bids	Percentage (%)
United Nations Development Programme (UNDP)	27	30
Municipal Development & Lending Fund (MDLF)	44	48
Ministry of local government (MOLG)	20	22
Total	**91**	**100**

Table 4.23: Bids based on classification of projects

Project Type	No. of bids	Percentage (%)
Roads	53	58
Buildings	10	11
Water & Wastewater	28	31
Total	**91**	**100**

The researcher re-evaluates all contractors depend on a multi procedures as follow:

- Technical re-evaluation: The output of this stage is determination of technical scores of the submitted bids (Ts).

- Financial re-evaluation: The output of this stage is determination of financial scores (Fs) of the submitted bids.

- The best contractor: The final cumulative score (CS) of the bids proposals will be computed for both technical scores (Ts) and financial scores (Fs), based on a pre-defined formula .The bid will be awarded to the Contractor whose proposal achieves the highest (Cs).

The weights assigned to the selection criteria by the researcher is too close to the weights assigned by the respondents through the field investigation, the total weight of all criteria still equal to 100.

The Financial scores in re-evaluation process shall be computed based on the following criteria:

The Lowest evaluated Financial Proposal (Fm) shall be given a maximum "Financial Score" (Fs) of 100 points. Then, the financial scores of the other Financial Proposals

shall be computed based on the following formula:

$Fs = 100 \times Fm / F$

In which;

Fs = Financial scores of the Financial Proposal under consideration.

Fm = Amount of lowest Financial Proposal.

F = Amount of the Financial Proposal under consideration.

The Final Cumulative Score (CS) of the proposals will be computed for both the technical scores (Ts) and financial scores (Fs), based on the following formula:

$Cs = (Ts * 50\% + Fs * 50\%)/100$

The contract will be awarded to the contractor whose proposal achieves the highest score. The researcher reevaluates some of management capabilities factors, Organizational structure, Policy of health and safety, Experience of the managerial staff, and Training system which have values between excellent and passable as in Table 4.24 .

Table 4.24: Requirements for some of management capabilities factors

No.	Factor	Description	Requirements
1	Organizational structure	Excellent	General Manager+ Financial Manager+ managerial Manager+ secretary+ Accountant+ managerial employee
		Good	General Manager+ Financial Manager+ Accountant
		Passable	Accountant + Management employee
2	Policy of health and safety	Excellent	Plan+ training+ safety engineer
		Good	Plan
		Passable	Safety procedures
3	Experience of the managerial staff	Excellent	General manager > 20 years
		Good	10 years ≤ General manager ≥ 20 years
		Passable	General manager < 10 years
4	Training system	Excellent	Plan+ previous training
		Good	previous training
		Passable	workshops

All contractors are reevaluated based on the weights of main and sub main factors. This process conducted through three steps. The first step is determining the weights of main and sub-criteria wich is calculated by using RII. The second step is collected all necessary information for all contractors with respect to the main and sub-criteria. The third step is determining the overall weight of all the contractors in order to select the best contractor. Table 4.25 presents this process.

Table 4.25: Re-evaluation for contractors

Project No.	Contractors	Lowest evaluated bid price	Factor's weight. (CS) (%)	Order based on re-evaluation	The best contractor
1	1.1	---------	0.795	4	---------
	1.2	---------	0.786	6	---------
	1.3	---------	0.736	7	---------
	1.4	√	0.809	5	---------
	1.5	---------	0.810	3	---------
	1.6	---------	0.964	1	√
	1.7	---------	0.869	2	---------
	1.8	---------	0.734	8	---------
2	2.1	---------	0.590	6	---------
	2.2	√	0.955	1	√
	2.3	---------	0.840	3	---------
	2.4	---------	0.844	2	---------
	2.5	---------	0.828	4	---------
	2.6	---------	0.634	5	---------
3	3.1	---------	0.852	3	---------
	3.2	---------	0.943	1	√
	3.3	√	0.911	2	---------
4	4.1	---------	0.703	3	---------
	4.2	√	0.899	2	√
	4.3	---------	0.907	1	---------

Table 4.25: Cont.

5	5.1	---------	0.899	2	---------
	5.2	---------	0.742	4	---------
	5.3	---------	0.831	3	---------
	5.4	√	0.962	1	√
6	6.1	---------	0.826	3	---------
	6.2	---------	0.639	4	---------
	6.3	---------	0.862	2	---------
	6.4	√	0.920	1	√
7	7.1	---------	0.673	8	---------
	7.2	---------	0.821	3	---------
	7.3	---------	0.929	1	√
	7.4	---------	0.803	4	---------
	7.5	---------	0.783	6	---------
	7.6	---------	0.772	7	---------
	7.7	---------	0.828	2	---------
	7.8	√	0.795	5	---------
8	8.1	---------	0.749	8	---------
	8.2	---------	0.866	4	---------
	8.3	---------	0.757	7	---------
	8.4	---------	0.885	2	---------
	8.5	---------	0.887	1	√
	8.6	---------	0.741	9	---------

Table 4.25: Cont.

8	8.7	---------	0.838	5	---------
	8.8	√	0.822	6	---------
	8.9	---------	0.882	3	---------
9	9.1	√	0.763	5	---------
	9.2	---------	0.660	6	---------
	9.3	---------	0.641	7	---------
	9.4	---------	0.976	1	√
	9.5	---------	0.827	2	---------
	9.6	---------	0.800	3	---------
	9.7	---------	0.788	4	---------
10	10.1	---------	0.870	2	---------
	10.2	---------	0.688	9	---------
	10.3	---------	0.667	10	---------
	10.4	---------	0.738	6	---------
	10.5	---------	0.877	1	√
	10.6	√	0.753	4	---------
	10.7	---------	0.710	7	---------
	10.8	---------	0.740	5	---------
	10.9	---------	0.714	8	---------
	10.11	---------	0.807	3	---------
11	11.1	√	0.759	3	---------
	11.2	---------	0.956	1	√

Table 4.25: Cont.

11	11.3	---------	0.672	5	---------
	11.4	---------	0.940	2	---------
	11.5	---------	0.772	4	---------
12	12.1	√	0.844	2	---------
	12.2	---------	0.655	4	---------
	12.3	---------	0.773	3	---------
	12.4	---------	0.968	1	√
13	13.1	---------	0.862	3	---------
	13.2	---------	0.744	10	---------
	13.3	---------	0.720	15	---------
	13.4	---------	0.730	13	---------
	13.5	---------	0.770	7	---------
	13.6	---------	0.778	6	---------
	13.7	---------	0.672	18	---------
	13.8	---------	0.814	5	---------
	13.9	---------	0.745	9	---------
	13.10	---------	0.629	19	---------
	13.11	---------	0.921	1	√
	13.12	---------	0.707	16	---------
	13.13	---------	0.727	14	---------
	13.14	---------	0.741	11	---------
	13.15	√	0.900	2	---------

Table 4.25: Cont.

13	13.16	---------	0.574	20	---------
	13.17	---------	0.759	8	---------
	13.18	---------	0.828	4	---------
	13.19	---------	0.737	12	---------
	13.20	---------	0.706	17	---------

4.5 Conclusion

From the results obtained, analyzed, and discussed, the researcher concludes that:

- ✓ Regarding the part of organization profile:

- It is clear that the building constitutes 51% of the implemented projects, waters and wastewater are 7%, and roads are 26%. On the other hand, the other projects constitute 4%.

- Over the past five years, 43 % of executed projects are over 5 million dollars.

- The results indicate the importance of the respondents to enrich the survey in order to achieve the objective of this research.

- Respondents of the questionnaire are long-experienced in construction business where 50% of them have been in this field for more than 10 years.

- Hence, this result indicates that PCU classification is essential for all the targeted organizations in Gaza Strip where 24% stated they always depend on it while 46% stated they often depend on it.

- The results shows that 32% of the respondents' organizations always awards on the contractor with the lowest price, and 48% often awarding on the contractor with the lowest. The results show high tendency toward awarding on the contractor with the lowest.

- ✓ Regarding the part of the selection criteria, the criteria were ranked from the highest to lowest according to the relative importance index as follows:

- "The experience of the company" has been ranked in the first position with relative importance index 79% and this agreed with the previous studies conducted by Alfred (2006), Ng and Skitmore (1999), and Bubshait and Al-Gobali (1996).

- "The technical ability of the company" has been ranked in the second position with relative importance index 77%. The result indicates the importance of technical abilities of the company.

- "The financial stability of the company" has been ranked in the third position with relative importance index 72%. This result agreed with several previous studies such that conducted by Alfred (2006) in 15 African countries, 4 Asian countries, and 2 South American countries; Tarawneh (2004) in Jordan; Ng and Skitmore (2000) in UK.

- "The management capabilities of the company" has been ranked in the fourth position with relative importance index 70%. This result agreed with previous studies conducted by Ng and Skitmore (2000).

