Estimation and Prediction of Construction Building Cost Index for Jordanian Construction Industry

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ABSTRACT

Construction Cost Index is an indicator of the average cost movement over time of particular goods and services that represent the construction industry. The main purpose of Construction price indicators is to estimate the degree of price variations of either the inputs, or outputs, of construction activity. Nevertheless, the nomenclature used mainly depends on the context of indices and can vary between countries. At the same time, every individual construction project is a mixture of a specific collection of structural elements, mechanical elements, and other expenses. Therefore, the price changes that indicate a specific type of construction sector should be estimated using suitable cost indices to achieve consistency in construction prices.

In Jordan, many governmental institutions are involved in the reproduction of several types of Indicators. In this study, three main governmental indicators that have a direct effect on the construction industry had been chosen. In sequence, their ability to estimate the annual variations in the construction cost was measured. On the other hand, a new indicator had been constructed using the available material price lists. These indicators were also evaluated in terms of effectiveness to estimate the construction sector and then compared with others.

The comparison of these indicators was based on efficiency to determine the prices of construction projects and their extent to impact the industry. In which the chosen indicators were effective in the estimation of both previous and current projects values and their ability to anticipate future prices. Finally, the most adequate cost indicator amongst them was considered to be applicable in the estimation process of the construction projects.

Keywords: Cost index, Fluctuations, Regression Analysis, Future predictions, Construction cost, index, Inflation, Estimating, Forecasting.

ÖZ

İnşaat Maliyet Endeksi, inşaat sektörünü temsil eden belirli mal ve hizmetlerin zaman içindeki ortalama maliyet hareketinin bir göstergesidir. İnşaat fiyat göstergelerinin temel amacı, inşaat faaliyetinin girdilerinin veya çıktılarının fiyat değişikliklerinin derecesini tahmin etmektir. Bununla birlikte, kullanılan isimlendirme esas olarak endekslerin içeriğine bağlıdır ve ülkeler arasında değişebilir. Aynı zamanda, her bir bireysel inşaat projesi, yapısal elemanların, mekanik elemanların ve diğer masrafların belirli bir koleksiyonunun bir karışımıdır. Bu nedenle, belirli bir inşaat sektörünü gösteren fiyat değişiklikleri, inşaat fiyatlarında tutarlılığı sağlamak için uygun maliyet endeksleri kullanılarak tahmin edilmelidir. Ürdün'de birçok hükümet kurumu çeşitli Göstergelerin çoğaltılmasına katılmaktadır. Bu çalışmada, inşaat endüstrisi üzerinde doğrudan etkisi olan üç ana hükümet göstergesi seçilmiştir. Sırayla, inşaat maliyetindeki yıllık değişimleri tahmin etme yetenekleri ölçülmüştür. Öte yandan, mevcut malzeme fiyat listeleri kullanılarak yeni bir gösterge oluşturulmuştur. Bu göstergeler, inşaat sektörünü tahmin etmede etkinlik açısından da değerlendirilmiş ve daha sonra diğerleriyle karşılaştırılmıştır. Bu göstergelerin karşılaştırılması, inşaat projelerinin fiyatlarının belirlenmesinde verimliliğe ve bunların sanayiyi etkileme boyutuna dayanmaktadir ve seçilen göstergelerin hem önceki hem de mevcut proje değerleri ve gelecekteki fiyatları öngörme kabiliyetlerine etkilidir. Son olarak, aralarındaki en uygun maliyet göstergesinin inşaat projelerinin tahmin sürecinde uygulanabilir olduğu düşünülmüştür.

Anahtar Kelimeler: Maliyet endeksi, Dalgalanmalar, Regresyon Analizi, Geleceğe

DEDICATION

I dedicate this thesis to my ***FAMILY***

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LIST OF ABBREVIATIONS

BCMCI	Belgium Chemical Manufactory Cost Indices
BOS	Group of Merchandise
CCI	Consumer Cost Index
CI	Cost Index
CMCI	Chemical Manufactory Cost Indices
CMCI	The Chemical Manufactory Cost Indices
DOCT	Department of The Central Tenders
DOS	Department of Statistical Affairs
DPI	Developed Price Indicators
ENR	Engineering News-Record
ENR	The Engineering News-Record
GOS	Governmental Structures
GTD	Government Tenders Department
HCI	Health Care Institutions
M&S	Marshall And Swift
MAPE	Mean Absolute Percentage Error
MOFWH	Ministry of Public Works & Housing
NFCC	Nelson-Farrar Construction Cost
NOLE	Little or No Evidence
PCI	Production Cost Index
PEF	Public Education Facilities
PHB	Public Housing Building

S&M	Swift and Marshall
STE	Strong Evidence
UNECE	United Nations Economic Commission for Europe
VSE	Very Strong Evidence
WE	Weak Evidence

Chapter 1

INTRODUCTION

1.1 Background

The Cost Index (PI) is an essential statistical indicator for the purposes of planning and research in various disciplines. Minh-Tu, Min-Yuan, & Yu-Wei (2015) defined Cost Indicators (PI) as a variable reference point that has weight and depends on the prices of specific quantities and materials. Statistic institutes and agencies in different countries consistently compile these indices based on the prices of a group of building materials and construction services commonly used during the construction process (Statistic Centre Abu Dhabi, 2016). Construction cost indices are generated for the reason of determining the amount of fluctuation in construction price; adjust the change in labour fares and materials prices. Akintola, 1991 states in his research that construction cost indices are used in evaluating, updating cost changes, approximating the economy to real terms, supervision on sector escalation and calculating the fluctuation cost of the buildings.

The construction indicator comprises the changes in costs in the long-term and short-term in order to obtain higher precision values of the tender price (Trefor P., 1994). The usage can differ from user to other according to the purpose of use, but the main idea remains all the same. For instance, it is used to get the feasible costs in projects, so entrepreneurs will employ it in tender stages and gain the ability to present their bids with a greater percent of accuracy to achieve success. It is also used in the Price setting process to properties that intended to let or sell.

Consequently, the preciseness in short term construction price prediction plays a major role in the success of an entrepreneur. The accuracy in the long term is also required and very necessary for forecasting other remarkable future tasks, such as; the refurbishment and maintenance construction building over the life span of the building. Therefore, the changes in prices must be adjusted periodically suit the new market indicators (Ka Wai, 2014), Ka Wai Yu also has declared in his research 2014 that the role of construction cost indices is not only limited to predictions and forecasting but also can include:

a. Transforming the previous construction output into the new current prices according to today's constant prices,
b. Locate the relative price changes in the construction sector; in intend to have a more apparent direction of market conditions,
c. Continuous upgraded of cost historical data to be able to handle the planning process,
d. Can be also utilized in comparing the outgrowth of price, actual output, and productivity.

In contrast to several other sectors, investigations into construction pricing have not gained much advancement theoretically, practically to provide advance explanations of the price levels. Furthermore, the interest was mostly regarding prognosticate the future bidding price other than promoting more accurate and better explanations of price tendencies (Sunday, 1991).

The country’s economy has a great effect on the construction industry. It is noteworthy to say that it is a reciprocal relationship where each of them can influence the other in a direct or indirect way. The importance of the construction industry is not limited to the objective of meeting the population's housing needs, but it is also a major contributor to the capital accumulation process which has a direct effect on tangible assets over the long economic period. The main economical contribution lies in the forms of buildings, homes, offices, and infrastructure in general, which is considered as a reflection of the country's well-being and an indicator of economic power. On the other hand, it takes apart in the production of goods and services, thus affect the competitiveness of an economy and the living standards of its people. The change in the cost of construction outputs decides also the fluctuation in the property price, which will affect the demand market and can cause an indirect loss to the overall economy. This issue was discussed by many researchers, for example, Fleming in 1986, Fellows in 1991, and Browned and Taylor in 1987 all of the researchers identified the practicality of using such construction cost indicators.

There are various factors should be monitored while constructing an index. Each particular type of construction has a different combination of these factors. This brings the fact, that the measurement of the cost variations of distinct types of constructions requires a different combination of factors that must be suitable to the type of cost indicators been utilized. These indicators are mainly based on measuring the price changes concerned with specific factors, which mostly are identified based on the type of construction projects. In other words, as Cheung, et al. mentioned in his study in 2004 that type of indicator can be identified either by looking at the type of facilities that were contained, or by looking throw specifications of components such as; the indicator aims, deciding price factors, taking mass weight for every component, and picking the base year.

Many institutions in Jordan are engaged in the production of construction Indices. The main institutions that are considered to be most important for the construction sector are; the Department of Statistical affairs (DOS), Ministry of Public Works & Housing (MOFWH), Department of the Central Tenders (DOCT), Government Tenders Department (GTD). These organizations create mainly three indices that have a direct effect on the construction sector; Price Index for Construction Projects (CCI), Total Construction Cost Index (CI) and Construction Product Price Index (PCI). These indices mostly depend on the data extracted from previous projects. However, in this study, the efficiency of the governmentally provided indicators to calibrate the annual changes in tender projects prices will be compared based on resource prices and the rate of change in them. In consequence, other new indicators will be created using the material prices and a nomination will be made to select the best indicator. The chosen indicator should be effective for both previous and current projects and it will be used to anticipate future prices. Afterward, comparisons of these indicators will be made using statistical methods, such as regression analysis. The main objective of the comparison is to validate the efficiency of the indicator of the changes in the construction sector. Whereas, the statistical office of the United Nations Economic Commission for Europe (UNECE) in 2009 considered that the objective of the construction price indicator existence is to be used in analyzing the construction sector.

The cost indicators have great importance in the construction industry. These indicators have various uses as listed in the following:

- Estimating the fluctuations in construction prices. For instance, (materials prices used construction work).
- A way to judge to price inclinations for project initial state through; providing assessments to tender, matching appraisals with previous bids, and controlling the limits of project funding.
- To scrutinize the total construction cost and construction selling prices in terms of them to be influenced by price changes.
- Predicting future price changes in the short term.
- A valuable appraisement tool for insurance firms.
- Adjust the construction contract before and through the assembling process.
- Planning the production of construction material.

1.2 Problem Statement

The tender price audit according to the year in which the current exchange rate was determined is very important in terms of accuracy in followed comparison procedures and obtaining results. The number of concluded projects also plays a significant role in the tendering process for any construction company. For instance, the increase in the number of projects that were implemented by the participating entity is a measurement that facilitates the estimation of the competency of the company that will be employed to complete the project. Thus, applicants can be preliminarily nominated in any bidding process, depending on the number of projects that have been performed in the past. So that the comparison depends entirely on the quantities only, such as the number of projects, but this method is not considered accurate. It is often used primarily to reduce a large number of applicants. Quality comparison is considered to be the main judgment of this process. Whereas, the process of measuring quality and cost depends entirely on the total and partial prices of the project sub-branches. Accordingly, the contract prices for these completed projects are examined, along with other standards related to technical and administrative issues. Nevertheless, consideration must be given to the price index, which in turn makes a significant difference in the quality assessment process and is known for the changes in construction unit prices. As a result of the variation in the implementation period for different projects of each contractor, the effect of shifting in the construction unit price should be included in these accounts.

The change in the construction unit price does not consider only the practice of estimation the present cost of previous scheme; it is also used as a reference to predict the future costs for construction projects, which is a very important factor to ensure acquire the bid, given the fact that high-precision forecasts will lead to a lower bid price and increases the success rate, and thus increases the proportion of the profits of the company executing the project. Furthermore, the change in the construction index price must be analysed for the largest number of previous projects to be able to anticipate the resulting change in the economy and the price of construction products to achieve a higher rate of profits and reduce the margin of error. On the other hand, the use of the unit price scale is not limited to the period before the start of projects, but it must also be applied during the implementation period of the project. Since most constructions require a long time of several years or months to get fully completed, construction expenses are in continuous change even throughout the construction and preforming process of the project. For these projects, contractors must estimate the future costs of construction in the period of implementation of the contract and include these costs in the proposition values. Contractors tenders of these contracts must take into consideration the possibility of a change in construction-related costs where worker wages and material costs are used by contractors.

In Jordan, Department of Statistical affairs (DOS) is the government authority that is responsible for data collection and statistical analysis, DOS also issues annually different type of reports and articles that deliver the change in construction expenses and several different indices (Department of Statistical affairs, 2018). However, these indices are the costs of individuals taken from previous projects and do not reflect the real variations in construction costs (Al-Momani, 1996). That brings up the need for a new index that integrates real prices of the basic component into the calculation.

The construction cost indices become recognized as highly unstable since there is a wide difference amongst yearly index values and the actual construction cost. For instance, between the years 2000 and 2006, construction cost Indicator (CCI) has increased in which the data reached a high value of 702139 JOD in 2006 and a record low of 133077 JOD in 2000 (Jordan Construction Cost: Buildings Completed, 2006). Construction Cost Index (CCI) increased at a constant rate value of 1.3 per year in comparison to responded of Total Construction price Index (CI) which increased by 1.8 per year as a constant ratio. On the other hand, the construction Product cost Index (PCI) faced an inflationary of the rate of 2.3 percent per year (Department of Statistics in Jordan, 2018).

Through differences such as the ones mentioned above, the intentions of many researchers have been improved both the basic theoretical basis and the technical specifications of these indicators and to create an independent index that reflects the bidding process (Akintoye, Akintola, Bowen, & Hardcastle, 1998, Akintoye & Skitmore, 1991a, 1991b), as it will also be discussed in the following parts of the study.

1.3 Scope, Aim, Objectives

To interpreting with the last discussion, this research focuses on developing equations to define, describe, monitoring and forecasting tender price movements. The aim of this research was mainly to calculate approximately the price of the Construction tender price Index on the basis of past data of completed tender projects using the significant cost factors and provide a more reliable tool for accurately predicting construction prices for upcoming future projects. The main motive to perform this research was the inaccessibility to such indicators in Jordan, due to the fact that there is a lack of awareness in the statistical agencies that there is a need for such cost indicators to be estimated and published as in developed nations countries.

The study was limited to tender projects in Jordan. The result indicators and equations will be available for the tenders only. The main target sample of the building was Public housing building, Governmental structures, Public education facilities, and Health care institutions. This sample represents the major varieties of governmental tender projects in Jordan.

To achieve the purpose of this research the following objectives were considered:

- Analyse the movements in Jordan cost index;
- Categorize and inspect the factors that are responsible for indices movements;
- Developing models that can explain and track the historical changes in cost index; and

- Appraise the efficiency of these models.

1.4 Achievements

In this study, the central achievement is the production of a tender Price index of items to determine the cost of construction building. Another achievement is making sure of reliability by conducting a comparison of the current prices index with respect to the new indicators. Moreover, equations developed that are able to describe, monitor and forecast the tender price movements.