- "The price of bid" with weight equal 50%, "The experience" with weight equal 13.26%, "The technical ability" weight equal 12.92%, "The financial stability" weight equal 12.08%, and "The management capabilities" weight equal 11.74%.

CHAPTER 5
Model Development

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

The following sections present the steps performed to design the artificial neural network model, the limitation of adopted model, and finally the discussion and analysis of results.

5.1 Model Limitations

In spite of great accuracy of using ANN in selection of the best contractor, 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 study the most important project variables used in Gaza Strip were included. After analyzing the collected data, it is found that some limitations on input parameters should be assigned to give the best output. Table 5.1 illustrates the available range of input data in ANN model such as; price of bids has a range between 142000 – 454110 $ (100%-67.4%). The capital of the company ranges from 80000 up to 1500000 $ (100%-6.5%) Amount of projects implemented from 3 years ranges from 57500 up to 2333000 $ (100%-9.2%) and experience of the technical staff also ranges from 7 to 30 years (100%-30%).

Table 5.1: Limitations of input factors

Models numeric variables	Maximum value	Maximum Percentage(%)	Minimum value	Minimum Percentage(%)
Bid price	454110 $	100	142000 $	67.4
Capital of the company	1500000$	100	80000$	6.66
Liquidity	1400000$	100	26667$	2.3
Debt volume	15000$	100	800$	6.66
Banking facilities	YES	100	NO	0
Profitability	484618$	100	4800$	2.8
Organizational structure	Excellent	100	Passable	33.33
Policy of health and safety	Excellent	100	Passable	33.33
Experience of the managerial staff	Excellent	100	Passable	33.33
Availability of training system	Excellent	100	Passable	33.33
Use of computerized systems	YES	100	NO	0
Availability of monitoring, tracking, and evaluation system	YES	100	NO	0
Number of projects implemented from 3 years	23	100	1	7.6

Table 5.1: Cont.

Amount of projects implemented from 3 years	3500000$	100	120000$	9.2
The amount of similar projects implemented from 3 years	2333000$	100	57500$	9.2
The adherence to the contractual period from 3 years	YES	100	NO	0
Volume of equipment and machinery	678000$	100	13500$	1.9
Number of the technical staff	8	100	1	12.5
Experience of the technical staff	30	100	7	32
Technological means used	YES	100	NO	0
Classification of company	First	100	Fifth	33.33

5.2 Data Encoding

Artificial networks only deal with numeric input data. Therefore, the raw data must often be converted from the external environment to numeric form (Kshirsagar & Rathod, 2012). 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). In this research data were converted to numeric form as shown in Table 5.2.

Table 5.2: Inputs/output encoding

NO.	Input Factors	Encode (%)	Code
1	Bid Price	<65	1
		>=65-<75	2
		>=75-<85	3
		>=85-<95	4
		>=95-<=100	5
2	Capital of the Company	<5	0
		>=5-<20	1
		>=20-<40	2
		>=40-<60	3
		>=60-<80	4
		>=80-<90	5
		>=90-<=100	6
	Liquidity	<5	0
		>=5-<20	1
		>=20-<40	2
		>=40-<60	3
		>=60-<80	4
		>=80-<90	5
		>=90-<=100	6

Table 5.2: Cont.

2	Debt Volume	<5	0
		>=5-<20	1
		>=20-<40	2
		>=40-<60	3
		>=60-<80	4
		>=80-<90	5
		>=90-<=100	6
	Banking facilities	0	0
		100	1
	Profitability	<5	0
		>=5-<20	1
		>=20-<40	2
		>=40-<60	3
		>=60-<80	4
		>=80-<90	5
		>=90-<=100	6
3	Organizational structure	<35	1
		>=35-<75	2
		>=75-<=100	3

Table 5.2: Cont.

3	Policy of health and safety	<35 >=35-<75 >=75-<=100	1 2 3
	Experience of the managerial staff	<35 >=35-<75 >=75-<=100	1 2 3
	Availability of training system	<35 >=35-<75 >=75-<=100	1 2 3
	Use of computerized systems	0 100	0 1
	Availability of monitoring, tracking, and evaluation system	0 100	0 1
4	Number of projects implemented from 3 years	<5 >=5-<20 >=20-<40 >=40-<60 >=60-<80 >=80-<90 >=90-<=100	0 1 2 3 4 5 6

Table 5.2: Cont.

4	Amount of projects implemented from 3 years	<5	0
		>=5-<20	1
		>=20-<40	2
		>=40-<60	3
		>=60-<80	4
		>=80-<90	5
		>=90-<=100	6
	The amount of similar projects implemented from 3 years	<5	0
		>=5-<20	1
		>=20-<40	2
		>=40-<60	3
		>=60-<80	4
		>=80-<90	5
		>=90-<=100	6
	The adherence to the contractual period from 3 years	0	0
		100	1
5	Volume of equipment and machinery	<5	0
		>=5-<20	1
		>=20-<40	2
		>=40-<60	3
		>=60-<80	4
		>=80-<90	5
		>=90-<=100	6

Table 5.2: Cont.

5	Number of the technical staff	<5	0
		>=5-<20	1
		>=20-<40	2
		>=40-<60	3
		>=60-<80	4
		>=80-<90	5
		>=90-<=100	6
	Experience of the technical staff	<30	1
		>=30-<40	2
		>=40-<60	3
		>=60-<80	4
		>=80-<90	5
		>=90-<=100	6
	Technological means used	0	0
		100	1
	Classification of company	<35	1
		>=35-<75	2
		>=75-<=100	3
No.	**Output Parameter**	**Encode**	**Code**
1	The Best Contractor	percentage	1

5.3 Model Building

There are several types of ANNs softwares are used to predict the future values based on the past data like SPSS, MATLAB, NeuroSolution …etc. Many researchers used NeuroSolution application in building their neural networks that it achieved good performance (Wang et al., 2012).

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 NN model. In addition, the modeler has the flexibility to specify his own neural network type, learning rate, momentum, activation functions, number of hidden layers/neurons, and graphical interpretation of the results. Finally, It has multiple criteria for training and testing the model.

5.4 Data Organization

Initially, the first step in implementing the neural network model in NeuroSolution application is to organize the Neurosolution excel spreadsheet. Then, specifying the input factors that have been already encoded, which consist of 21 factors; Bid price, Capital of the company, Liquidity, Debt volume, Banking facilities, Profitability, Organizational structure, Policy of health and safety, Experience of the managerial staff, Availability of training system, Use of computerized systems, Availability of monitoring, tracking, and Evaluation system, Number of projects implemented from 3 years, Amount of projects implemented from 3 years, The amount of similar projects implemented from 3 years, The adherence to the contractual period from 3 years, Volume of equipment and machinery, number of the technical staff, experience of the technical staff, technological means used, classification of company. The desired parameter (output) which is (the best contractor).

5.5 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 in modifying the network weights to minimize the network error, and monitoring this error by cross validation set during the training process. However, test set does not enter in the training process and it hasn't 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 91 exemplars that were divided logical randomly, into three sets with the following ratio:

-Training set (includes 60 exemplars ≈ 66%).

-Cross validation set (includes 16 exemplars ≈ 18%).

-Test set (includes 15 exemplars ≈ 16%).

5.6 Building Network

Once all data were prepared, then the subsequent step is represented in creating the initial network by selecting the network type, number of hidden layer/nodes, transfer function, learning rule, and number of epochs and runs.

An initial neural network was built by selecting the type of network, number of hidden layers/nodes, transfer function, and learning rule. However, before the model becomes ready, a supervised learning control was checked to specify the maximum number of epochs and the termination limits, Figure 5.1 presents the initial network of Multilayer Perceptron (MLP) network that consists of one input, hidden, and output layer.

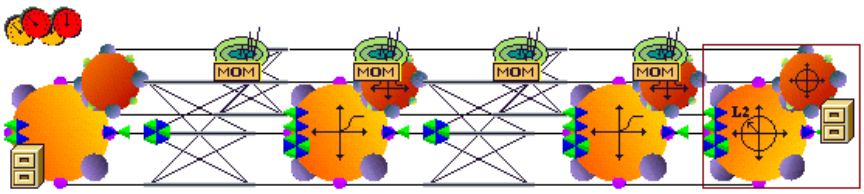

Figure 5.1: Multilayer Perceptron (MLP) network

5.7 Model Training

The objective of training neural network is to get a network that performs best on unseen data through training many networks on a training set and comparing the errors of the networks on the validation set (Dindar, 2004). Therefore, several network parameters such as number of hidden layers, number of hidden nodes, transfer functions and learning rules were trained multiple times to produce the best weights for the model.

As a preliminary step to filter the preferable neural network type, a test process was applied for most of available networks in the application. Two types Multilayer Perceptron (MLP) and General feed Forward (GFF) networks were chosen to be focused in following training process due to their good initial results.

It is worthy to mention that, previous models that have been applied in the field of selection of the best contractor by neural networks used earlier two types of networks because of giving them the best outcome.

Figure 5.2 shows the procedures of the model training, which starts with selecting the neural network type either MLP or GFF network. For each one, six types of learning rules were used, and with every learning rule eight types of transfer functions were applied, and then 3 separate hidden layers were utilized with increment of hidden nodes from 1 node up to 30 nodes in each layer. All this to obtain the best model having the best weight and minimum error percentage.

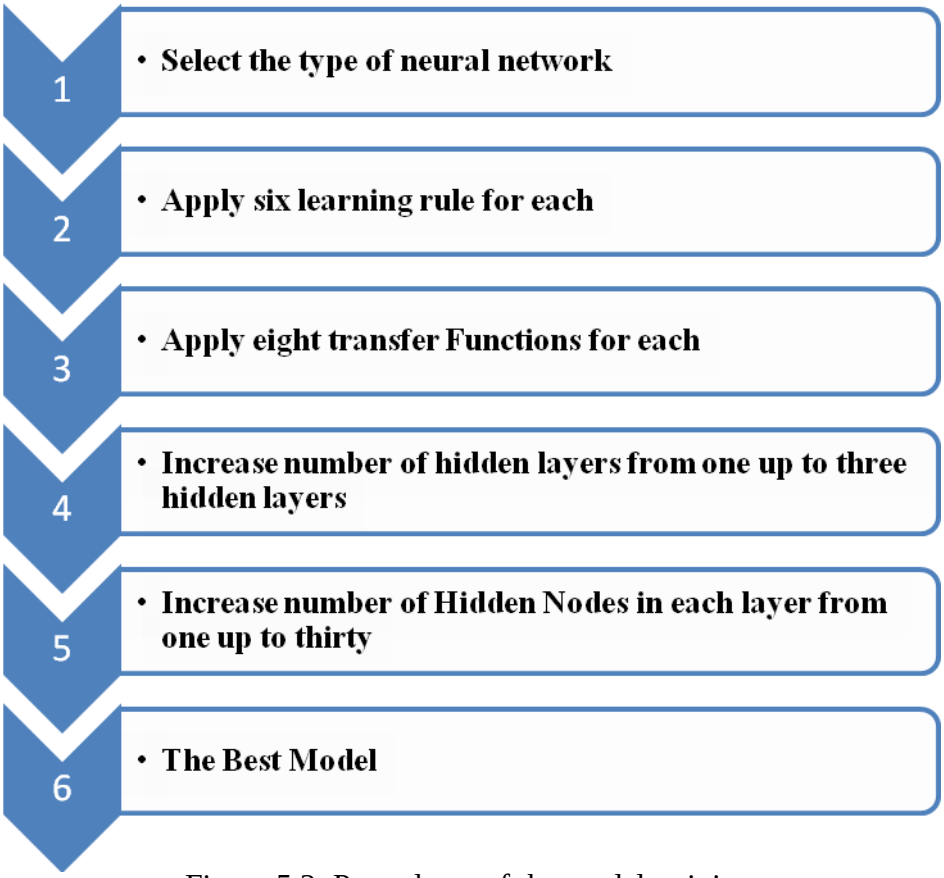

Figure 5.2: Procedures of the model training

By another word, three thousand trials contains 30 variable hidden nodes for each were executed to obtain the best model of neural network. Figure 5.3 clarifies training variables for one trial. It compromises of number of epochs, runs, hidden nodes, and other training options.

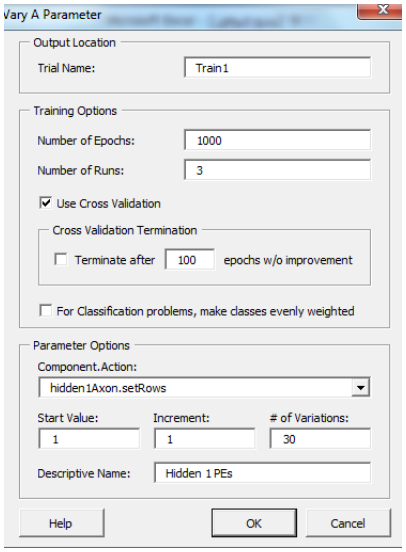

Figure 5.3: Training options in Neurosolution application

Three runs in each one 1000 epochs were applied. A run is a complete presentation of 1000 epochs, each epoch is a one complete presentation of all of the data (Principe, et al., 2010). 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.

The model was started with one hidden layer and one hidden node in order to begin the model with simple architecture, and then the number of hidden Processing Elements (PE) was growing up by one node up to 30 hidden nodes.

5.8 Model Results

As mentioned above, the purpose of testing phase of ANN model is to ensure that the developed model was successfully trained and generalization is adequately achieved. The best model that provided more accurate selection of the best contractor without

being overly complex was structured of Multilayer Perceptron (MLP) includes one input layer with 21 input neurons and one hidden layer with (30 hidden neurons) and finally one output layer with one output neuron (the best contractor) as in figure 5.4. However, the main downside to using the Multilayer Perceptron network structure is that it required the use of more nodes and more training epochs to achieve the desired results. Table 5.3 summarizes the components of the model as number of hidden layer/nodes, type of network and transfer function.

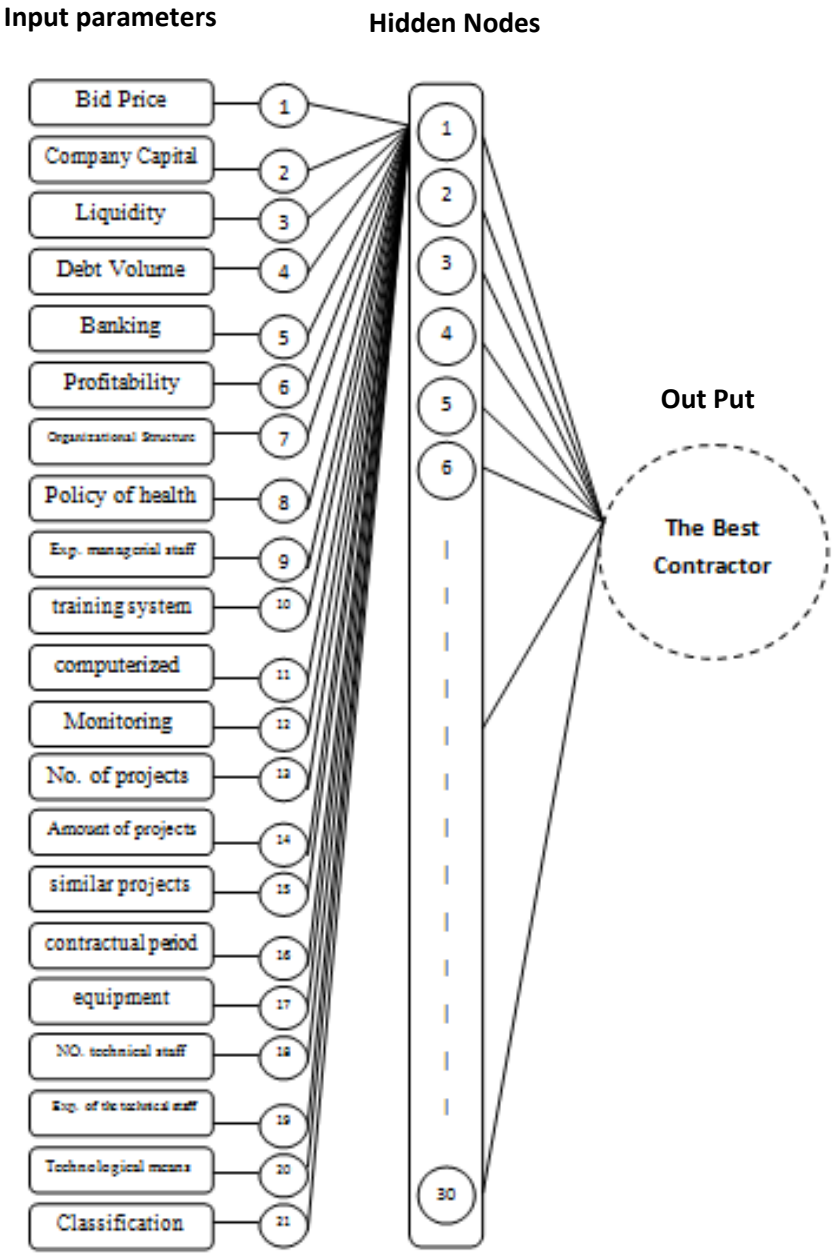

Figure 5.4: Network Architecture

Table 5.3: Components of the model

Model Type	Transfer Function	Update Methods	Gradient Search
Multilayer Perceptron	SigmoidAxon	Batch	Momentum
No. of hidden layer	**No. of PEs in the input layer**	**No. of PEs in the 1st Hidden layer**	**No. of PEs in the output layer**
1	21	30	1

5.9 Results Analysis

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

A Neurosolution test tool was used for testing the adopted model accordingly to the weights adopted. Table 5.4 presents the results of these fifteen bids with comparing the real result of tested project with estimated result from neural network model, and an absolute error with both price and percentage are also presented.