1.5 Structure of Thesis

This research is consisting of an introduction chapter, one result and a conclusion chapter and three other more chapters provide a general idea and the method. These chapters can be represented as follow:

- Chapter 2 is a Literature Review that summarizes the history of relevant studies on this topic and provides numerous of the previous studies that followed the same producer to calculate different types of cost indices. Also included a chapter of general information is considered to be a preparatory stage that delivers general knowledge regarding cost indices and the related mathematical analysis. It also provides a brief definition of the current indicator that been used in the calculating index for the construction industry.

- The methodological analysis was the fourth chapter explains in detail the methodology used in generating the newly established indexes with making use of the completed data and statistical analysis. The efficiency of the produced functions will be tested by considering the forecasting of the upcoming values. The most accurate will be selected as an appropriate index.

Moreover, this chapter included the results of the studies and provide some notations on the results whether the objective of the study has been accomplished.

- Conclusions and recommendation: This chapter provides a short summary of the research aim, the accomplishments along with a recommendation for more further future studies.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This is the field of study that will provide a better understanding of the concept of cost indices. This chapter will also provide a summary of the construction cost indicators establishment through the previous lectures by giving some steps and expatriation the structure of the equation.

There are two common mechanisms used to help in gauging the changes in price levels across the industrial economy of any sector; the Gross Domestic Product deflator (GDP deflator) and the Price Index is also known as the PI, both of these indices measure inflation and deflation levels by comparing subsequent years using the index changes. The first mechanism used by economists to measure aggregate price level changes yearly is the GDP deflator, it can be defined as a mechanism that uses real and nominal indices to determine the effects of the deflation on an aggregate economy or an individual industry within an overall economy in a single year. The second mechanism is known to be the Price Index or PI. This mechanism is most commonly used among these two mechanisms. It is recognized to be used in measuring price change in the macroeconomy or industry over several consecutive years. In essence, the GDP deflator takes nominal indices which are increased by higher prices and deflates it by dividing real indices. As a result, the inflation impact can be measured depending on GDP data in a particular year. On the other hand, the Price index PI depends on the market basket of a specific year to be calculated. The calculated value is converted to a reference point and got compared with the upcoming outcomes of the subsequent year basket values. The proportional difference between each year's index number and the base year's index number visualizes the degree of inflation or deflation in the industry from year to other.

In this research, the author adopted the Price Index PI mechanism to establish the new construction cost indices. This mechanism has been chosen to be utilized considering several factors such as; Efficiency factor, previous studies have shown a high level of accuracy, Ease of calculation and application, and Reliability factor, it is commonly used in many areas that require accuracy (Litra, 2009). The following section is going to give an explanation of methods used in calculating price index PI.

2.2 Methods of Constructing Price Index

A number of different formulas and methods have been proposed as a means of establishing price indices. In order to have a better understanding, this section will provide a summary of these methods and choose the most reasonable method for this study. These methods can be illustrated in the hierarchy (ILO, 2001). The Construction of index numbers can be divided into two majors of Weighted indices and Unweighted indices:

1) Unweighted (Simple) Index Numbers:

   In this method, all items of the series are given equal importance. Index numbers are constructed in two methods: Simple aggregative method, Simple average of price relative method.

I. Simple Aggregative Method:

This method is also known as the actual price method. It consists of expressing the aggregate price of all commodities in the current year as a percentage of the aggregate price in the base year as can be present in equation 1.

$$P_{01} = \frac{\sum p_1}{\sum p_0} \times 100 \qquad (1)$$

P_{01} price index, $\sum p_1$ sum of prices of commodities of current year, $\sum p_0$ sum of prices of commodities of base year.

II. Simple Average of Relatives Method:

The current year price is expressed as a price relative of the base year price. These price relatives are then averaged to get the index number. As equation 2 shows that the used average could be arithmetic mean, geometric mean.

$$P_{01} = \frac{\sum\left(\frac{p_1}{p_0} \times 100\right)}{N} \text{ Or } P_{01} = \frac{\sum log\left(\frac{p_1}{p_0} \times 100\right)}{N} \qquad (2)$$

Where N is Numbers of items, log/N represent the geometric mean equation, p_1 prices of the current year, and p_0 prices of the base year.

2) Weighted Index Methods:

In the construction of these indices, all the factors are assigned rational weights to provide a more specific form. These weights are responsible for the factor's significance rate and reflect their importance. Weighted Aggregative Index generally comes off in the form of percentages. As a result, the used weights in various formulas can be constructed as the outcome of this method. The most common methods in economics books such as; the Paasche method, Kelly's method, Laspeyres method, and other methods that represent a combination of these three main methods (franklin & karl, 1972 ,Afriat & Milana, 2009). These methods can be summarized as follow:

I. Paasche's Method was derived by a German statistician Paasche in 1874. The weights in this method are represented by the quantities of the commodities in their current year. The formula 3 represents:

$$p_{01} = \frac{\sum p_1 q_1}{\sum p_0 q_1} \times 100 \tag{3}$$

P_{01} price index, p_1 prices of the current year, p_0 prices of the base year, and q_1 is the current Item quantity.

II. Kelly's Method is considered to be a general form of Paasche's method. The ratio of quantities related to the selected year price is not necessarily a specific year's quantities, but any ratio can also give approximate results (McClave, Benson, & Sincich, 2017). Kelly's method can be displayed by equation 4 below:

$$p_{01} = \frac{\sum p_1 q}{\sum p_0 q} \times 100 \tag{4}$$

Where P_{01} price index, p_1 prices of the current year, p_0 prices of the base year and q is any year quantities.

III. Laspeyres Method:

This method was developed in 1871 by Étienne Laspeyres. It used mainly to measure the change in the prices of a basket of goods and services relative to a specified base period weighting. The Laspeyres Price Index is also called the base year quantity weighted method. The Laspeyres method can be displayed by equation 5 below:

$$p_{01} = \frac{\sum p_1 \mathrm{w}}{\sum p_0 \mathrm{w}} \times 100 \qquad (5)$$

Where P_{01} price index, p_1 prices of the current year, p_0 prices of the base year and w is factors weight corresponding to the quantity and item's significance.

In this research Laspeyres method for establishing index was utilized after reviewing several aspects, for instance, a large quantity of the studies that considered this method which approves the popularity and success of it (B. W & Ki-Hong, 1997). In 2009, the International Monetary Fund (IMF) published a Manual named "Export and import price index manual: theory and practice" mentioned that Laspeyres is a very suitable method to be used for the purposes of establishing cost index. Similarly, other big organizations such as the Organization of Economic Cooperation and Development, the General Directorate of the European Statistical Committee (OECD & EUROSTAT, Sources, and Methods: Construction Price Indices, 1997), and the U.S. Bureau of Labour Statistics (BLS) adopted this method to create their own indices (International Labour Office (ILO), 2004).

The advantages of the Laspeyres index include (corporate finance institute (CFI), 2019):

- Simplicity: easy to calculate and most commonly used method
- Reliability: The most commonly used method as mentioned before.

- Efficiency: this method depends mostly on the factor's weights combined with their quantities which gives the more precise results in comparison to other methods.
- Timesaving: the methods do not require recalculating the base year for future indices, only base year weights are used.
- Presents a meaningful comparison, as changes in the index are attributable to the changes in the price.

2.3 Construction Cost Index in Literature

A very few numbers of researches were found to carry out the idea of establishing a new indicator. Most of the other currently available studies considered the calibration of the continuous change in prices. In the few found types of research, the calculations of new indices usually were conducted using the weights of items assigned to the costs of material and labour payments included within the project. In addition, some researches also subjected the new price indicators to be examined in order to define their ability to imitate the situation in the construction sector. On the other hand, other researches were meant to compare the best indicators available currently. In general, this section aims to provide brief knowledge about the previous researches in this field, considering their calculation methods too.

In 1997 a research was conducted by Pintelon & Geeroms, looked through the efficiency of building factories in Belgium. The study indicated the suitability of cost indices and their feasibility to be used in producing new cost rates for construction industrial factories. The study took a sample considering only the chemical factories in Belgium. The used data were belonging to 15 years and the prices were exchanged according to the central bank prices to be able to compare them. Afterward, the prices were returned to the base year by dividing the cost on base year cost. The study faced a lot of difficulties and was not very successful. The reason for that, the big quantity of devices and chemical substances have huge varieties. In 1976 by Cran, a simpler model was assembled. The model included only labour wages and steel cost as in equations 6:

$$(Index)_{Cran} = 0.7 \, * \, L_{Lab} + 0.3 \, * \, L_{St} \qquad (6)$$

Which represents L_{St} is the construction steel cost index and L_{labur} represents manpower wages fees.

Mainly two common factors were selected as indices. The availability of these two factors was an agent made calculation very easy to obtain. In contrast, the model was not reliable, and the results could be used to predict the cost for other manufacturers.

In parallel, the demand for construction indicators also was rising in the US government. The following indices represent the very few first indices that are an outcome of the construction industrial revelation in the USA at that time;

- Engineering News-Record (ENR): The ENR indexes measure how much it costs to purchase this hypothetical package of goods compared to what it was in the base year. The ENR index was not directly related to chemical engineering applications.
- Chemical Manufactory Cost Indices (CMCI): USA Chemical Manufactory Cost Indices was established in1983 to estimate only Chemical plants.
- Swift and Marshall (S&M): Originally known as Marshall and Stevens Index is a composite of two major components; process and industry equipment

average and all-industry equipment averages. It was established in 1947 to be used for specific industries considered in the process and industry equipment average such as; chemicals, petroleum products, rubber, and paper (Vatavuk, 2002).

- Nelson-Farrar construction cost (NFCC): Known as the Nelson Refinery Construction Indexes, it was firstly established in 1946 mainly considers the petroleum industry. NFCC index is published monthly in the Oil and Gas Journal.

Although the Engineering index of New Records was a general indicator with no relevance to the chemical industry, the Nelson-Farrar construction cost was also different from others. Nelson-Farrar construction cost was speciated for the petroleum industry. In 1997 Pintelon & Geeroms, found that the Chemical Manufactory Cost Indices (CMCI) and Marshall and Swift (M&S) were also to most applicable to perform on chemical manufactory. Consequently, the Belgium Chemical Manufactory Cost Indices (BCMCI) was revealed.

The procedure used to develop this indicator contained the main four steps as; Establishing a cost index prototype or model, Analysing the resulting cost index with the Chemical Manufactory Cost Indices (CMCI), adjusting the new cost index for the Belgian circumstance on that time and Final assessment step.

Firstly, new cost indices were generated using the available data. Secondly, the new indices were compared to the original index Chemical Manufactory Cost Indices (CMCI). Accordingly, the results that achieved a closer number to Chemical

Manufactory Cost Indices (CMCI) were selected to be more efficient. Intending to obtain the highest accurate outcomes these first two steps were iterated by continuously changing in the number of factors, which give varieties of choices. Whereas, the small values have less effect on total than the greater factors which highlights the reality that a very small adjustment in mass weights of functions should not influence the index value in a comprehensive way.

The iteration selection method (Trail method) was used to find a suitable number of variables while developing the models. For instance, the two variables model is consisting of two construction major parts labour and material. In the third model manufactory equipment for productivity enhancement, lastly in forth cost price for raw materials as oil, plastic, etc. in total four different models. As a conclusion, the third model which contains three elements was more accurate and efficient than other models. In conclusion, the equation number 7 of the function represented as below:

$$\text{Index} = 0.27\, L_{\text{St}} + 0.38\, L_{\text{Prod}} + 0.35\ L_{\text{lab}} \qquad (7)$$

which L_{St} is the construction steel cost index, L_{prod} productivity is the ratio of the productivity ratio and l_{lab} labour wages fee index.

In the third stage, the average construction weights of Belgian in past projects were used to develop the weighted cost index. Lastly, an assessment of the new indices was performed to make sure of their efficiency to forecast the movement in construction cost. Thus, these evaluations were considered in small periods been covered by certain projects and measured up according to the new price index predictions with keeping the same period. On the other side, the authors states; a failure may occur in the assessment outcomes and the new cost index would not succeed to estimate the construction progress correctly. In this case, a new Chemicals factory Cost Indices (CMCI) model should be created using the same previously followed criteria. Hence, the new model should be responsible for a greater number of variables than the used once.

As summery of this research outcome, the influence of cost indicator on a newly constructed project was measured, to make sure of the preciseness in estimated costs. The findings showed that new indices were suitable for use only in applications related to chemical factory construction. The reason for this restriction was mainly based on the utilized data of the previously constructed chemicals factory in Belgium.

The authors arrived at the conclusion that the generated indicates give the impression of very pleasing outcomes. Nevertheless, they pointed out that this type of price indicator needs to be dealt with in very carefulness and the precautions of being really up-to-date; being only based on genuine Belgian statistics and their own mean value.

Afterward the researches started to go forward and find new indicators such as; Wang and Mei (1998) made a model for forecasting construction cost indices in Taiwan. Wilmot and Cheng (2003) made a study in order to develop a model that estimates future highway construction costs in Lousiana. In 2005, Serhan a built a price index for escalation of building construction costs in turkey represented in the following equations 8:

$$\text{Index} = 0{,}343L_{\text{steel}} + 0{,}348L_{\text{farmework}} + 0{,}309L_{\text{concrete}} \qquad (8)$$

which L_{Steel} is the construction steel cost index, $L_{framework}$ is the ratio of the frameworks index of the items and $L_{concrete}$ concrete price index.

2.4 Price Indices General Information

2.4.1 Price Indices in Jordan

These indicators have an extensive range of implications that has a direct impact on the construction industry such as; regulating the construction insurance and a reference for construction contracts and controlling the house rents. Brief information about the currently available cost indicators in Jordan will be granted, before going deep into the derivation and the methodology of constructing new cost indicators and performing a comparison in terms of their sufficiency. These indicators are usually estimated by governmental organizations and updated annually (Fares, 1988). Numerous amounts of indicators are used to measure the variation in prices every day. These measurements in the construction field can be summarized by the Consumer Price Index for Construction Projects (CCI), Total Construction Cost Index (CI) and Construction Product Price Index (PCI). This section includes brief knowledge regarding the perception of Consumer cost Index for Construction Projects (CCI), Total Construction Cost Index (CI) and Construction Product Price Index (PCI) and the techniques involved in them to be calculated. These indicators usually calculated separately and publish on a regular base in different sources that are related to the department of statistics in Jordan, which is mainly operated through the Ministry of Public Works and Settlement. Conducting a very precise inquiry and using the calculations of the indicators is an appropriate way to generate a clear idea of the main perception in relation to the price indicators.