Table 5.4: Results of neural network model at testing phase

Bid No.	Recommended bid	Estimated	Absolute Error AE	Absolute Percentage Error (%)
1	0	0.01987141	0.019871	1.987141
2	0	0.02241828	0.022418	2.241828
3	0	0.04367968	0.04368	4.367968
4	0	0.00737893	0.007379	0.737893
5	0	0.00133661	0.001337	0.133661
6	1	0.7511902	0.24881	24.88098

Table 5.4: Cont.

7	0	0.0004668	0.000467	0.04668
8	0	0.00113442	0.001134	0.113442
9	0	0.04301872	0.043019	4.301872
10	0	0.14319484	0.143195	14.31948
11	0	0.00422406	0.004224	0.422406
12	0	0.0080163	0.008016	0.80163
13	0	0.05867468	0.058675	5.867468
14	0	0.0012155	0.001216	0.12155
15	0	0.0030539	0.003054	0.30539

- ✓ **Performance Measures of the model**

- The Mean Absolute error (MAE) for the presented results in Table 5.4 equals (0.0404), difference between an estimated and the actual value of the projects is small.

- The mean absolute percentage error of the model is calculated from the test cases as shown in Table 5.4, which equals 4.04%, this result can be expressed in another form by accuracy performance (AP) according to Wilmot and Mei, (2005) which is defined as (100−MAPE) %.

AP= 100% - 4.04% = 95.96%

That means the accuracy of adopted model in conceptual phase is 95.96%. It is a good result especially when no details are available.

- Regression analysis was used to ascertain the relationship between the estimated and the recommended out put. The results of linear regressing are illustrated graphically in Figure 5.5. The correlation coefficient (R) is 0.96, indicating that; there is a good linear correlation between the actual value and the estimated neural network at tested phase.

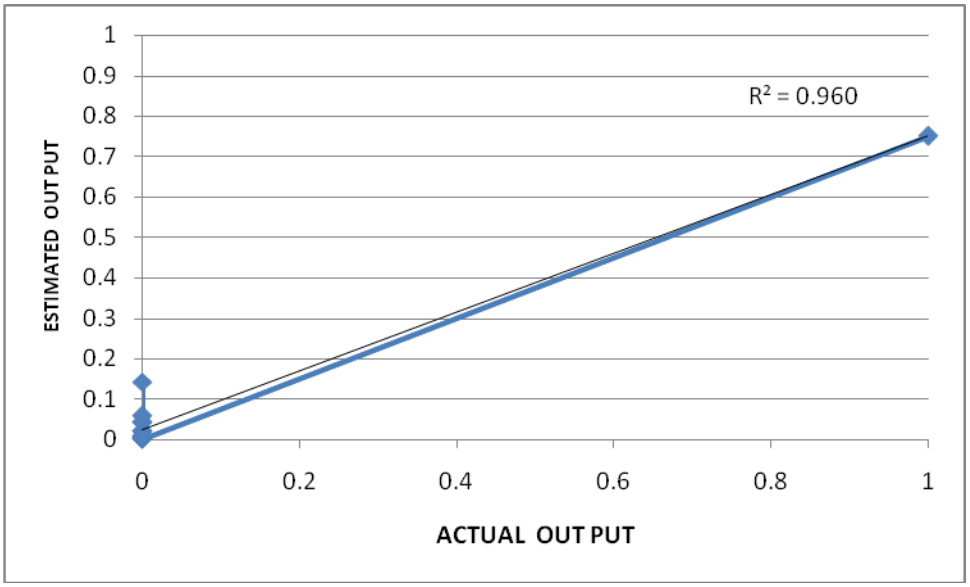

Figure 5.5: Linear regression of actual and estimated results

The results of performance measures are presented in Table 5.5, where the accuracy performance of adopted model is 94%. In which the average error is 6%.

Table 5.5: Results of performance measurements

	MAE	**MAPE**	**AP**	**R**
MLP Model	0.0404	4.04%	95.96	0.96

Figure 5.6 describes the actual output comparing with estimated out put for cross For test dataset . It is noted that there is a slight difference between two lines.

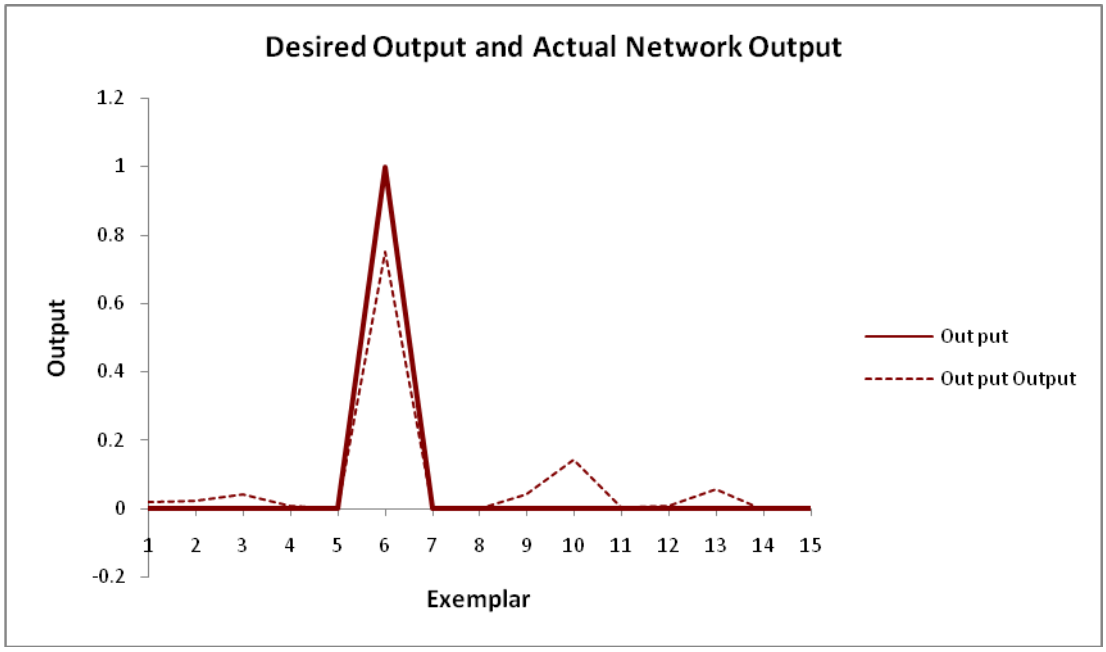

Figure 5.6 Comparison between desired and actual output for test dataset

Sensitivity analysis was carried out by Neurosolution tool to evaluate the influence of each input parameter to output variable for understanding the significance effect of input parameters on model output. Figure 5.7 presents the sensitivity analysis results for each input parameter.

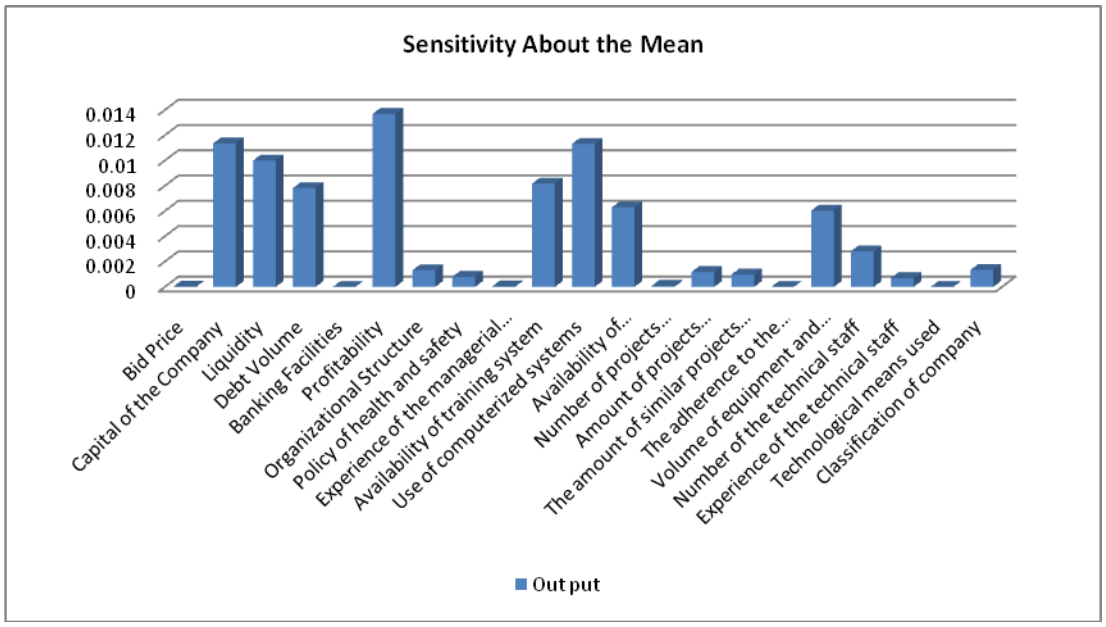

Figure 5.7: Sensitivity about the mean

The increase of Standard Deviation refers to the strength influence of this parameter on the overall selection process, Figure 5.7 shows that the Area of profitability has the highest rate of influence on the selection process.