DOS department of statistics in Jordan classifies the indices in terms of Location or Time, consistency or Variability, and Simplicity or Complexity. Location indices can be verified as the analysis of the fluctuations of numerous statistical variables such as production rates, population increase rates, industry region growth movements, and many other ratios that considers the place, regions, and states (DOS Jordan book, 2018). Likewise, time indices were founded to measure the magnitude of change in time-based statistics. For example, birth rates on a daily or annual basis, population growth rates and continuous changes in production rates. Most of the indicators are built on time perspective using time-series techniques and being utilized in a large percentage of sectors. On the other hand, constant rates are also times based indicate. The constant indicators are prescribed as the indicator that already present and offered as a percentage of the mean to some specific periods. Where the constant period is the duration was chosen to calculate specific data (Dos Jordan, 2018). In contrast, the variable indicators are time base ratios with non-completed values, they use the previous data to be compared with currently available data. Lastly, simple and complex indices are rates calculated according to the number of elements as the one includes only one substance is known to be simple and many elements for the complex.

2.5 Construction Cost Indicators related Definitions

2.5.1 Price Index

Department of Statistics (DOS) in Jordan (2018) identifies the price indicators as a rate to measure the slope of the changing prices over time, while the prices can be related to merchandise or services. Mainly the prices are measured according to a standard called merchandise basket that symbolizes a group of goods or services (consumer, producer, export, import, etc.) that is essential for the considered market. This group is been supervised and measured on a regular basis to achieve the indicators. The given names to index demonstrate a direct relation with index purpose of it, an instance for this, the consumer price index determines the consumption price rate, producer price index determines production price ratio. The price indices play a significant role in defining the economic infrastructure of the country, which are essential for making decisions and setting the procuring power of the population, defining goods costs and employers' minimum fares, stabilizing fees of any services acquired from the customer and identifying the variation in these prices in time.

The fundamental variables demanded in calculating the cost indicators are:

- Group of merchandise (BOS)
- Reference year
- The reference year values
- Present costs
- Mass weight

2.5.2 Group of Merchandise (BOS)

Group of Merchandise is a number of essential and highly demand goods or service in a specific market are supervised by governments on a regular base, mainly used for the purpose of calculating indices. The goods are limited with two restrictions; essentiality for the market was the first condition, which meant that the goods have a great significant weight in the market overall. Secondly, a highly requested product (the good has to take a great part in the market demand), which affords comfort and ease to reach the products form every source and any time. The services chosen by the government are described according to type, amount and nature, and modify with respect to the scope of an indicator.

2.5.3 Mass Weight (Influence Rate)

The mass weight can be described as the ratio of each and every good with respect to the total value of the merchandise basket. The main object for the weights is to serve as a ratio measurement tool for the quantity and value of the goods in the indices. In general, mass weight can be classified into two main groups:

1 Variable influence rates: The variable mass weights are identified to be the weights goods with continuous changing values mainly regarding the time, or according to the situation in the market. For instance, the consumption or production of the construction building sector can be influenced by the time or the situation of the economy.

2 Constant mass weights: It is also known as the stable weights, which refers to their stability regardless of the change in all other aspects.

2.5.4 Reference Year

The reference year is the year chosen as the base average value of the materials and construction elements in the whole year.

2.5.5 Present Costs

Present prices are the currently available value of material widely to estimate the cost indicators. As an annual routine, the department of statistics in Jordan recalculates the indicators. The main reason for this periodical process is the continuous change in the economy, increase in population, the transformation in the demand rates, which has a direct effect on the products and services. In contrast, some specific productions and services become unnecessary and new replacement appears to place them, due to the potential of products to lose their weights to other more important goods. These implied modifications must be involved in the basis of production and consumption and updating the necessary indices (DOS of Jordan, 2018).

2.5.6 Outline of Developing Index Processes

The formation of a cost indicator of the construction process is considered to be a very lengthy and complicated operation. This procedure is comprised of different combinations of formulas as declared by the (OCED, 1997). The efficiency of this developed index depends mainly on the perspicacity to comprehend the aim and scope and knowing the required properties of the index and in comparison, to the once needed in the considered industry.

European Statistics Communities, 2006 conducted a research and highlights the important properties such as the importance of considered construction scale that is being carried out within the investigated region, the commonalty and applicability of the procedures to any type of construction, types of companies undertaking a construction project, and their properties, supervising the maintenance of construction standards and managing the governmental permission of each construction projects. The European Statistics Communities, 2006 exemplify the main important conditions in order to conduct construction cost indices using the model price method as listed below:

- Collecting a random sample that represents a great combination factor.
- The projects must be already completed, and the number of expected projects depends on the covered ranges; such as the region, project type, and activities.
- Details tasks should be provided with the descriptions of these construction projects, these details are mostly found in plans and bill of quantities, also these reports can include as management task scheduler and cost assessment.
- The selection of the samples must be based on cost and material coverage of materials.
- Details for each ingredient should be considered as the quantities and unit prices. Note that data should be very accurate in order to prevent any risk of different analysis through different results.
- A sample of contractors with suitable geographical regions to the research.
- All reports of these components must be collected from subcontractors.
- The weighted prices of these components must be used to calculate the unit price.
- A continuous assessment of the produced index to review and revise results.

2.6 Consumer Cost Index (CCI)

The Consumer Cost Index (CCI) defined as the tool to compare time and price for specific goods according to the type of basket that been measured in a definite time period of time. It is conditioned that indices should represent the price motion of every good in the chosen market basket only (DOS Jordan, 2018). The Consumer Cost Index (CCI) is one of most used as stated by the European statistical institute in (2006). This index can be utilized for many purposes, for instance; determine the changes in the macro-economic and compare it, giving a summary about the country’s economic situation, adjust living standards such as the employees' fares, refinement of relevant data from cost changes. It is also can be used to regulate the selling and rental prices. In the base year (2009) consumer price index was calculated by the department of statistical affairs that covers all of the consumption expenses in Jordan.

2.7 Production Cost Index (PCI)

In Jordan (2018) their ministry of work and public settlement describes the Production cost Index (PCI) the cost index that estimates the cost variations corresponding to manufactured products for the country economy in a specific reference of time duration. In general, The Production cost Index (PCI) is the cost of basic products before introducing it to external rates such as value-added tax, transport costs, consumption taxes, and other indices. Therefore, the Production cost Index (PCI) is a primary price that comes directly by the production side of the industry. These costs are concerned and supervised by producers, for instance, mining metals, petroleum extraction, lumber producing. Variance in such product costs can easily affect the other industries and, for this reason, it was very necessary to establish such an index. Furthermore, Production cost Index (PCI) do not involve commercial increases.

The producer cost index is utilized for numerous objectives, the most critical ones are mentioned below:

- Shows the general tendencies in cost indices and the construction sector.
- A measurement tool for government economic strength.
- Controlling the improvements in employee fares and wages.
- It helps to estimate the market demand and controls input and outputs within the construction industries.
- Predicting the upcoming Financial trends.
- Analysing changes in the prices.

2.8 Cost Index (CI)

The Jordanian Ministry of Human Settlement and work periodically distributes some indicator including (CI) cost index that is used to measure changes in the price of previously constructed projects in Jordan. Cost index (CI) was established depending on the expenses fluctuation effects of the construction project materials, equipment's and labour fares rate. Furthermore, cost index (CI) is defined to be the mean weight of construction elements variation rate.

Chapter 3

METHOD AND ASSESSMENT

3.1 Introduction

Construction cost indicators represent fluctuations in the value of construction. Differences in construction price indices are mainly due to the prices of a combination of building materials and construction services regularly used through the majority of the construction process. Statistical agencies and governments in most countries compile these indicators periodically and continuously. Therefore, the collected data forms a time series that provides a scale of the development in the cost of construction over time. Many cost indicators are calculated and disseminated by government institutions for multiple uses purposes; While the ministries have conducted numerous studies in order to find more accurate cost indicators appropriate can be applied to the majority of constructions. The cost of construction elements such as materials and operatives must be taken into account in this particular type of study. Accordingly, the variables are examined the prices of these elements and operator's wages to calculate this specific type of construction price indicator.

One of the objectives was contrasting to current price indicators and emerging cost indicators through this research. Moreover, the comparison is going to be in terms of suitableness and adequacy to represent the differences in construction costs in Jordan.

Accordingly, the most accurate and reliable scale will be selected to calculate new quantities and predict the following years.

In this chapter, the analysis methods and steps to establish a tender cost indicator will be presented in a piecemeal and simplified manner. The analysis will be based primarily on construction project data in general. However, the sources of information were curtailed and relied mainly on public data in the Ministries of Works and Housing and the Government Tenders Department for accuracy and reliability of the data.

3.2 Data Collection

A random sample of the 23 available government data was taken. Different types of samples and projects were taken, including residential buildings, schools, government offices, and hospitals. The samples included two housing projects, two hospitals, four schools, and three government office buildings ranging between 1 to 4 stories number structures. Construction projects were carried out within the time frame from 2009 to 2018, the majority of which were government tenders that were completed. The main reasons for selecting government tenders as the main source of information are:

- The amount of data collection from a government source for the presence of a large number that is implemented each year.
- The accuracy of data in which government data is audited by departments that check prices and costs.
- The data reliability that data is certified and sealed by the responsible entities, minimum cost to obtain the lowest prices so that government tender prices are considered to be less expensive for the private sector.

- Reduction of spent time to gather data from a government source reduces the time of research to the large number in one place, accessibility of government projects is considered as bids available to all public and entrepreneurs.
- Use government data used to calculate the cost index that reduce the error factor in the calculations.

The data mainly covered the date of contract issuance, the final total cost of the contract and the total project area of the selected samples. The total cost included the total expenditures for the construction, electrical, mechanical, labour wages and total reserves of the project savings. Table 3.1 includes the completed tender projects and characterize them according to their types and illustrates their implantation year. The unit cost values of the project are also represented in Table 3.1 by the Jordan dinars by meter square (JD/m2).

Table 3.1: Projects List

No	Project Title	Stories Number	Type	Year	Unit Cost (JD/m^2)
1	PROJ 1	1	PHB	2009	272.08
2	PROJ 2	3	GOS	2009	255.63
3	PROJ 3	2	PEF	2010	380.69
4	PROJ 4	2	PEF	2010	349.61
5	PROJ 5	1	PEF	2011	499.80
6	PROJ 6	2	PHB	2011	313.20
7	PROJ 7	2	PHB	2012	439.90
8	PROJ 8	2	HCI	2012	747.14

Table 3.1 (cont.)

9	PROJ 9	3	PHB	2012	700.38
10	PROJ 10	3	PHB	2013	454.34
11	PROJ 11	2	HCI	2013	614.98
12	PROJ 12	4	GOS	2014	685.67
13	PROJ 13	3	GOS	2014	640.08
14	PROJ 14	4	PHB	2015	783.18
15	PROJ 15	2	HCI	2015	403.71
16	PROJ 16	3	GOS	2016	685.67
17	PROJ 17	2	GOS	2016	523.55
18	PROJ 18	4	GOS	2017	584.00
19	PROJ 19	4	PHB	2017	702.15
20	PROJ 20	3	GOS	2017	857.08
21	PROJ 21	2	HCI	2018	773.95
22	PROJ 22	3	GOS	2018	836.94
23	PROJ 23	4	PHB	2018	843.12

* PHB: Public housing building, GOS: Governmental structures, PEF: Public education facilities, HCI: Health care institutions.

The prices of contracts submitted in previous years were rectified by the average exchange rate according to the Central Bank, and the exchange rate was set in 2018 to reduce variables and reduce error. The weights were calculated using the weights of the detailed materials or items given in the project scheme as they were found using the record of each project item and summed and divided by number of projects. Further explanation is going to be provided in the methodology chapter. The material categories of the projects that covers the majority of the projects works according to their relative weight to the total cost of the project as shown in Figure 3.1; the total cost included civil, electrical, mechanical works and other important costs such as the works wages, and value-added tax (VAT).

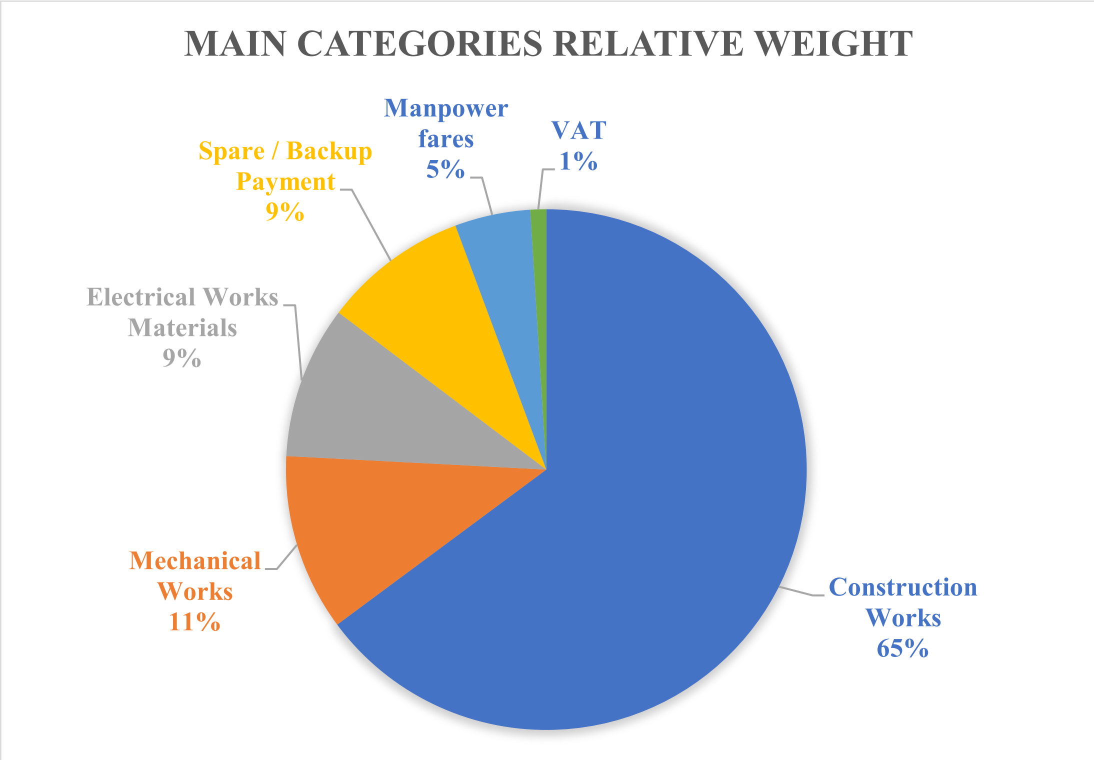

Figure 3.1: Main Categories Relative Weight

The value-added tax VAT was included to increase the preciseness of calculation. These subcategories were also further subdivided into factors or items according to the materials provided by the tendered projects. Figure 3.2 represents the floor area of buildings, ranging from 500-4000 square meters. Using the provide areas, the unit cost of the project can be calculated by dividing the total cost by total area, represented in the following formula 8:

$$Unit\ Cost = \frac{Total\ Cost}{Total\ Area} \quad (8)$$

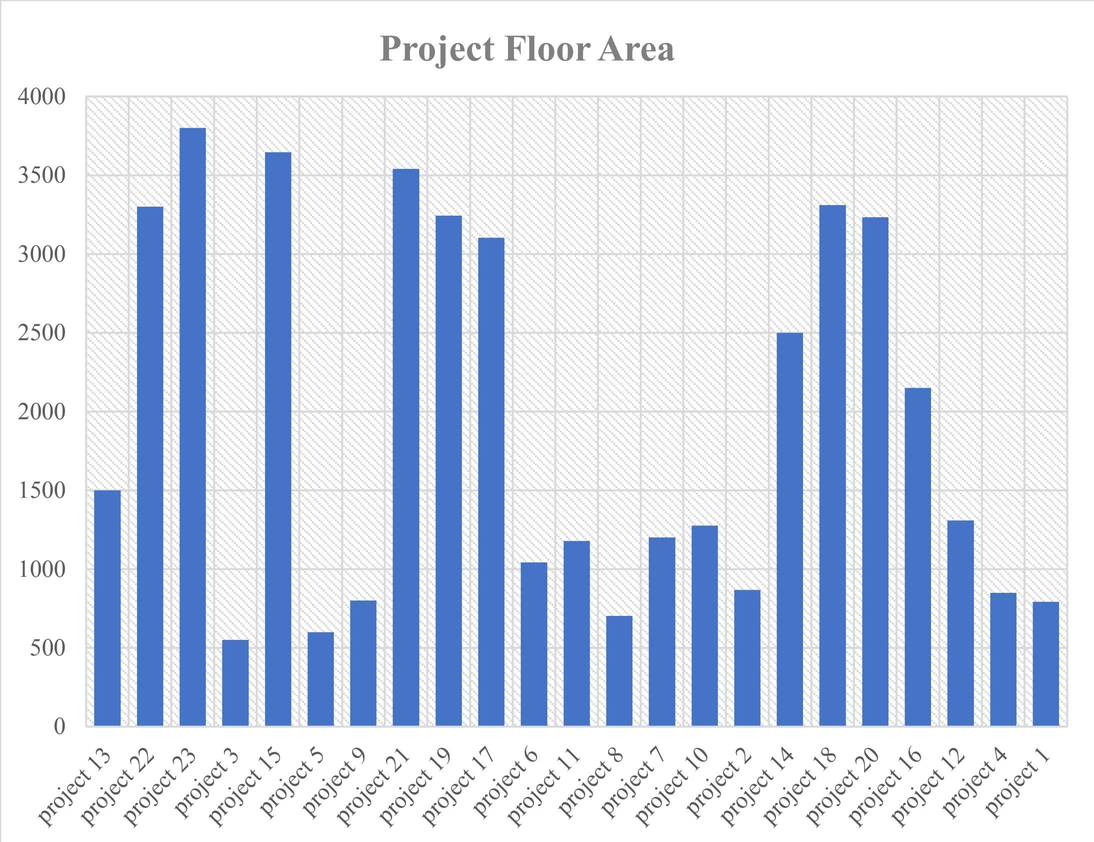

Figure 3.2: Projects Floor Area

3.3 Classification of Price Indicators

Price indicators can be determined by their availability into two main groups; pre-available indicators and generated indicators.

3.3.1 Pre-Available Indicators

This set consists of price metrics extracted by government departments and the Ministry of Works and Housing by surveying data from various projects within a specific time frame estimated to be ten years from 2009 to 2018. The Consumer Price Index for Construction Projects (CCI), Construction Cost Index (CI) and Construction Product Price Index (PCI) are the three indicators that the research looks forward to. The information was collected through the websites of ministries and government statistics offices.

3.3.2 Developed Indicators

In contrast to the available indicators mentioned above, the generated indicators are the price indices produced during this research with the aim of comparing them with the available price indices, where they were calculated using the data of the projects taken from the Ministry of Public Works and Housing and tenders department. Detailed calculation methods and steps for these indicators are described below in the following sections.

3.3.2.1 Developed Price Indicators (DPI)

As the prime stage of producing the new indicators, a search was performed to find the factors that have been most commonly used in projects and measure their influence in the project. As a result of this process, Table 3.2 classified the main and subcategories in every construction project. These categorize filtered the factors and the material used in the calculation.

Table 3.2: Construction Works Categories

NO	Main categories	Sub Categories
1A	Construction Works	Preliminary Work
2A		Underfloor Structure
3A		Structure Above Tiles
4A		Plastering
5A		Tile Works
6A		Formwork
7A		Glazing & Metal works
8A		Painting
9A		Roof Works
10A		External Works

Table 3.2 (cont.)

1B	Mechanical Works	Plumbing and Drainage Materials
2B		Water, Cooling and Heating
3B		VFR
4B		A/C
5B		Fire Fighting
6B		Gas
1C	Electrical Works Materials	
1D	Extra works	
1E	Manpower	
1F	Spare Backup Payment	

According to the above shown Table 3.2, the total cost of construction was characterized by the weights and the prevalence of these works. Consequently, the further investigation in the detailed breakdown of the project’s quantities, the Structural materials, Electrical materials, Mechanical materials, Extra Backup Payment and Workers' Wages were classified as the majority of the project's cost.

European governmental institutions and international organizations provide the following steps as a basis for creating a newly developed price index:

1. The first step to calculating (Equation 9) this indicator was determining the weight of construction factors or material $\left(W_{factor\ z,n}\right)_y$. The total costs for each of the components were found in the summary of a detailed bill of quantities for each project.

2. The overall cost of each subdivision has been up divided with the summation of all sub costs, in order to get their weights.

$$\left(W_{factor\ a,1}\right)_y = \frac{\left(C_{factor\ a,1}\right)_y}{\left(C_{factor\ a,1}\right)_y + \left(C_{factor\ b,1}\right)_y + \cdots + \left(C_{factor\ z,n}\right)_y} \quad (9)$$

Where y is the year, $C_{factor\ a,1}$ is the cost of considered factor, while (a,1) refers to the factor and project number. Equation 9 can be rearranged to the following form Equation 10:

$$\left(W_{factor\ n}\right)_y = \frac{\left(C_{factor\ 1}\right)_y}{(Total\ cost\ _1)_y} \quad (10)$$

The summation of factors can be replaced with total project cost, looking to fact that almost all major factors are considered in calculations.

The total weights of all project factors should sum up to 1. As signified in Formula 11 that is used to calculate the validity of the provided weights. This expression is valid for the sum of all total weights in the same year which means that the total is a fraction of the general total.

$$\left(W_{factor\ 1}\right)_y + \left(W_{factor\ 2}\right)_y + \cdots + \left(W_{factor\ n}\right)_y = 1 \quad (11)$$

3. Calculating the average weights for every subdivision in a construction project: Equation 3.5 illustrates the mean weight of the detailed materials or items given in the project scheme. Detailed analysis of project costs should be available to calculate these weights. Accordingly, the mean weight is calculated for each record of the project items where the average weights are represented with the letter $(W\ )_{ave}$ followed by the type of works. For instance, in Equation 12 $(W\ sub_1)_{ave}$is the weighted mean of the selected materials in construction first subdivision.

$$\left(W_{sub_1}\right)_{ave} = \frac{\Sigma\left((W_{factor\ 1})+(W_{\ factor\ 2})...+(W_{factor\ n})\right)_y}{n} \tag{12}$$

Where y is the year, $W_{factor\ n}$ is the weight of induvial material or factor valid in the same subcategory for every project, and (n) represents the total number of that items or material which equal the number of projects.

4. Calculate the yearly cost index:

   Using the unit prices of construction materials published monthly by the Ministry of Public Works and Housing and the Government Tender Department during the period from 2009 to 2018, the construction costs categories can be calculated. The cost of construction projects is mainly consisting of the following: structural materials cost, mechanical materials cost and electrical works materials cost, employee wages and others. For each and every category many subdivisions valid. These subdivisions $(UR\ sub_1)_y$ signifies the annual unit price for subcategory construction materials.

   Equation 13 represents the formula to calculate the sub indicators index for item per year. There is no dimension for Indicators, due to the fact that it is a division of the value in a specific year $(UR_{\text{sub}})_y$ with respect to the base year$(UR_{\text{sub}})_{\text{base year}}$. The base year value will represent automatically 1 or relatively 100%. The base year in this research is 2009, which is fixed for all indicators.

$$\left(I_{sub_1}\right)_y = \frac{\left(UR_{sub_1}\right)_y}{(UR_{sub})_{\text{base year}}} \tag{13}$$

5. The formula 14 is used to calculate DPI, the general formula can be rearranged into the following form Equation 15:

$$(DPI)_{iy} = \sum\left(\left(W_{sub_\eta}\right)_{\text{ave}} * \left(I_{sub_\eta}\right)_y\right) \tag{14}$$

Or

$$(DPI)_{iy} = \begin{bmatrix} ((W_{sub_1})_{\text{ave}} * (I_{sub_1})_y) + \\ ((W_{sub_2})_{\text{ave}} * (I_{sub_2})_y) + \\ ((W_{sub_3})_{\text{ave}} * (I_{sub_3})_y) + \\ . \\ . \\ . \\ . \\ ((W_{sub_n})_{\text{ave}} * (I_{sub_n})_y) \end{bmatrix} \tag{15}$$

Where y is process year, $\left(I_{sub_\eta}\right)_y$ sub indicators index for item per year, $\left(W_{sub_\eta}\right)_{\text{ave}}$ is the weighted mean of the selected materials in construction subdivision, and (η) represents the sub category number for each item.

3.3.2.2 Developed Price Indicators (DPI 1)

In DPI 1 only the construction works were taken into consideration, as mentioned in Table 3.3; Preliminary Work materials (1A), Underground Structure materials (2A), aboveground Structure materials (3A), Plastering (4A), Tile Works (5A), formwork (6A), Glazing & Metal Works (7A), Painting (8A), Roof works (9A), and External works (10A). The average of all weights was calculated using the method mentioned below Equation 16.

$$(DPI_1)_Y = \begin{bmatrix} (W_{A1})_{\text{ave}} * (I_{\text{A1}})_y + \\ (W_{A2})_{\text{ave}} * (I_{A2})_y + \\ \dots \\ (W_{A10})_{\text{ave}} * (I_{A10})_Y \end{bmatrix} \tag{16}$$

Table 3.3 and Table 3.4 illustrates the Average Weights of DPI 1 and the results material price index. DPI 1 is the final product of Equation 16 as Table 3.5 included the results of the DPI1 index for every construction element that valid in 10 years period of 2009-2018.

Table 3.3: Mean Weights DPI1

NO	Main Categories	Subcategories	W avg
1A	Construction Works 65.2%	Preliminary work	1.0%
2A		Underfloor structure	10.5%
3A		Structure above tiles	18.8%
5A		Plastering	4.3%
6A		Tiles works	5.5%
7A		Formwork	2.9%
8A		Glazing	5.0%
9A		Painting	1.7%
10A		Roof works	1.8%
11A		External works	13.7%

Table 3.4: Index Percentage Value DPI1

Index	Construction Works									
Year	Preliminary Work	Underfloor Structure	Structure Above	Plastering	Tiles Works	Formwork	Glazing	Painting	Roof Works	External Works
2009	100	100	100	100	100	100	100	100	100	100
2010	114.44	116.12	117.79	119.46	121.13	122.80	126.15	127.82	129.49	131.16
2011	117.32	118.95	120.58	122.21	123.84	125.47	128.73	130.36	131.99	133.62
2012	121.11	122.88	124.65	126.42	128.19	129.96	133.49	135.26	137.03	138.80
2013	108.35	108.20	108.05	107.91	107.76	107.61	107.31	107.16	107.01	106.86
2014	96.50	94.62	92.73	90.85	88.96	87.08	83.30	81.42	79.53	77.65
2015	112.67	112.59	112.50	112.42	112.33	112.24	112.07	111.99	111.90	111.81
2016	129.75	131.65	133.54	135.44	137.33	139.23	143.02	144.92	146.81	148.71
2017	146.23	149.98	153.74	157.49	161.25	165.00	172.51	176.27	180.03	183.78
2018	162.85	168.50	174.14	179.79	185.44	191.08	202.37	208.02	213.66	219.31

Table 3.5: Index Values Result DPI1

Index	Construction Works									
Year	Preliminary Work	Underfloor Structure	Structure Above	Plastering	Tiles Works	Formwork	Glazing	Painting	Roof Works	External Works
2009	1.02	10.46	18.85	4.25	5.46	2.92	5.04	1.69	1.81	13.65
2010	1.17	12.15	22.20	5.08	6.61	3.59	6.36	2.15	2.34	17.91
2011	1.20	12.44	22.73	5.20	6.76	3.67	6.49	2.20	2.39	18.25
2012	1.23	12.85	23.50	5.38	7.00	3.80	6.73	2.28	2.48	18.95
2013	1.10	11.32	20.37	4.59	5.88	3.15	5.41	1.81	1.93	14.59
2014	0.98	9.90	17.48	3.86	4.86	2.55	4.20	1.37	1.44	10.60
2015	1.15	11.78	21.21	4.78	6.13	3.28	5.65	1.89	2.02	15.27
2016	1.32	13.77	25.17	5.76	7.50	4.07	7.21	2.44	2.65	20.31
2017	1.49	15.69	28.98	6.70	8.80	4.83	8.69	2.97	3.25	25.09
2018	1.66	17.62	32.82	7.65	10.12	5.59	10.20	3.51	3.86	29.95

3.3.2.3 Developed Price Indicators (DPI 2)

The same procedure used in calculating DPI1 was applied to calculate DPI2. Nevertheless, unlike DPI1, this index included constructions and mechanical material and factors. These work items include the previously mentioned construction factors in DPI (A1, A2,…, A10) and mechanical (B) listed below:

- Plumbing and Drainage Materials (B1): this factor considered various types all Plumbing Material, Drainage System, and Disabled People Health Works
- Water, Cooling and Heating (B2): Cold water line of steel with accessories and insulation, A water line from the upper tanks {galvanized steel}, White and hot water network white galvanized with attachments, Hot and cold plastic piping network.
- VFR (B3): is a central heating system, consist of boilers, pipe networks, heating devices, and pumps.
- And other elements such as; A/C (B4) an air conditioning system, Fire Fighting system elements (B5) Material (B6)

Giving that this phase main objective is to find a tender cost index that is formed by the use of subcategorize elements, for instance; structural elements and mechanical elements. Equation 17 is the DPI 2 index estimation formula.

$$(DPI_2)_Y = \begin{bmatrix} (W_{A1})_{\text{ave}} * (I_{\text{A1}})_y + \\ \cdots \\ (W_{B1})_{\text{ave}} * (I_{\text{B1}})_Y + \\ (W_{B2})_{\text{ave}} * (I_{B2})_Y + \\ \cdots \\ (W_{B6})_{\text{ave}} * (I_{B6})_Y \end{bmatrix} \tag{17}$$

Where W_{B1} the average weight for Plumbing and Drainage Materials; I_{B1} Total Plumbing and Drainage Materials yearly cost index. The mean weight of the mentioned elements has been determined all the way according to equation 3.10 and the previously provided steps. The mean weight results are presented in Table 3.6. Table 3.7 illustrates the Average Weights of DPI 2. Table 3.8 lists the values of DPI 2 indices for both construction and mechanical work item in ten years' time frame.

Table 3.6: Mean Weight DPI2

No	Main Categories	Elements Sub Categories	W Avg
1a	Construction Works 65.2%	Preliminary Work Elements	1.0%
2a		Underfloor Structure	10.5%
3a		Structure Above Tiles	18.8%
5a		Plastering	4.3%
6a		Tiles Works	5.5%
7a		Formwork	2.9%
8a		Glazing	5.0%
9a		Painting	1.7%
10a		Roof Works	1.8%
11a		External Works	13.7%

Table 3.6 (cont.)

1b	Mechanical Works 10.7%	Plumbing and Drainage Materials	2.7%
2b		Water, Cooling and Heating	1.9%
1b		VFR	4.7%
2b		A/C	1.4%
1b		Fire Fighting	0.4%
2b		Gas System	1.0%

Table 3.7: Index Percentage Value DPI2

Group No	A	1b	2b	3b	4b	5b	6b
Index	Construction Works	Mechanical Works					
Year	All Construction	Plumbing and Drainage Materials	Water, Cooling and Heating	VFR	A/C	Fire Fighting	Gas System
2009	All Considered Values For Construction Category Provide In Table 4.3.2	100	100	100	100	100	100
2010		115.54	118.68	96.95	122.17	122.21	144.38
2011		128.81	134.92	108.09	132.31	136.25	164.87
2012		142.65	146.53	119.70	150.84	150.88	178.26
2013		164.16	167.02	164.97	159.37	163.87	167.40
2014		187.18	182.46	215.13	177.21	177.15	143.80
2015		192.23	195.64	192.15	187.16	192.26	197.45
2016		196.49	201.83	164.88	207.77	207.83	245.55
2017		211.08	214.99	210.43	205.61	211.31	217.79
2018		226.06	220.35	259.82	214.01	213.95	173.67

Table 3.8: Index Values Result DPI2

Group No	A	1b	2b	3b	4b	5b	6b
Index	Construction Works	Mechanical Works					
Year	All Construction	Plumbing and Drainage Materials	Water, Cooling and Heating	VFR	A/C	Fire Fighting	Gas System
2009	All Considered Values For Construction Category Provide In Table 4.3.2	1.02	2.70	1.95	4.73	1.36	0.39
2010		1.17	3.13	2.31	4.59	1.67	0.48
2011		1.20	3.48	2.63	5.12	1.80	0.53
2012		1.23	3.86	2.85	5.67	2.06	0.59
2013		1.10	4.44	3.25	7.81	2.17	0.64
2014		0.98	5.06	3.55	10.18	2.42	0.69
2015		1.15	5.20	3.81	9.09	2.55	0.75
2016		1.32	5.32	3.93	7.80	2.83	0.81
2017		1.49	5.71	4.18	9.96	2.80	0.83
2018		1.66	6.11	4.29	12.30	2.92	0.84

3.3.2.4 Developed Price Indicators (DPI 3)

Similarly, In DPI 3 construction, mechanical, electrical and other works will be used to calculate the price index, as represented in Equation 18:

$$(DP3)_y = \begin{bmatrix} (W_{A1})_{\text{ave}} * (I_{\text{A1}})_y + \\ \dots \\ (W_{B1})_{\text{ave}} * (I_{\text{B1}})_Y + \\ \dots \\ (W_{D1})_{\text{ave}} * (I_{\text{D1}})_Y + \\ (W_{E1})_{\text{ave}} * (I_{E1})_Y \\ \end{bmatrix} \quad (18)$$

DPI 3 was estimated according to the subcategories such as Construction elements, Mechanical elements, Electrical elements Materials, and extras work elements: includes various materials available in construction, electrical elements, the rest of other construction materials.

Where (W_{A1}) refereed to average weight construction from 1 to 10; (W_{B1}) symbolize the mean weight of mechanical elements; (W_{D1}) is the mean weight for Electrical Materials; W_{E1} is the mean weight of other various materials available in construction, electrical works and the rest of other construction materials index are the characters of DPI 3 index values, while the calculation was performed in the similar to PBPI1 and PBPI2; and y is meant to be numbering of projects. The estimated mean weights are given in Table 3.9 and the considered indexes are shown in Table 3.10 below.

Table 3.9: Mean Weights DPI3

No	Main Categories	Sub Categories	W Avg
1A	Construction Works 65.2%	Preliminary Work	1.0%
2A		Underfloor Structure	10.5%
3A		Structure Above Tiles	18.8%
4A		Plastering	4.3%
5A		Tiles Works	5.5%
6A		Formwork	2.9%
7A		Glazing	5.0%
8A		Painting	1.7%
9A		Roof Works	1.8%
10A		External Works	13.7%
1B	Mechanical Works 10.7%	Plumbing and Drainage Materials	2.7%
2B		Water, Cooling and Heating	1.9%
1B		VFR	4.7%
2B		A/C	1.4%
1B		Fire Fighting	0.4%
2B		Gas System	1.0%
1C	Electrical Works Materials	9.5%	9.5%
1D	Others (VAT)	1.1%	1.1%

Table 3.10: Index Values Result DPI3

Group No	A	1B	1C	1D
Index	Construction Works	Mechanical Works	Electrical Works Materials	OTHERS (VAT)
Year	All Construction	Plumbing and Drainage Materials		
2009	All Considered Values For Construction, Category Provide In Table 4.3.2	All Considered Values For Mechanical, Category Provide In Table 4.3.2	9.45	1.07
2010			12.22	1.61
2011			13.63	1.83
2012			15.09	1.99
2013			15.46	1.77
2014			15.74	1.43
2015			18.18	2.10
2016			20.79	2.75
2017			20.00	2.31
2018			19.01	1.73

3.3.2.5 Developed Price Indicators (DPI 4)

In DPI 4, all construction categories will be used to calculate the price index. In this index workman fares and other extra costs were considered as well. Average weights and indices are presented in Tables 3.11 and 3.12, respectively.

Table 3.11: Index Values Result DPI4

Group No	A	1b	1c	1d	1e	1f
Index	Construction Works	Mechanical Works	Elect Work	Other (Vat)	Man power	Spare / Backup Payment
Year	All Construction	Plumbing and Drainage Materials				
2009	All Considered Values For Construction, Category Provide in Table 4.3.2	All Considered Values For Mechanical, Category Provide in Table 4.3.2	9.45	1.07	4.67	8.98
2010			12.22	1.61	6.23	11.18
2011			13.63	1.83	6.95	12.11
2012			15.09	1.99	7.70	13.80
2013			15.46	1.77	7.63	14.30
2014			15.74	1.43	7.48	15.61
2015			18.18	2.10	8.98	16.81
2016			20.79	2.75	10.60	19.01
2017			20.00	2.31	9.89	18.47
2018			19.01	1.73	9.04	18.85

Table 3.12: Mean Weights DPI4

No	Main Categories	Sub Categories	W Avg
1A	Construction Works 65.2%	Preliminary Work	1.0%
2A		Underfloor Structure	10.5%
3A		Structure Above Tiles	18.8%
5A		Plastering	4.3%
6A		Tiles Works	5.5%
7A		Formwork	2.9%
8A		Glazing	5.0%
9A		Painting	1.7%
10A		Roof Works	1.8%
11A		External Works	13.7%
1B	Mechanical Works 10.7%	Plumbing and Drainage Materials	2.7%
2B		Water, Cooling and Heating	1.9%
1B		VFR	4.7%
2B		A/C	1.4%
1B		Fire Fighting	0.4%
2B		Gas System	1.0%
1C	Electrical Works Materials	9.5%	9.5%
1D	Others (VAT)	1.1%	1.1%
1E	Manpower	4.7%	4.7%
1F	Spare / Backup Payment	9.0%	9.0%

3.3.2.6 Summary List for the Price Indices

The following Table 3.13 is a summary of all the price indices so that the previously available indicators are: Consumer Price Index for Construction Projects (CCI), Total

Construction Cost Index (CI) and Building Product Price Index (PCI). Calculated in a time frame from 2009 to 2018 and these consist of; developed price indicators (DPI1, DPI2, DPI3, and DPI4).

Table 3.13: Index Summary

Year \ Index	CCI	PCI	CI	DPI1	DPI2	DPI3	DPI4
2009	100	100	100	65.15	77.27	87.79	101.44
2010	104.57	96.21	108.70	79.56	93.14	106.98	124.39
2011	108.60	101.13	114.80	81.31	96.48	111.94	131.00
2012	112.30	106.05	120.90	84.19	100.96	118.05	139.54
2013	119.98	110.96	127.00	70.15	90.10	107.33	129.27
2014	125.68	115.88	133.10	57.24	80.55	97.73	120.81
2015	126.40	120.80	139.21	73.15	96.49	116.76	142.55
2016	127.86	125.72	145.31	90.20	113.30	136.83	166.44
2017	131.43	130.63	151.41	106.49	132.11	154.42	182.79
2018	135.73	135.55	157.51	122.98	151.13	171.88	199.76

3.4 Regression Method Analysis

The following phase was the process of analysis technique, which aimed to discover the relationship between the indicators mentioned earlier in the research. All indicators were considered separately as an independent and dependent variable of the regression analysis model. In other words, the regression analysis is a tool used to explain the nature of relevance among two variables. These variables are usually divided into independent variables and the dependent variable. For this research unit price is considered to be the dependent variable and the construction cost indicators will represent the independent variables.

According to Tieman in his book Introductory Business Statistics, 2010 stated that fitting the sample using the Regression Line method (Least Squares) is meant to find the dependent variable (y) value corresponding to a given independent value x. Usually, this type of regression line is meant to be related to the unit price that deals only with data that construction cost indicators curves of both temporal response function and the gradient line are known as the trend line. A trend line is a powerful tool, which is mainly used for the purpose of forecasting and predicting future values.

The notion of fitting a curve to a set of sufficient points is essentially the problem of finding the parameters of the curve. The best-known method is that of least squares (regression). Since the desired curve or equation is to be used for estimating or prediction purposes, the curve or equation should be so modelled as to make the errors of estimation small. An error of estimation means the difference between an observed value and the corresponding fitted curve value for the specific value of x. It will not do require that the sum of these differences or errors be as small as possible. It is a requirement that the sum of the absolute value of the errors is as small as possible.

However, sums of absolute values are not convenient mathematically. The difficulty is avoided by requiring that the sum of the squares of the errors be minimized. If this procedure is followed, the values of parameters give what is known as the best curve in the sense of least squares difference (Ostwald, 2001, p.146-148).

The regression trend line was found using the linear fitting analysis method (regression) and the price indicator was the independent x values that are analysed corresponding to dependent y variables (unit cost price). As mentioned beforehand, the main idea to perform the regression linear analysis is to figure the fittest linear line to the calculated values of cost unites and developed cost indicators.

The trend line plays an important role in predicting the next values. Therefore, the integrity of the line between the data points in a way to be close to all points is very important. Better integrity provides better results and reduces error margins. The prediction's effectiveness will be measured by comparing the regression models with price indices. As a result of the comparison, the adoption of the sufficient cost Index will be performed. Before the initiate of the regression analysis process, the project unit costs versus the price indices were drawn (see Appendix A Figures 4.1 to 4.7), which describe the values in Table 3.14. However, to measure the relationships of unit price, regression test was applied, as well as, the obtained outcomes were given in Table 3.14.

Table 3.14: Regression Results

Index	R Square	P-Value Significance F
CCI	0.848142155	0.001551885
PCI	0.762065002	0.009747729

Table 3.14 (cont.)

CI	0.83592691	0.001704928
DPI1	0.357941543	0.067677843
DPI2	0.527834585	0.017320185
DPI3	0.592259056	0.00923874
DPI4	0.844553749	0.001653268

As a result of regression analysis, two main statistic values where produced; significance level and variance coefficient. The significance level or probability value (P-value) can be defined as the possibility of achieving values that are very close to the real values. Whereas the variance coefficient is represented by the squared R symbol and it is used to determine inconsistency of sample values in comparison to population avg. Both of these statistics values are given in Table 3.14. As can be clearly observed from the table, the coefficient of determination has a value range of 0.35 - 0.85. On the other hand, the significance indication, where ranging between 100 and 700 to the power -5. These values exemplify the degree of fluctuation in unit price. Nevertheless, many other factors can cause these variations in project total cost, such as; management costs, equipment cost, and diesel prices were not introduced in this analysis. Accordingly, the analyses were only demonstrated by the costs that have a direct connection with the project cost unit price.

The coefficient of determination has an inverse correlation with the significance level. In other words, the higher is the coefficient of determination (R square value), the significance grade (p-value is) presumed to be lower in value for the same regression analysis. In Table 3.14, the lowest p-value that is 0.00155, and the highest R squared value that is 0.8481 are related to sample CCI. Followed by DPI 4 which scored 0.00165 and 0.844 for each p-value and variance.