Capital of the company has also a very significant influence, while the other parameters have a considerable gab of influence on selection of the best contractor.

The results show, the contractor has higher profitability in projects and capital of the company, the chance of winning the tender is greater.

CHAPTER 6
Conclusion and Recommendations

This study aimed at developing a new technique to improve the awarding policies in construction projects in the Gaza Strip, through developing a model that is able to help parties involved in construction projects in selection the best contractor.

The selection based on the low price basis can be one of the reasons for project completion delays, poor quality and/or financial losses, etc.

6.1 Conclusion

Respondents of the questionnaire have long-experience in construction business where 50% of them have experience of more than 10 years, and 34% of the implemented projects got an average annual value exceeds 10 million dollars.

It was found that PCU classification is essential for all the targeted organizations in Gaza Strip where 24% of the contractors are always depend on it, while 46% of them is often depend on it.

The results showed that 32% of the respondents' organizations are always awarding to the contractor with the lowest price, and 48% are often awarding to the contractor with the lowest price. The results show high tendency toward awarding on the contractor with the lowest price.

The main factors for selection the best contractor are weighted as follows: "the price of bid" is 50%,"the experience" is 13.26%, "the technical ability" is 12.92%, "the financial stability" is 12.08%, and "the management capabilities" is 11.74%. It was interaction between the financial and technical capacity to select the best contractor.

The results showed that 50% of the respondents considered that the suitable awarding system is to award the bid to the highest weight after combination of the technical and financial scores, this helps in the introduction to develop a model to award the contracts other than the lowest prices.

The causes for adopting lowest price awarding method, the results show 35% of the respondents consider the cause is speed and ease of decision awarding, this is referred to

necessity of training & awareness to the project parties about another ways of the awarding process to select the best contractor.

The results showed 43% of the respondents considering the price factor is the most important factor in the awarding process.

Ninety one contracts were used to develop ANN model. The actual bids were collected from Gaza Strip organizations were divided randomly into three sets as training set (60 bids), cross validation set (16 bids), and testing set (15 bids).

The best model that provided more accurate selection of the best contractor without being overly complex was structured of Multilayer Perceptron (MLP) includes one input layer with 21 input neurons and one hidden layer with (30 hidden neurons) and finally one output layer with one output neuron (the best contractor) .

The accuracy performance of adopted model in conceptual phase is 95.96%. It is a good result especially when no details are available.

Sensitivity analysis was performed using Neurosolution tool. The test revealed that, the profitability and capital of company had the highest influence, so the contractor has higher profitability and capital, the chance of winning the tender is greater.

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6.2 Recommendations

The current research showed very promising results in predicting the the best contractor, and this approach will continue to make impressive gains especially in civil engineering field. However, some recommendations should be presented for decision-makers in the construction sector and future studies to support the findings of this study;

All construction parties are encouraged to be more aware about contractor selection development by conducting more studies and workshops to obtain maximum advantage of this new approach, and pay more attention for using this developed technique in contractor selection.

The implementing agencies is recommended to establish comprehensive and database regarding contractors who dealt with them with respect to their financial abilities, experience, performance etc. in order to be used as the base of any selection process in future.

The implementing agencies are recommended to establish awarding committee consisting from all the parties that interested in the implementation of the specific projects.

Encouraging the implementing agencies to use ANN in the selection process and helping them to understand and apply ANN approach by initiating training and workshops.

In order to achieve the aims of a construction project, contractors must be selected for implementation of construction works through a rigorous evaluation system based on evaluation criteria which should be clearly defined in the bidding documents to the contractors before the bid submission.

The ultimate aim of contractor selection should identify the "best bidder", and not the "lowest bidder",.

6.3 Proposed Further studies

The factors weights need to be carefully examined to set commonly acceptable standard or range. It is recommended to conduct a future study to identify the suitable criteria and their weights separately for each sector (public buildings projects, rods projects, and sewage projects).

The relationship between a contractor selection approach and project's success factors is important to conducted and enhanced in future study.

References

Abu Shaban, S., 2008. Factors affecting the performance of construction projects in the Gaza Strip. Master thesis in construction management, The Islamic University of Gaza Strip.

Abu Samra, S., 2006. Assessment of procurement system of municipalities in Gaza Strip. Master thesis in construction management, The Islamic University of Gaza Strip.

Arafa, M. & Alqedra, M., 2011. Early stage cost estimation of buildings construction projects using ANN. Journal Of Artifical Intelligence, 4(1), pp. 63-75.

AL-Rashidi, A., 1999. Designing Neural Networks for the prediction of the drilling parameters for Kuwait Oil and Gas fields, USA. Master thesis in construction management, West Virginia University.

Al-Najjar, J., 2008. Factors influencing time and cost overruns on construction projects in the Gaza Strip. Master thesis in construction management, The Islamic University of Gaza Strip.

Al-Najjar, H., 2005. Prediction of ultimate shear strength of reinforced concrete deep beams using Artificial Neural Networks. Master thesis in construction management, The Islamic University of Gaza Strip.

Al Wahaidi, S., 2012. An analytical hierarchy process (AHP) based prequalification system for Gaza Strip Construction Contractors. Master thesis in construction management, The Islamic University of Gaza Strip.

Attal, A., 2010. Development of Neural Network Models for prediction of highway construction cost and project duration, USA: Ohio University.

Akadiri, p., Olomolaiye, p. & Chinyio, E., 2013. Multi-criteria evaluation model for the selection of sustainable materials for building projects. Automation in Construction, 30 (2013), pp. 113–125.

Bouabaz, M. & Hamami, M., 2008. A cost estimation model for repair bridges based on artificial Neural Network. American Journal of Applied Sciences, 5(4), pp. 334-339.

Cengiz, Y., Gunes, F. & Caglar, M., 2005. Soft computing methods in microwave active device modeling. Turkish Journal of Electrical Engineering and Computer Science, 13(1).

Chen, Y., Okudan, G. & Riley, D., 2010. Sustainable performance criteria for construction method selection in concrete buildings. Automation in Construction, 19(2010), pp. 235–244.

Cheng, W., Hung, S. & Kuo, R., 2014. Application of an optimization artificial immune network and particle swarm optimization-based fuzzy neural network to an RFID-based positioning system. Information Sciences, 262 (2014), pp. 78–98.

Darvish, M. & Saeedi, A., 2009. Application of the graph theory and matrix methods to contractor ranking. Journal of Project Management, 27 (2009), Feb., pp. 610–619.

Dindar, Z., 2004. Artificial Neural Networks applied to option pricing., s.l.: s.5.

Dowler, J., 2008. Using Neural Networks with limited data to estimate manufacturing cost, Master thesis in science. Ohio University.

Dong, R. & Zhao, G., 2014. The use of artificial neural network for modeling in vitro rumen methane production using the CNCPS carbohydrate fractions as dietary variables. Livestock Science, 162 (2014), Jan., pp. 159–167.

Edara, P., 2003. Mode choice modeling using artificial neural networks, Virginia. Master thesis in civil engineering. Virginia Polytechnic Institute and State university.

El-Sawalhi, N., Eaton, D. & Rustom, R., 2007. Contractor pre-qualification model: State-of-the-art. Journal of Project Management, 25 (2007), pp. 465–474.

El Karriri, A., 2008. Fctors affecting bidders' participation in the construction tenders. Master thesis in construction management, The Islamic University of Gaza Strip.

Emsley, W., & Alzahrani, J., 2013. The impact of contractors' attributes on construction project success: A post construction evaluation. Journal of Project Management, 31 (2013), pp. 313–322.

ElSawy, I., Hosny, H. & Abdel Razek, M., 2011. A Neural Network model for construction projects site overhead cost estimating in Egypt. International Journal of Computer Science Issues (IJCSI), 8(1).

Gaojun, L., & Yan, Z., 2006. Credit assessment of contractors: A rough set method. tsinghua science and technology, 1007-0214 13/16, pp. 357-362.

Hatush, Z., & Skitmore, M., 2000. contractor selection using multicriteria utility theory: An additive model. Building and Enviroment, Vol. 33, Nos 2-3, pp. 105-l 15.

Holt, G., 1998. Which contractor selection methodology?. Journal of Project Management, Vol. 16, No. 3, pp. 153–164.

Holt, G., & Harris, F., 2001. A Review of contractor selection practice in the U.K. construction industry. Building and Enviroment, Vol. 30, No. 4,pp. 553-561..