The equations below were used to measure the error of forecasting capability in Table 3.14, and to estimate the mean absolute percentage error these formulas were used: Equation 19 represents the Coefficient of Determination (R square),

$$R^2 = \frac{S_{yy} - SSE}{S_{yy}} \tag{19}$$

Where S_{yy} refers to the overall variability in y-values can be estimated through Equation 20, while *SSE* refers to the unexpected variability found by Equation 21.

$$S_{yy} = \sum (y - \mu_y)^2 \tag{20}$$

$$SSE = \sum (y - \hat{y})^2 \tag{21}$$

Where μ_y is the average of y-values, usually named as mean, and $\hat{y}$ is an estimated value can be found using Equation 22.

$$\hat{y} = \beta_0 + \beta_1 x \tag{22}$$

Equations 23 and 24 are the least-squares estimation equations, so they can anticipate values of β_0 and β_1 sequentially. The total variability of x-values is given the symbol S_{xx}, as well, the overall variability of X and Y values are symbolized with S_{xy}. The Equations 25 and 26 is used to calculate S_{xx} and S_{xy}, while μ_x is the average of x values.

$$\beta_1 = \frac{S_{xy}}{S_{xx}} \tag{23}$$

$$\beta_0 = \mu_y - \beta_1 \mu_x \tag{24}$$

$$S_{xx} = \sum (x - \mu_x)^2 \tag{25}$$

$$S_{xy} = \sum (x - \mu_x)(y - \mu_y) \tag{26}$$

The following formula 27 is usually used to measure the error of forecasting capability by regression specimens in Table 3.16. MAPE refers to the mean absolute percentage error.

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n} \frac{|\text{act}_i - \text{pred}_i|}{|\text{pred}_i|} \times 100 \tag{27}$$

The number of projects is represented by (n); while (act) is the project real value in JD/m^2, and (pred) represents the project forecasted value in JD/m^2.

3.4.1 Cross-Validation Method

This method was used to evaluate the forecasting capability; the instructions to the evaluation process can be summarized as in the following:

- The most recent projects of 2018 were selected for the purpose of testing and removed from the projects list. Consequently, the new project list is different than the old list with a smaller number of projects.
- A regression analysis was done again. The newly calculated data set performed differently from the previous data and the new set of parameters were created.
- The removed projects of the 2018 unit price were used as a testing sample, and their unit price values were forecasted using the new set of parameters.
- Mean absolute percentage error (MAPE) values were determined using Equation 27 for the regression models.

Evaluation of the forecasting capability test of projects 2018 results for all regression tests are proved in Table 3.15.

Table 3.15: Forecasting Capability Test

Index	Reg Line Equation	Forecast (2018)	Actual (2018)	R Square	P-Value Sig-F	MAPE
CCI	y = 12.822x - 969.78	134.43	135.73	0.80439	0.00104	0.0265
PCI	y = 10.84x - 679.71	138.16	135.55	0.72276	0.00657	0.0389
CI	y = 8.2382x – 510	161.20	157.51	0.79281	0.00115	0.0289
DPI 1	y = 5.1718x + 129.8	183.26	122.97	0.33948	0.04564	0.2331
DPI 2	y = 5.3405x + 8.3827	154.7394	151.1315	0.50061	0.011683	0.32896
DPI 3	y = 5.0152x - 47.433	172.5626	171.8754	0.56171	0.006232	0.03983
DPI 4	y = 4.5322x - 92.459	200.8874	199.7603	0.80099	0.001115	0.02611

The assessment of prognostication behaviour was mainly based on the famous method known by k-fold or validity estimation (Refaeilzadeh P., 2009). The estimation has been conducted through a comparison of the mean absolute percentage errors MAPE's of each index. The best captured behaviour was proposed by CCI, DPI 4 with the MAPE value of 0.005611, 0.003983 respectively being the lowest among the others. But due to the closeness and minimal in values differences of MAPE, These DPI3, DPI4, CCI, PCI, CI, must be taken into consideration for further calculations.

3.5 Evaluation of Indicators Results

The cost indicators efficiencies were compared along with their ability to represent building costs for construction works (see Table 3.16). Linear regression method was applied to provide the best linear fit for each set of data including the 23 projects, the results showed that the DPI3, DPI4, CCI, PCI and CI indicators delivered the most linear and efficient relation. Models generated using these price indicators had the best predictability performance between the other studied linear index models. Hence, it can be summarized that the DPI3, DPI4, CCI, PCI and CI indicators have the highest efficiency between the cost indices examined with regard to representing the divergences in construction costs for project works due to fluctuations in construction industry prices.

Table 3.16: Comparison Table for the Models

Index	R Square	P-Value (Sig- F)	Evidence
CCI	0.8481422	0.0015519	$p(X) < 0.01$ VSE
CPPI	0.7620650	0.0097477	$p(X) < 0.01$ VSE
TCI	0.8359269	0.0017049	$p(X) < 0.01$ VSE
DPI1	0.3579415	0.0676778	$p(X) \in (0.05, 0.1)$ WE
DPI2	0.5278346	0.0173202	$p(X) \in (0.01, 0.05)$ STE
DPI3	0.5922591	0.0092387	$p(X) < 0.01$ VSE
DPI4	0.8445537	0.0016533	$p(X) < 0.01$ VSE

* R (50 % and more are closer to mean), With VSE very strong evidence, STE strong evidence, WE weak evidence, NOLE little or no evidence.

3.6 Future Estimations for Indicators

The last section of the research included, the DPI3, DPI4, CCI, PCI and CI indicators were recognized as suitable indicators to represent the cost changes. The main idea beyond this part was to deliver a suitable equation for that index to be able to forecast the future. The establishment of a new forecasting index equation can become possible by implementing the regression analysis on the previously validated data. In contrast to the previous regression analysis, the new analysis will be in a wider perspective for the reason that it includes various types of equations such as polynomial, non-polynomial, logarithmic and exponential equations. After that these developed equations are going to be used for the purpose of forecasting the upcoming changing rates which in turn will be considered as a reference point to the government tenders related to construction projects. Thus, creating a very highly competitive environment and increases the accuracy ratio in the conclusions of the project. Furthermore, governments can use this indicator to predict the change in the prices and settle the cost differences and use the equations to financially compensate the entrepreneurs due to the escalating costs during the project fulfilment period. Similarly, tender contractors can also benefit from it by Financial fortifying using the equation to find a suitable improved budget that can avoid the price changes. The correlation identification amongst the considered years and investigated indices are very essential to the derivation of these equations. Analysis of regression was key to answer this question by providing various models with the ability to determine the relationship. The general formula for functions was used in identifying the equations is mentioned in the steps below (Equation 28 -33):

Exponential $$\mathrm{Index}_y = ae^{cx} \tag{28}$$

Linear $$\mathrm{Index}_y = \mathrm{ax} + \mathrm{c} \tag{29}$$

Logarithmic $$\mathrm{Index}_y = \ln_{\mathrm{b}}\mathrm{x} + \mathrm{c} \tag{30}$$

Quadratic $$\mathrm{Index}_y = \mathrm{ax}^2 + \mathrm{bx} + \mathrm{c} \tag{31}$$

Cubic $$\mathrm{Index}_y = \mathrm{ax}^3 + \mathrm{bx}^2 + \mathrm{cx} + \mathrm{d} \tag{32}$$

Power $$\mathrm{Index}_y = \mathrm{a}x^c \tag{33}$$

The phrase y represents the index of the calculated year; x demonstrates the chosen year number which ranges from 2009 to 2018, in which number (1) refers to the base year 2009, number (2) to 2010, …. number (10) to 2018; and a, b and c express the regression equations coefficients for each of the function. The relationships were examined through the regression technique using the functions (equations 28 - 33) to determine the proper outfit for the set of data and to enhance the forecasting behaviour. In intend to get a better point of view; graphs were essential to provide further information and a better understanding of the Interactions amongst considered years and the applied indices which can observe Figures from 3.3 to 3.9.

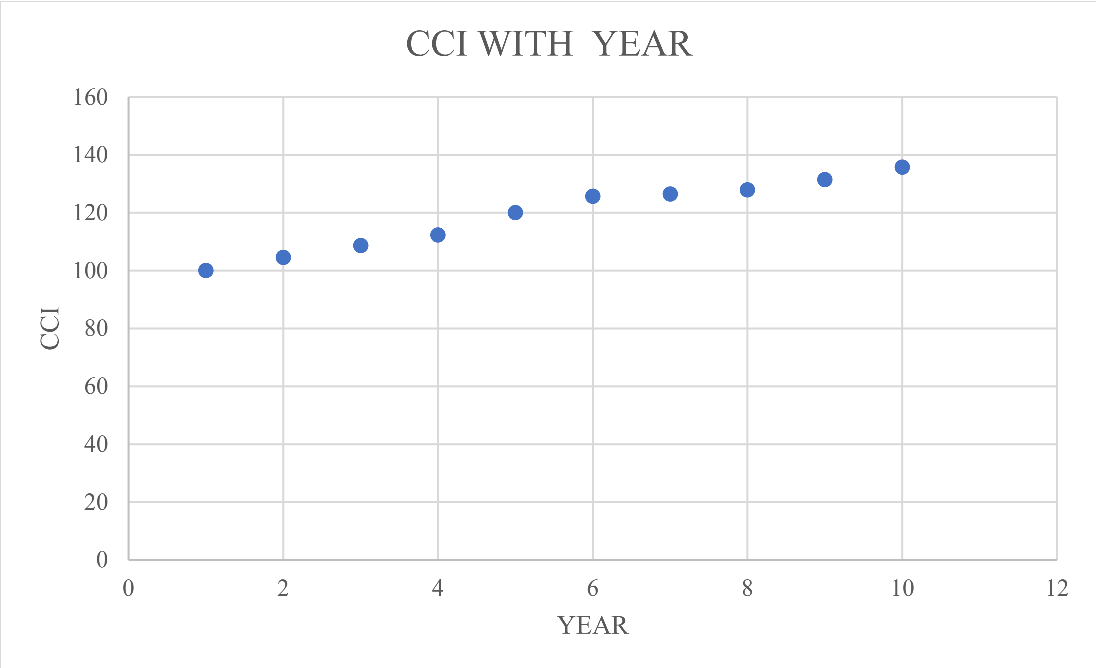

Figure 3.3: CCI with Years

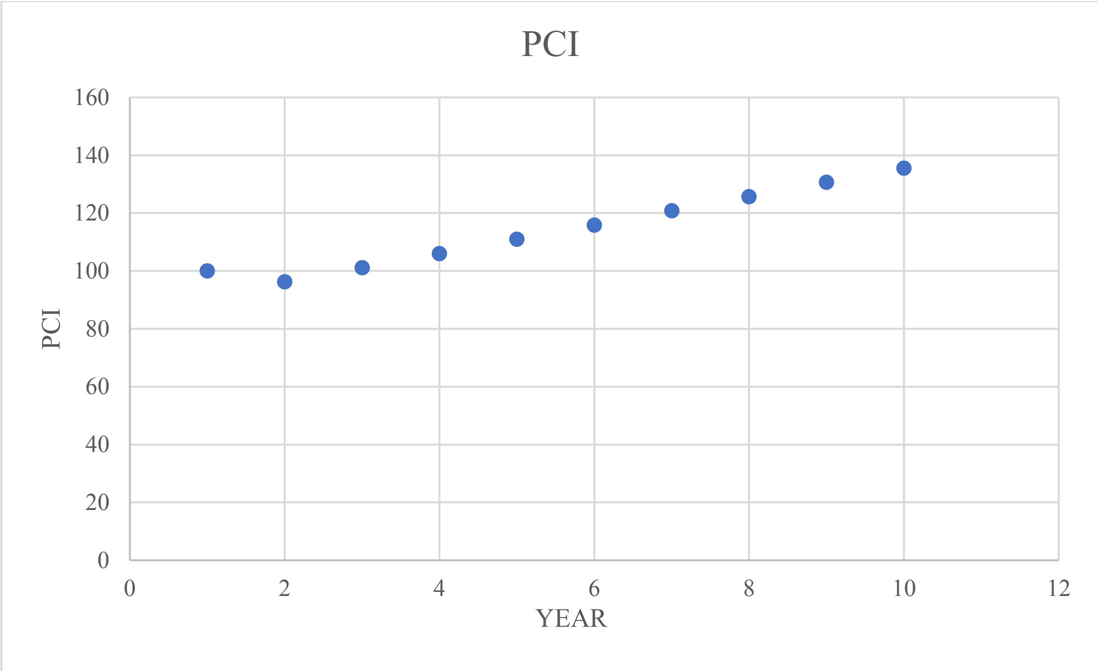

Figure 3.4: PCI with Years

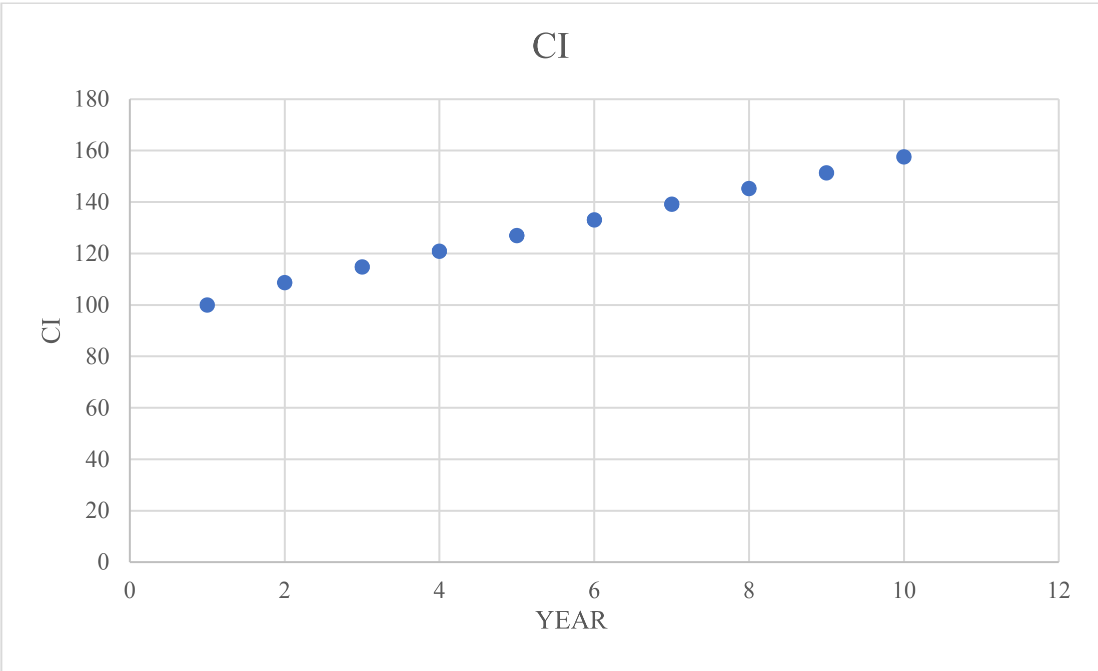

Figure 3.5: CI with Years

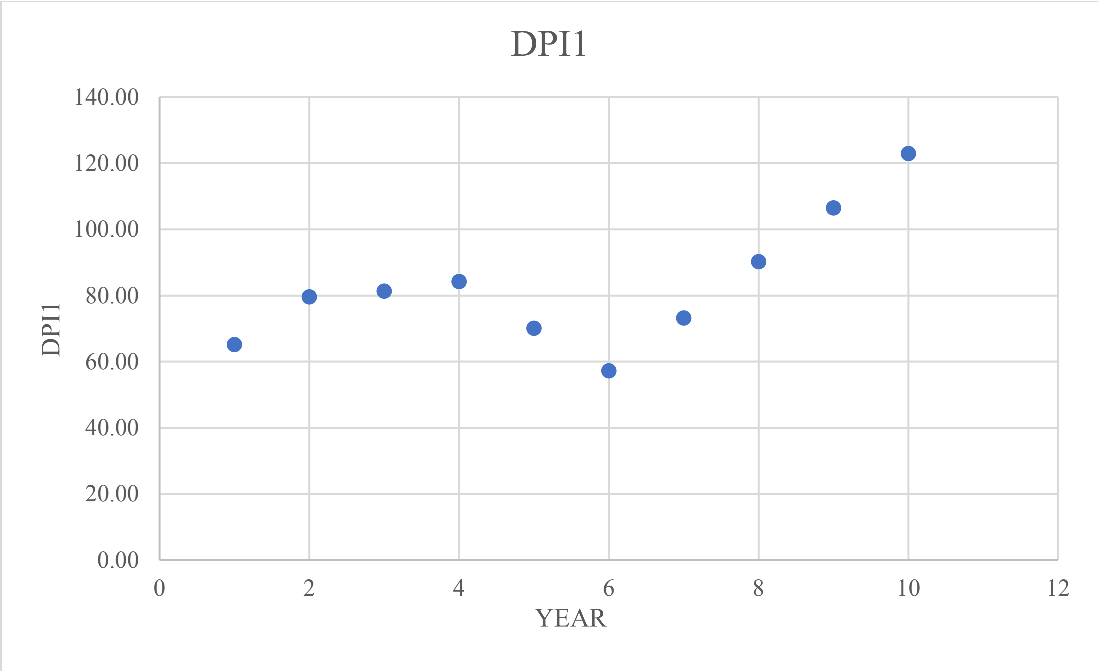

Figure 3.6: DPI1 with Years

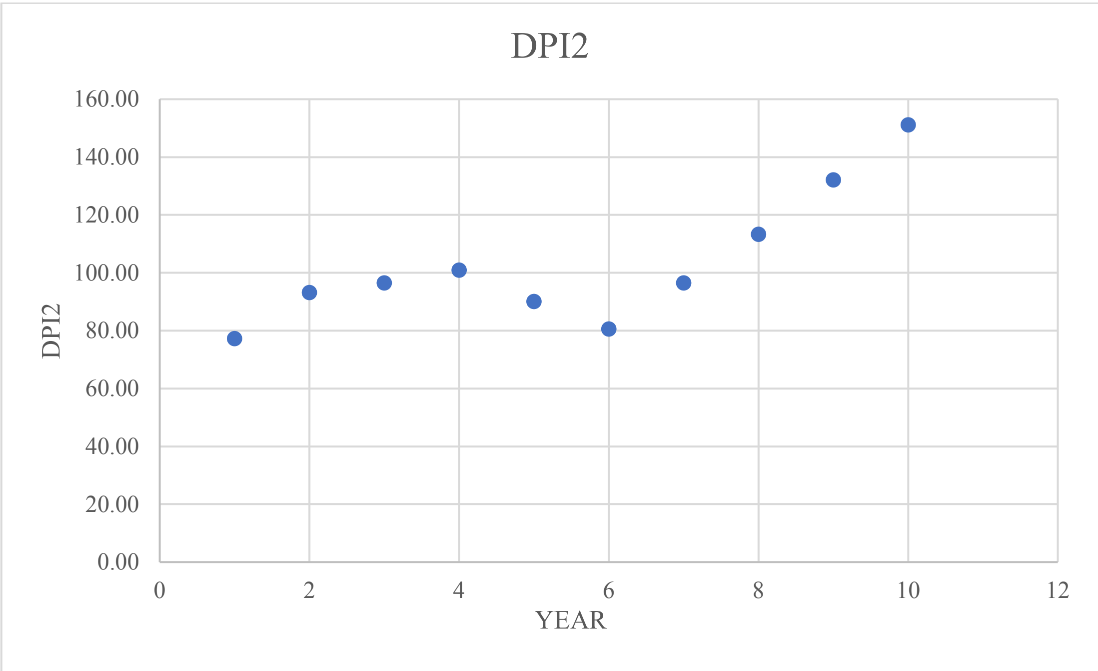

Figure 3.7: DPI2 with Years

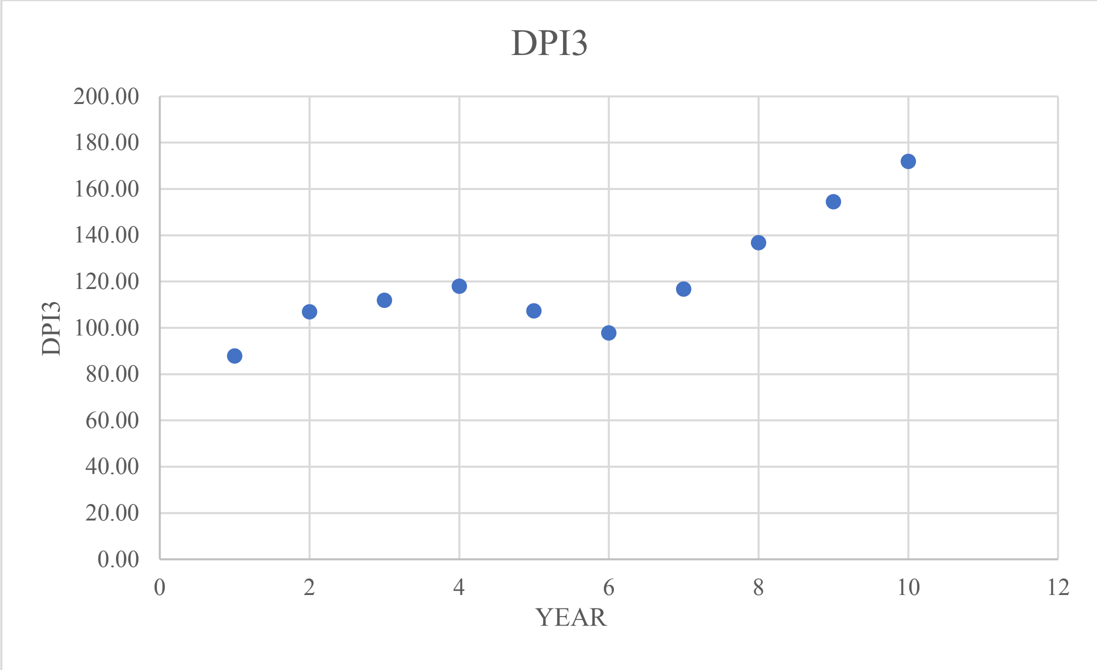

Figure 3.8: DPI3 with Years

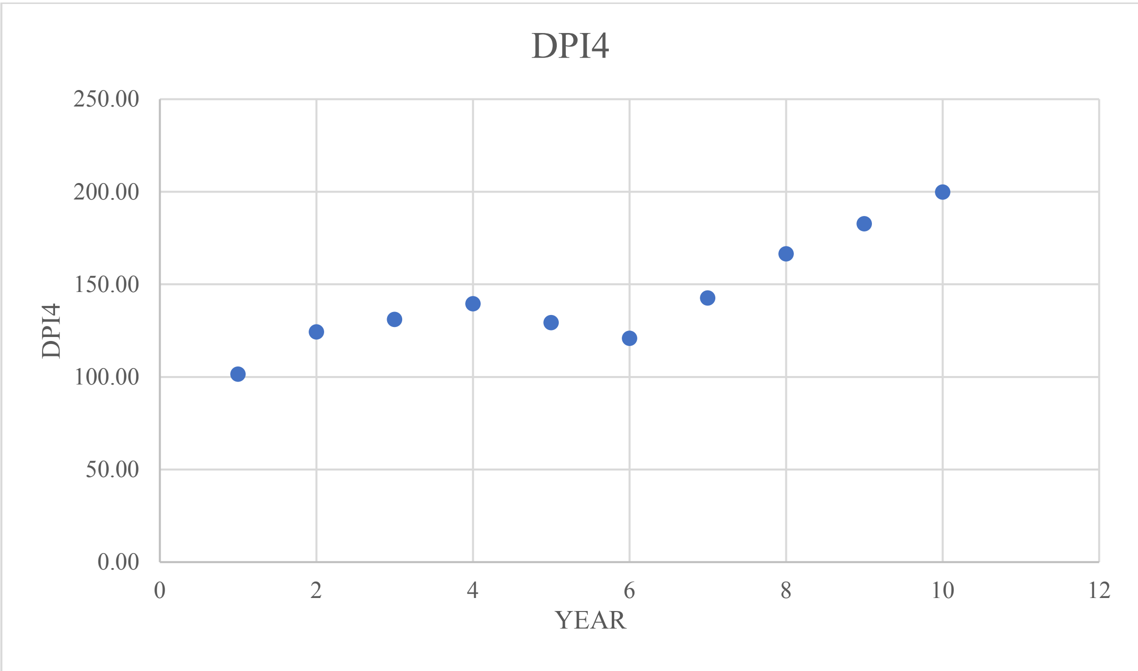

Figure 3.9: DPI4 with Years

As can be summarized from these graphs that several types of relationships do exist between the factors (years and indictors), which suggests that regression analysis of various models should be performed for each index chosen from the last section. The equations used in calculating regression analysis were number from 27 to 33. Furthermore, knowing the average distance for each point from the general average curve (regression curve) has of great importance that increases the reliability of the equation, which this distance is nominated by the standard deviation (R). The squared value of the standard deviation is the variance (R squared). R squared is represented for each equation and index in Table 3.17 along with regression curve equations.

Table 3.17: Regression Statistic Equations and Variance Factor (R2)

Equation & R^2	CCI	PCI	CI	DPI3	DPI4
Exponential	y = 98.579e0.0337x	y = 91.744e0.0388x	y = 98.257e0.0488x	y = 86.451e0.0575x	y = 101.13e0.0605x
R^2	$R^2 = 0.962$	$R^2 = 0.9712$	$R^2 = 0.9807$	$R^2 = 0.7188$	$R^2 = 0.8007$
Linear	y = 3.9632x + 97.457	y = 4.4427x + 89.858	y = 6.2432x + 95.456	y = 7.272x + 80.976	y = 8.9176x + 94.753
R^2	$R^2 = 0.9707$	$R^2 = 0.9704$	$R^2 = 0.9686$	$R^2 = 0.7161$	$R^2 = 0.7945$
Logarithmic	y = 16.054ln(x) + 95.005	y = 16.61ln(x) + 89.204	y = 24.794ln(x) + 92.343	y = 26.517ln(x) + 80.919	y = 33.33ln(x) + 93.457
R^2	$R^2 = 0.9337$	$R^2 = 0.7951$	$R^2 = 0.9233$	$R^2 = 0.5581$	$R^2 = 0.6505$
Quadratic	Y = -0.1847x2 + 5.9953x + 93.393	y = 0.1979x2 + 2.2661x + 94.212	y = -0.059x2 + 6.8921x + 94.158	y = 1.1643x2 - 5.5353x + 106.59	y = 1.0512x2 - 2.6452x + 117.88
R^2	$R^2 = 0.9842$	$R^2 = 0.9828$	$R^2 = 0.9562$	$R^2 = 0.8335$	$R^2 = 0.9865$
Cubic	y = -0.0106x3 - 0.0097x2 + 5.1881x + 94.303	y = -0.071x3 + 1.3699x2 - 3.1395x + 100.31	y = 0.0212x3 - 0.4084x2 + 8.5036x + 92.341	y = 0.4178x3 - 5.7301x2 + 26.263x + 70.739	Y = 0.4039x3 - 5.6134x2 + 28.093x + 83.223
R^2	$R^2 = 0.9831$	$R^2 = 0.9762$	$R^2 = 0.9096$	$R^2 = 0.922$	$R^2 = 0.992$
Power	y = 96.302x0.1383	y = 91.022x0.1465	y = 95.32x0.1979	y = 85.504x0.2168	y = 99.035x0.2342
R^2	$R^2 = 0.9478$	$R^2 = 0.8117$	$R^2 = 0.9538$	$R^2 = 0.5982$	$R^2 = 0.7029$

Alternatively, to investigate the prediction performance of the equation in Table 3.17, the mean average percentage error (MAPE) was introduced to show the error ratio from according to the mean average of the sample. The values predicted by the models for each year are listed in the APPENDIX B (Table 4.1), Table 3.18 shows the MAPE results for these equations.

Table 3.18: MAPE values

		Exponential	Linear	Logarithm	Quadratic	Cubic	Power
CCI	AVG MAPE	0.4206	0.10019	0.22602	0.01490	0.03147	0.16238
PCI		0.1520	0.15179	0.62398	0.03452	0.21025	1.05154
CI		0.2536	0.07512	0.82041	0.01559	0.05889	0.30209
DPI1		0.6742	0.10441	0.06246	0.09124	0.07586	0.82338
DPI2		0.3539	0.10468	0.09268	0.07193	0.04394	0.49278
DPI3		0.2697	0.08443	0.09355	0.04426	0.03444	0.36644
DPI4		0.1255	0.06777	0.06532	0.01305	0.01446	0.17903

The followed phase was to elect the best equation that would perform better for that type of index, in general, the most reasonable results belonged to quadratic and cubic equations, also, the lowest error values were DPI4 and CCI. In other words, the highlighted values were the lowest among all, which meant high performance in all equations. Furthermore, the produced reasonable results were again put under the test for the predictions accuracy percent. Finally, the actual values of all indexes and the predicted results of each year from 2019 to 2022 are demonstrated in Table 3.19.