Hong, Y., 2012. Dynamic nonlinear state-space model with a neural network via improved sequential learning algorithm for an online real-time hydrological modeling. Journal of Hydrology, 468–469 (2012), pp. 11–21.

Kaushik, S., Tomar, R. & Kaushika, N., 2014. Artificial neural network model based on interrelationship of direct, diffuse and global solar radiations. Solar Energy, 103, pp. 327–342.

Kourentzes, N., Arrow, D. & Crone, S., 2014. Neural network ensemble operators for time series forecasting. Expert Systems with Applications, 41, pp. 4235–4244.

Kumaraswamy, M., 2003. Contractor evaluation and selection: a Hong Kong perspective. Building and Envrronmmt,, Vol. 31, No. 3, pp. 273-282.

Kumar, P. & Nigam, S., 2014. Vehicular traffic noise modeling using artificial neural network approach. Transportation Research Part, C 40, pp. 111–122.

Kuo, R., Hung, S. & Cheng, W., 2014. Application of an optimization artificial immune network and particle swarm optimization-based fuzzy neural network to an RFID-based positioning system. Information Sciences, 262, pp. 78–98.

Lai, K., Liu, S. & Wang, S., 2004. A method used for evaluating bids in the chinese construction industry. Journal of Project Management, 22, pp. 193–201.

Marzouk, M., El Kherbawy, A. & Khalifa, M., 2013. Factors influencing sub-contractors selection in construction projects. HBRC Journal, 9, pp. 150–158.

Medoukh, Z., 2008. Development of a multi-criteria awarding system for construction contractors in Gaza strip. Master thesis in construction management, The Islamic University of Gaza Strip.

Morote, A. & Vila, F., 2012. A fuzzy multi-criteria decision-making model for construction contractor prequalification. Automation in Construction, 25, pp. 8–19.

Muqeem, S. & Idrus, A., 2011. Prediction modeling of construction labor production rates using Artificial Neural Network. International Conference on Environmental Science and Technology, ICEST 2011.

Nygren, K., 2004. Stock prediction – A Neural Network approach., s.l.: Royal Institute of Technology.

Padhi, S. & Mohapatra, P., 2010. Centralized bid evaluation for awarding of construction projects – A case of India government. Journal of Project Management, 28, pp. 275–284.

Principe, J., Park, J. & Cao, G., 2010. NeuroSolution Help, s.l.: NeuroDimension, Inc.

Shultz, T., 2012. A constructive neural-network approach to modeling psychological development. Cognitive Development, 27, pp. 383– 400.

Skitmore, M., Xia, B., & Bridge, A., 2013. Xamining the influence of participant performance factors on contractor satisfaction: A structural equati on model. Journal of Project Management.

Topcu, Y., 2004. A decision model proposal for construction contractor selection in Turkey. Building and Environment, 39, pp. 469 – 481.

Vilutiene', T., & Zavadskas, E., 2006. A multiple criteria evaluation of multi-family apartment block's maintenance contractors: I—Model for maintenance contractor evaluation and the determination of its selection criteria. Building and Environment, 41, pp. 621–632.

Watt, D., & Willey, K., 2010. The relative importance of tender evaluation and contractor selection criteria. Journal of Project Management, 28, pp. 51–60.

Wang, D., Liu, X. & Liu, L., 2012. Bid evaluation behavior in online procurement auctions involving technical and business experts. Electronic Commerce Research and Applications.

Weckman, G., Paschold, H. & Young, A., 2010. Using neural networks with limited data to estimate manufacturing cost. Journal of Industrial and Systems Engineering, 3(4), pp. 257-274.

Quan, H., Srinivasan, D. & Khosravi, A., 2014. Particle swarm optimization for construction of neural network-based prediction intervals. Neurocomputing, 127, pp. 172–180.

Annex 1
Arabic Questionnaire

الجامعة الإسلامية -غزة
قسم الهندسة المدنية

استبيان
حول تحديد معايير اختيار المقاولين وترسية العطاءات في قطاع التشييد في قطاع غزة

جزء من البحث التكميلي لنيل درجة الماجستير في إدارة التشييد

الباحث/ م يوسف جميل أبو حجر
المشرف/ د. نبيل الصوالحي

يونيو 2014

استبيان
حول تحديد معايير اختيار المقاولين وترسية العطاءات في قطاع التشييد في قطاع غزة

الأخ الكريم/الأخت الكريمة :

من المعروف لجميع العاملين و المشاركين في قطاع التشييد أن عملية اختيار المقاول الأنسب هي من أهم المحطات في حياة المشروع لما سيكون لها من أثر واضح في تحقيق أهداف المالك الرئيسة الثلاث و المتعلقة في الجودة و التكلفة والوقت، و مع تباين الطرق و الآليات المستخدمة لاختيار المقاولين في قطاع التشييد في قطاع غزة والمعتمدة في الغالب على الترسية على المقاول صاحب أقل الأسعار بما يمثل ذلك من إمكانية تعرض المشروع لعدد من المشاكل من زيادة التكلفة أو التأخير أو كثرة المطالبات من قبل المقاول ، ومن هنا تبرز أهمية هذا الاستبيان الذي سيحدد العوامل المؤثرة في عملية اختيار المقاول المناسب إلى جانب سعر العطاء المقدم من المقاولين ، و ذلك من خلال استدراج أراء أصحاب الاختصاص و الخبرة في الجهات المالكة حكومية وغير حكومية و مكاتب استشارية بغرض تحديد معايير للاختيار في قطاع التشييد وذلك بما يتناسب مع واقعنا المحلي والعمل على تطبيقها واستخدامها بشكل أشمل في عملية اختيار المقاولين والترسية عليهم في المشاريع المستقبلية.

لذا يرجى التكرم بتعبئة هذا الاستبيان بعناية قدر الإمكان وذلك للتعرف على كافة الآراء ووجهات النظر المتعلقة بهذا الموضوع الهام ، مع ملاحظة أن جميع المعلومات في هذا الاستبيان سوف تستخدم في أغراض البحث العلمي فقط.
ونتقدم لكم بوافر الشكر على مشاركتكم في إثراء هذا البحث الذي يشكل جزءا من رسالة الماجستير.

مكونات الاستبيان :
الجزء الأول : التعريف بالجهة المعنية.
الجزء الثاني :العوامل التي تؤثر على عملية اختيار المقاولين و الترسية عليهم في مشاريع التشييد في قطاع غزة .

أولا: معلومات عامة

1 - حدد الوصف المناسب للمؤسسة التي تعمل بها

مؤسسة حكومية	جهة ممولة	منظمة غير حكومية	مؤسسة منفذة للمشاريع	استشاري
جهة أخرى، الرجاء التوضيح				

2- حدد طبيعة المشاريع التي تم تنفيذها عبر مؤسستكم

مباني إسكان	مباني عامة	طرق	مياه ومجاري	مباني خاصة
مشاريع أخرى، الرجاء التوضيح				

3- حدد المعدل السنوي لقيمة المشاريع التي نفذت عبر مؤسستكم خلال الخمس سنوات الماضية

أقل من 1 مليون$	1 – 2 مليون$	2 – 5 مليون$	5 – 10مليون$	أكثر من 10 مليون$

4- حدد الوصف الأنسب لطبيعة عملك في المؤسسة التي تعمل معها

مدير مشروع	مهندس مشرف	مدير دائرة	مهندس مكتب	متخصص في العطاءات
طبيعة عمل أخرى،الرجاء التوضيح				

5- حدد عدد سنوات خبرتك العملية

أقل من 5 سنوات	5- أقل من 10سنوات	10- أقل من 15سنوات	15سنة فأكثر

6- هل تعتمد مؤسستك على تصنيف اتحاد المقاولين كبديل عن عملية تقييم قدرات المقاول ؟

مطلقا □ نادرا □ أحيانا □ غالبا □ دائما

7- هل تعتمد مؤسستك الترسية على المقاول صاحب أقل الأسعار ؟

مطلقا □ نادرا □ أحيانا □ غالبا □ دائما

ثانيا : العوامل التي تؤثر على عملية اختيار المقاولين و الترسية عليهم في مشاريع التشييد في قطاع غزة

- الأرقام من (1) إلى (5) تحدد مدى قوة تأثير العامل على عملية اختيار المقاولين في مشاريع التشييد من وجهة نظرك ، حيث أن الرقم (1) يشير إلى عدم تأثير هذا العامل نهائيا ، بينما يشير الرقم (5) أن العامل الأكثر تأثيرا في عملية اختيار المقاولين و الترسية عليهم .
- الرجاء تحديد أهمية العوامل التي تؤثر في عملية اختيار المقاولين بوضع إشارة (√) في الخانة لتعبر عن مدى الأهمية، كذلك وضع أي عوامل أخرى ترى إضافتها .

مجموعة (1) : العوامل المتعلقة بالقدرة المالية للشركة

م	العـــــامـــــــل المـــــــؤثـــــر	1	2	3	4	5
1	رأس المال					
2	التسهيلات البنكية					
3	السيولة المالية					
4	حجم ديون الشركة					
5	الربحية					
6						
7						

مجموعة (2) : العوامل المتعلقة بالقدرات الإدارية للشركة

م	العـــــامـــــــل المـــــــؤثـــــر	1	2	3	4	5
1	هيكلية الشركة					
2	خبرة الطاقم الإداري					
3	وجود نظام تدريبي للطاقم الإداري في الشركة					
4	استخدام أنظمة محوسبة في الإدارة					
5	توفر نظام مراقبة و متابعة و تقييم في الشركة					
6	وجود سياسة للصحة و السلامة					
7						
8						

مجموعة (3) : العوامل المتعلقة بخبرة الشركة

م	العـــــامـــــــل المـــــــؤثـــــر	1	2	3	4	5
1	عدد المشروعات التي نفذتها الشركة آخر 3 سنوات					
2	قيمة المشروعات التي نفذتها الشركة آخر 3 سنوات					
3	عدد المشروعات المشابهة التي نفذتها الشركة آخر 3 سنوات					
4	الالتزام بالشروط التعاقدية في تنفيذ المشاريع آخر 3 سنوات					
5						
6						

مجموعة (4) : العوامل المتعلقة بالقدرة الفنية للشركة

م	العـــــامـــــــل المـــــــؤثـــــر	1	2	3	4	5
1	حجم المعدات والآليات					
2	عدد الطواقم الفنية					
3	خبرة الطاقم الفني					
4	استخدام وسائل تكنولوجية حديثة في تنفيذ المشاريع					
5	تصنيف الشركة					
6						
7						

❖ **مرحلة الترسية**

1. بعد تقييمك للعوامل الرئيسية والفرعية المشار إليها أعلاه ،كيف ترى بأن يتم أخذ هذه العوامل بعين الاعتبار في قرار لجنة التقييم من ناحية ترسيه العطاء؟:

□ اعتبارها عوامل تأهيلية فقط ومن ثم الترسية على المقاول المؤهل صاحب أقل الأسعار المقيمة .

□ اعتبارها عوامل تأهيلية فقط ومن ثم الترسية على المقاول المؤهل صاحب أقرب الأسعار لمتوسط الأسعار المقيمة.

□ اعتبارها عوامل تأهيلية فقط ومن ثم الترسية على المقاول المؤهل صاحب أقرب الأسعار للتقديرات.

□ إعطاء كل عامل من العوامل درجة معينة ومن ثم الترسية على المقاول صاحب أعلى درجات التقييم بغض النظر عن السعر المقدم .

□إعطاء وزن معين للعرض المالي ووزن للعرض الفني ومن ثم الترسية على المقاول الحاصل على أعلى تقييم بعد دمج العرضين المالي والفني وفق معادلة رياضية معينة.

□اعتبار طريقة أو طرق أخرى :

حددها .....

2. في حال اختيارك لطريقة دمج العرضين المالي والفني وفق معادلة رياضية معينة ، كيف ترى أن تكون النسبة المئوية بينها خلال عملية التقييم للترسية على المقاولين ؟

- ☐ 20% للعرض المالي ، 80% للعرض الفني .
- ☐ 30% للعرض المالي ، 70% للعرض الفني .
- ☐ 40% للعرض المالي ، 60% للعرض الفني .
- ☐ 50% للعرض المالي ، 50% للعرض الفني .

نسب أخرى :حددها .....

3.هل تعتقد بأن طريقة ترسيه العطاءات على أقل الأسعار هي من الإشكاليات الرئيسية التي يعاني منها قطاع المقاولات ؟

☐نعم ☐ لا

ما هي مبرراتك لذلك : .....

.....

4.هل تعتقد بأن الطريقة المستخدمة حاليا في ترسيه العطاء على أقل الأسعار قادرة على تحديد المقاول الأفضل و المناسب لتنفيذ المشروع؟

☐**لا** ☐ **نادرا** ☐ **عادة** ☐ **نعم**

ما هي مبرراتك لذلك : .....

.....

5. هل تعتقد بأن لجان ترسيه العطاء تأخذ بعين الاعتبار" الكلفة التقديرية "للمشروع المعدة من طرف المصمم أو المالك؟

☐**لا** **نادرا** ☐ **عادة** ☐ **نعم**

ما هي مبرراتك لذلك : .....

.....

6. ما هي أسباب لجوء أغلب المؤسسات العاملة في قطاع غزة باعتماد طريقة الترسية على أقل الأسعار ؟

- ☐ سرعة وسهولة اتخاذ قرار الترسية .
- ☐ لا تحتاج إلى طاقم متخصص ومدرب في عملية الترسية .
- ☐ الشفافية والعدالة في عملية الترسية .
- ☐أسباب أخرى : حددها .....

7. ما هي أهم معوقات استخدام طرق أخرى في عملية الترسية في قطاع المقاولات خلاف طريقة الترسية على أقل الأسعار ؟

- ☐ عدم الوعي بمخاطر الترسية على أقل الأسعار.
- ☐ عدم قدرة المؤسسات (فنيا وماليا) للعمل على تطوير نموذج خاص بعملية الترسية .
- ☐ اعتبار عامل السعر هو العامل الأهم في عملية الترسية .

□أسباب أخرى : حددها .....

8. الرجاء التكرم بتسجيل ملاحظاتك وتوصياتك حول عملية اختيار وتأهيل المقاولين وكذلك طرق ترسية العطاءات عليهم

.....

.....

.....

Annex 2
English Questionnaire

Part 1: General Information

1- What is the proper description of your organization?

Governmental institution	Donor	NGO	Consultant	Executing institution
Others, Please Specify				

2- Specify the types of projects implemented by your organization?

Housing construction	Public buildings	Roads	Water & Sewage	Privet buildings
Others, Please Specify				

3-Specify the average annual value for the projects implemented through your organization over the past five years?

Less than 1 Million Dollars	1- 2 Million Dollars	2- 5 Million Dollars	5- 10 Million Dollars	More than 10 Million Dollars
Others, Please Specify				

4- Which is the best description of your occupation in your organization?

Project Manager	Supervisor Engineer	Head of Department	Consultant	Procurement Specialist
Others, Please Specify				

5- Specify the number of years of your practical experience

Less than 5 years	5- Less than10 years	10- Less than15 years	More than15 years

6- Does your organization depend on the classification of the Contractors Union as an alternative to the prequalification process?

☐ Always ☐ Frequently ☐ Sometimes ☐ Rarely ☐ Never

7- Have your organization ever practiced awarding the contractor with the lowest prices?

☐ Always ☐ Frequently ☐ Sometimes ☐ Rarely ☐ Never

Part 2: Identification of the factors that affect the prequalification process of the contractors:

Please specify the importance of the factors that affect the process of selection of contractors by marking "√" in the box to reflect its importance.

Number (1) indicates that no impact of this factor, while indicating the number (5) that the most influential factor in the process of selecting contractors and awarding them.

Group (1): The factors related to the financial stability of the company

NO.	Affecting Factor	1	2	3	4	5
1	The capital of the company					
2	The banking facilities provided by the company					
3	The liquidation of the company					
4	The debt volume of the company					
5	The profitability					

Group (2):The factors related to the management capabilities of the company

NO.	Affecting Factor	1	2	3	4	5
1	Organizational structure					
2	Qualifications of the managerial staff					
3	Availability of training system for managerial staff					
4	The use of computerized systems in the management					
5	The availability of monitoring , tracking, and evaluation system in the company					
6	The existence of policy in the field of health and safety					

Group (3): The factors related to the experience of the company

NO.	Affecting Factor	1	2	3	4	5
1	The number of projects implemented last 3 years					
2	The amount of projects Implemented last 3 years					
3	The number of similar projects implemented last 3 years					
4	Obligation to the conditions in the implementation of projects last 3 years					

Group (4): The factors related to the technical ability the company

NO.	Affecting Factor	1	2	3	4	5
1	The volume of equipment and machinery					
2	The number of the technical staff					
3	The experience of the technical staff					
4	The technological means used by the company					
5	Classification of company					

Part 3: Awarding Stage

1- After you have rated the significant level of main criteria and their sub-criteria mentioned above, please specifies how can it be taken into consideration in the bid awarding decision:

□ To consider the criteria as a qualification criteria only, and award the bid to the lowest evaluated bid price.

□ To consider the criteria as a qualification criteria only, and award the bid to the average evaluated bid price.

□ To consider the criteria as a qualification criteria only, and award the bid to the closest bid to project estimation.

□ To provide grade to each main criteria, and award the bid to whom with the high total grade.

□ To assign weights to the technical and financial proposals, and award the bid to the highest weight after combination of the technical and financial scores .

□ Others method, Please Specify, ……..

2- In the event of your choice for a way to integrate financial and technical presentations according to specific mathematical equation, how do you see that the percentage be among them during the evaluation process for the award of the Contractors:

□ 20% of the financial offer, and 80% Technical offer.

□ 30% of the financial offer, and 70% Technical offer.

□ 40% of the financial offer, and 60% Technical offer.

□ 50% of the financial offer, and 50% Technical offer.

3- Do you think that the current local awarding method used in the contractor's selection is one of the major problems in the construction sector?

□ Yes □No

Please Specify your justifications, ……...

4- Do you think that the methods used currently for bid awarding are capable of identifying the most suitable contractor:

□ Yes □No

□ Frequently □Rarely

Please Specify your justifications, ……...

5- Do you think the awarding committee takes into consideration the project "cost estimate" prepared by the designer :

□ Yes □No

□ Frequently □Rarely

Please Specify your justifications, ……...

6- What are the causes of the most of institutions in the Gaza Strip adopt awarding depend on a lower price as method to select the contractor ?

□ Quick and easy decision to award.

□ Do not need a specialized team and coach in the award process.

□ Transparency and fairness in the award process.

Other reasons,……...

7- What are the main obstacles to use of other methods in awarding way other lower price ?

□ Lack of awareness of the dangers of awarding a lower price.

□ inability of institutions (technically and financially) to work on the development of the process of awarding a special form.

□ price factor is considered the most important factor in the award process.

Other reasons,……...

8- Kindly, add your comments or recommendations related to the selection process & awarding method for the construction contractors :

……
……
……..

Annex 3
Collected Projects

No.	1*	2*	3*	4*	5*	6*	7*	8*	9*	10*	11*	12*	13*	14*	15*	16*	17*	18*	19*	20*	21*
1	4	3	3	2	1	1	3	3	3	2	1	1	3	3	3	1	4	4	5	1	3
2	4	3	2	2	1	3	3	3	3	1	0	1	3	3	3	1	3	2	4	1	3
3	5	1	1	6	1	2	2	2	2	1	0	1	2	2	2	1	1	2	3	1	2
4	5	5	4	2	1	3	2	2	2	1	0	1	3	3	3	1	2	2	3	1	2
5	5	3	2	2	1	2	3	3	3	2	1	1	2	2	2	1	3	4	4	1	3
6	5	6	4	1	1	6	3	3	3	3	1	1	6	6	6	1	6	6	6	1	3
7	4	4	6	2	1	4	3	2	3	2	1	1	4	4	4	1	3	4	5	1	3
8	4	2	1	3	1	3	2	2	2	1	1	1	3	3	3	1	2	2	3	1	2
9	3	1	1	6	1	1	1	1	1	1	0	0	1	1	1	1	0	1	2	1	1
10	5	4	6	1	1	6	3	2	3	2	1	1	6	6	6	1	5	5	6	1	3
11	5	6	4	1	1	4	2	2	2	1	0	1	4	4	4	1	3	3	4	1	2
12	5	3	2	2	1	2	3	3	3	2	1	1	2	2	2	1	6	6	5	1	3
13	4	3	2	1	1	3	3	3	3	2	1	1	3	3	3	1	4	5	6	1	3
14	4	1	1	6	1	1	1	1	1	1	0	0	1	1	1	1	1	1	2	1	1
15	5	2	1	6	1	1	3	3	3	2	1	1	3	3	3	1	3	5	4	1	3
16	5	6	6	2	1	6	3	3	3	2	1	1	5	5	5	1	6	6	5	1	3
17	5	3	2	5	1	0	3	3	3	2	1	1	6	6	6	1	3	4	6	1	3
18	4	1	0	6	1	1	2	2	2	1	0	0	3	3	3	1	1	2	3	1	2
19	5	3	3	2	1	2	3	2	3	2	1	1	6	6	6	1	3	4	5	1	3
20	4	6	6	1	1	6	3	3	3	3	1	1	3	3	3	1	6	6	6	1	3
21	5	3	2	3	1	0	3	3	3	2	1	1	6	6	6	1	3	4	6	1	3
22	4	2	1	6	1	1	2	2	2	1	1	1	3	3	3	1	1	2	3	1	2
23	5	2	1	4	1	1	3	3	3	2	1	1	3	3	3	1	3	5	4	1	3
24	5	6	6	2	1	6	3	3	3	3	1	1	5	5	5	1	6	6	5	1	3
25	5	3	2	1	1	0	3	3	3	2	1	1	3	3	3	1	3	4	5	1	3

26	4	1	0	6	1	0	1	1	1	1	0	0	1	1	1	1	0	1	2	1	1
27	4	5	2	1	1	2	3	3	3	3	1	1	6	6	6	1	5	6	6	1	3
28	5	6	6	1	1	6	3	3	3	3	1	1	3	3	3	1	6	5	6	1	3
29	5	1	1	5	1	1	1	1	1	1	0	0	1	1	1	1	1	2	3	1	1
30	4	2	2	2	1	3	3	3	3	2	1	1	3	3	3	1	3	6	6	1	3
31	4	6	6	1	1	6	3	3	3	2	1	1	6	6	6	1	6	4	5	1	2
32	5	1	1	3	1	2	3	3	3	2	1	1	2	2	2	1	2	3	4	1	2
33	4	1	1	4	1	2	3	3	3	2	1	1	2	2	2	1	3	3	4	1	2
34	4	1	1	6	1	2	3	3	3	2	1	1	2	2	2	1	2	3	4	1	2
35	5	1	1	3	1	4	3	3	3	2	0	1	4	4	4	1	3	3	4	1	2
36	5	2	1	3	1	1	3	3	3	2	1	1	1	1	1	1	4	3	4	1	2
37	4	2	2	6	1	2	2	2	2	1	0	1	2	2	2	1	3	3	4	1	2
38	4	3	2	4	1	4	3	3	3	2	1	1	4	4	4	1	6	5	6	1	3
39	4	2	2	6	1	3	2	2	2	1	0	1	3	3	3	1	3	3	4	1	2
40	5	6	6	2	1	6	2	2	2	1	0	1	6	6	6	1	3	3	4	1	2
41	5	3	2	4	1	5	3	3	3	2	1	1	4	4	4	1	5	4	5	1	3
42	4	2	2	6	1	3	2	2	2	1	0	1	3	3	3	1	3	3	4	1	2
43	5	4	3	3	1	4	2	2	2	1	0	1	4	4	4	1	4	4	6	1	3
44	5	3	2	3	1	1	3	3	3	1	1	1	1	1	1	1	5	2	6	1	3
45	5	3	2	4	1	3	3	3	3	2	1	1	3	3	3	1	6	6	6	1	3
46	5	5	3	2	1	1	2	2	2	1	0	1	1	1	1	1	2	4	4	1	2
47	2	2	2	5	1	4	2	2	2	1	0	1	3	4	4	1	2	3	4	1	2
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55	3	2	2	4	1	3	2	2	2	1	0	1	3	3	3	1	2	3	4	1	2
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63	5	4	3	3	1	1	2	2	2	1	0	1	1	1	1	1	2	3	4	1	2
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71	5	5	6	2	1	6	3	3	3	2	1	1	6	6	6	1	6	6	5	1	3
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76	5	1	1	3	1	2	3	3	3	2	0	1	2	2	2	1	2	3	4	1	2
77	5	1	1	3	1	2	3	3	3	2	1	1	2	2	2	1	2	3	4	1	2

78	4	2	2	2	1	2	1	1	1	1	0	0	2	2	2	1	2	3	3	1	2
79	4	3	2	2	1	3	3	3	3	1	1	1	3	3	3	1	3	3	6	1	3
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81	4	1	1	5	1	1	1	1	1	1	0	0	1	1	1	1	1	2	3	1	1
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84	5	2	1	3	1	2	2	2	2	1	0	1	2	2	2	1	1	2	3	1	2
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87	3	1	1	4	1	1	1	1	1	1	0	0	1	1	1	1	1	2	2	1	1
88	4	1	1	3	1	2	3	3	3	2	0	1	2	2	2	1	3	2	4	1	2
89	5	2	2	2	1	3	3	3	3	2	1	1	3	3	3	1	2	5	4	1	3
90	5	1	1	4	1	2	2	2	2	1	0	1	2	2	2	1	2	2	3	1	2
91	4	1	1	6	1	2	2	2	2	1	0	1	2	2	2	1	2	2	3	1	2

1* Bid Price, 2* Capital of the Company, 3* Liquidity, 4* Debt Volume, 5* Banking Facilities, 6* Profitability, 7* Organizational structure, 8* Policy of health and safety, 9* Experience of the managerial staff, 10* Availability of training system, 11* Use of computerized systems, 12* Availability of monitoring, tracking and evaluation system, 13* number of projects implemented from 3 years, 14* amount of projects implemented from 3 years, 15* The amount of similar projects implemented from 3 years, 16* The adherence to the contractual period from 3 years, 17* volume of equipment and machinery, 18* number of the technical staff, 19* experience of the technical staff, 20* technological means used, and 21* classification of company.