Table 3.19: prediction accuracy percent % according to 2018

Index	Year	No year	Quad Equation %	Cubic Equation %
CCI	2019	11	0.00928	0.00263
	2020	12	0.02215	0.00820
	2021	13	0.03230	0.00801
	2022	14	0.03973	0.00159
PCI	2019	11	0.05558	not accepted
	2020	12	0.10587	not accepted
	2021	13	0.15909	not accepted
	2022	14	0.21523	not accepted
CI	2019	11	0.03380	not accepted
	2020	12	0.06894	not accepted
	2021	13	0.10333	not accepted
	2022	14	0.13697	not accepted
DPI2	2019	11	0.33299	not accepted
	2020	12	0.74135	not accepted
	2021	13	1.27792	not accepted
	2022	14	1.95981	not accepted
DPI3	2019	11	0.08562	0.29386
	2020	12	0.20922	0.64491
	2021	13	0.34637	1.10431
	2022	14	0.49707	1.68663
DPI4	2019	11	0.00929	0.00273
	2020	12	0.02315	0.00924
	2021	13	0.03330	0.00912
	2022	14	0.04973	0.00279

As final results to the research the Figure 3.10 represents the flow of all equations including the best two equations of DPI4 and CCI, to provide better point of view of their trend in predicting the following years.

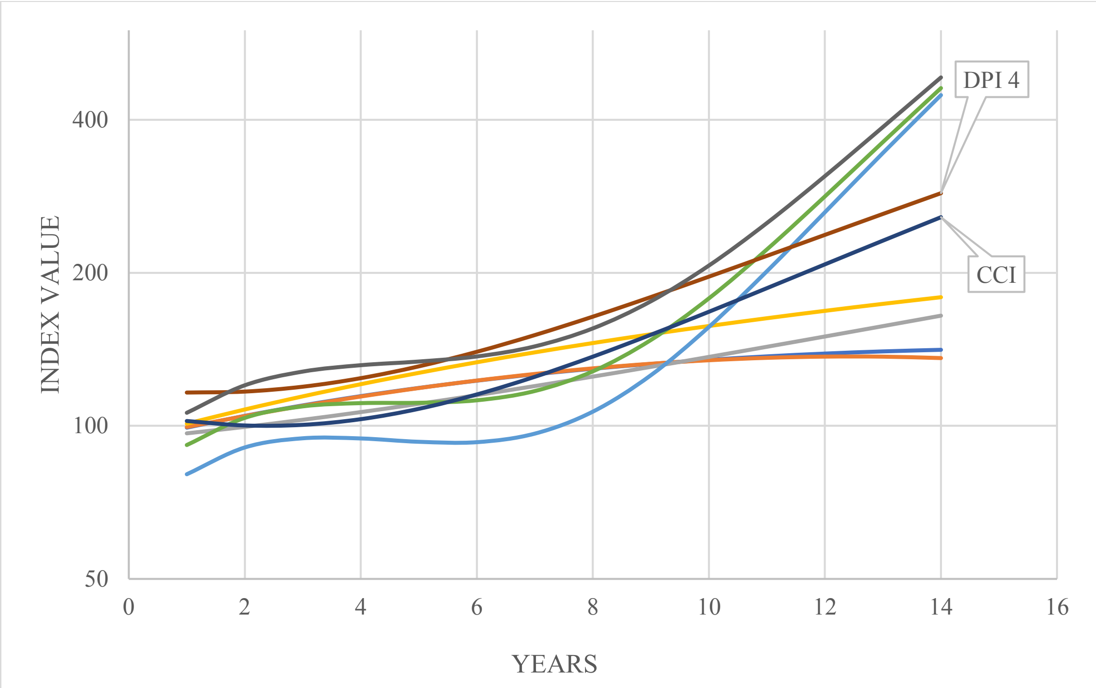

Figure 3.10: Predict Values

Chapter 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 Discussion

In this study, an election of cost indicators was performed among the previously available and the newly developed indices which resulted in finding the most suitable indices to represent the tendering sector of construction in Jordan. By employing these indices in Jordanian construction, the tenders will become more accurate and cost will be more reasonable as a general direction to follow in calculating project cost. In addition, the better quality of index can get, the higher is expectations of predicting the more precise future cost of a construction building. Consequently, a clear increase in the reliability of the index to forecast the industry flow. That can be considered as a major factor of successful supremacy in the tendering process for construction projects.

4.2 Conclusion

This research mainly considered the comparison between the current available and the newly generated tender cost indices on the base of efficiency and suitability to match the construction industry in Jordan. Consequently, the indicators have demonstrated the adequacy in terms of the ability to meet the trend. Accordingly, the indices were analysed by regression analysis technique, in order to be able to predict the future costs of the tender projects. The aim, scope, and objectives were stated in the introduction section. The chapter follows the introduction was the literature review which presents brief which includes the summary of existing knowledge and previous substantive findings in lectures. The second chapter was established to have an aspect of the past studies conducted in this same concept of price indices. Few dissertations have been conducted that dealt with establishing a contemporary indicator. Most of the found studies were related to a particular type of construction project. In this research, the developed cost indexes have been established using previous expense details from completed tendered projects. The study showed a positive response toward the suitability of using the newly developed unit price rather than using the current indices. The applied methods were shown in past studies in order to construct new cost indices. Then resulted index were examined, and the calculation steps were confined within the chapter. The calculations have been outlined and described in precise terms. Additionally, the section also described the cost index principle and offered general perception of cost indicators. The fundamental variables are essential for the designing process of cost indicators that have been outlined and the framework of progressions of emerging and assembling construction cost indices has been inspected. Additionally, the descriptions and components of the presently available price indices have been reviewed. The section about methodology and statistical analysis handled the stages of calculations and offer comprehensive descriptions about this research carried out a calculation to achieve the objectives of this study. The project's records were collected then have been employed to perform the calculations to enquire a new tender cost index. The established cost indices have been assessed accordingly with the currently available indicators, then the best once to interact with the prices of the construction projects were chosen as the adequate indicators. The approved indicators were also used to measure the cost increases of construction projects. However, these chosen indices have been investigated using the method of the regression. The Relation among years and these indices ' values have been also investigated. The intention of this stage was to construct a model that is able to forecast the upcoming values of the designated indices, which in turn, would become essential for the prediction process in the future price of a construction project. Moreover, the price indicators established in this research were built according to the data resulting from the real tender construction project prices, taking the point of view in the tender part of the construction. Including the costs related to structural, mechanical, electrical, and other important factors. These costs that are related to every part of the project were extracted from the past construction projects of the scope of the building projects, where their bill of quantities of the prices is accessible.

4.3 Recommendations

The tender price indicators for various types of building projects construction projects, such as infrastructure, industrial building, plants, highways, power plants, and drainage systems can also be considered in future calculations. Using the data of previous projects of more companies and the governmental industry tenders' projects similar cost index can be established for the industrial sector of construction. The most important part of performing this study is the availability of quantity bill in which permits the ability to further inspect the relationships between costs and indices value. On the other hand, other methods can be used to calculate the price index or different standards can be applied to get more variety of indices. In many countries around the world different types of indexes are being used, to investigate these indicators and apply them in Jordan will consider as a step forward to developing the construction industry in Jordan which is an idea that must be taken into account in the long run and future projects. As well as locally and global unit price can be taken in consideration for the reason that they may affect the projects price index and my give more precise results in international applications.

Furthermore, the number of projects has been used provide a great effect on the results, in this study only 23 projects were selected due to material restrains and resource limits. In the new research’s a greater or a smaller number of projects can be investigated and look throw the relationship of project number and quality of information as results.

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APPENDICES

Appendix A: Unit Cost vs Index

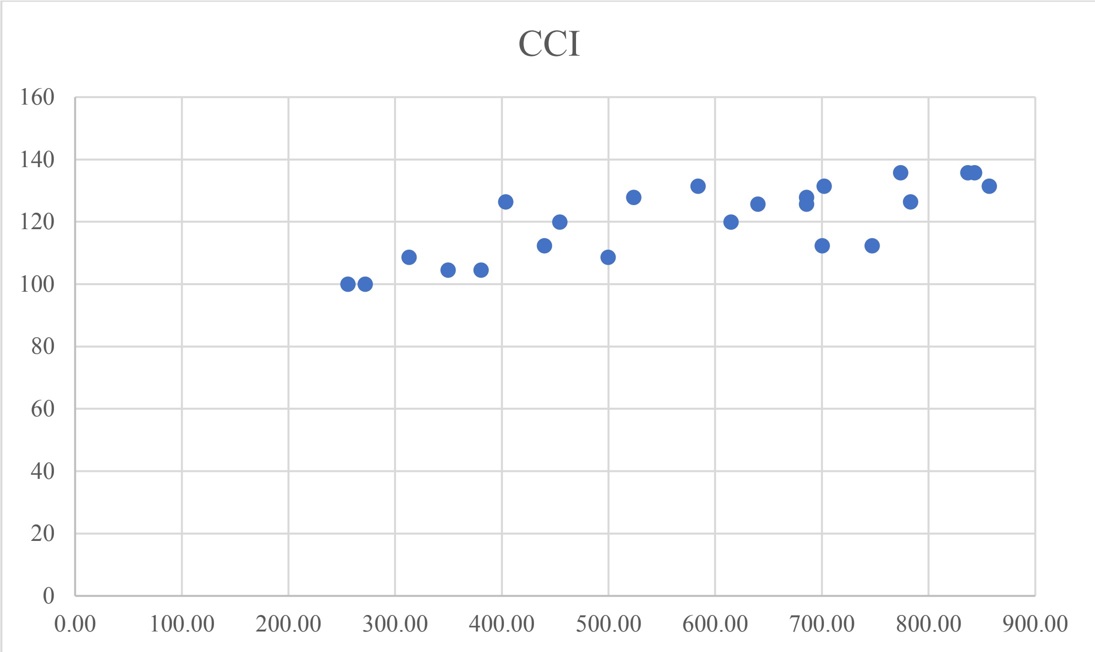

Figure A.1: Unit Cost with CCI

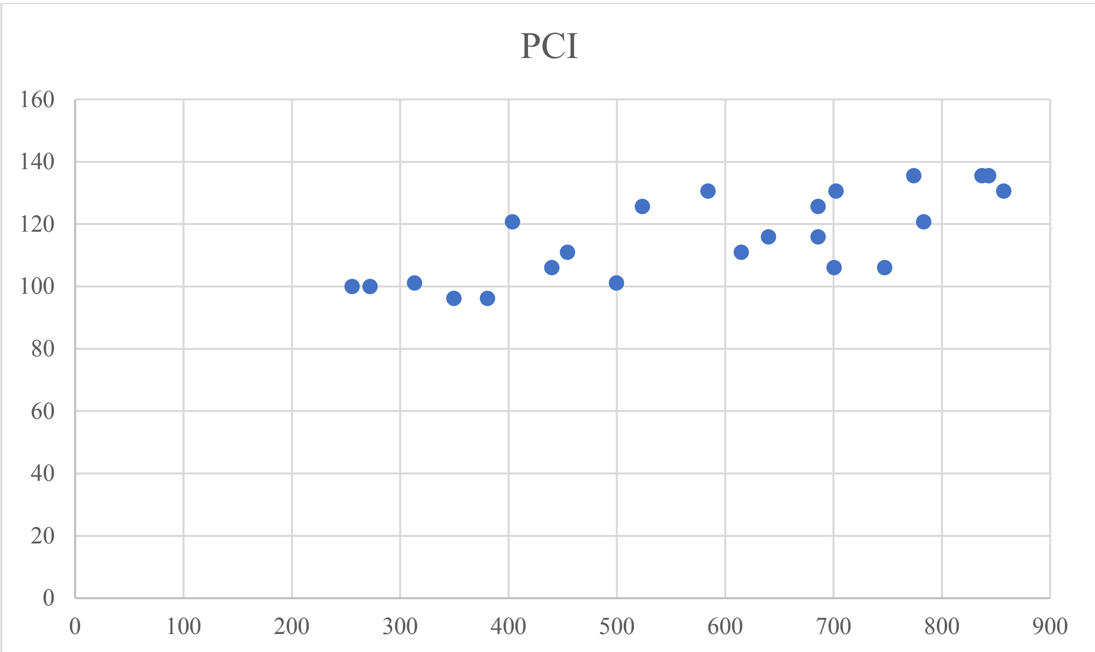

Figure A.2: Unit Cost with PCI

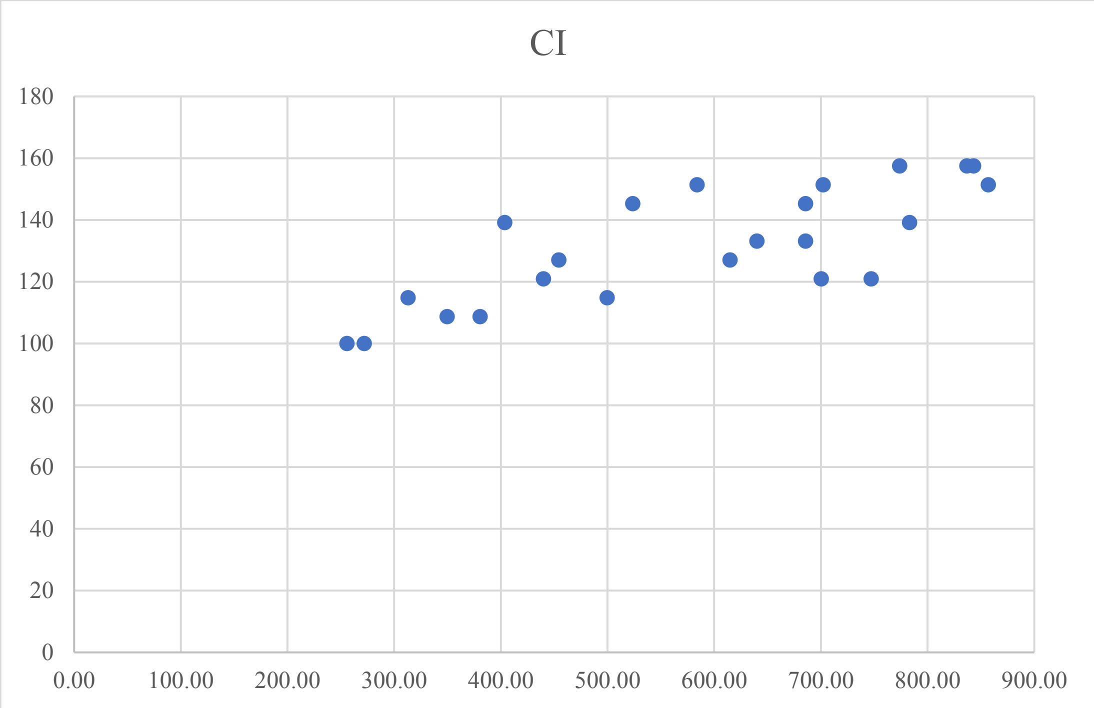

Figure A.3: Unit Cost with CI

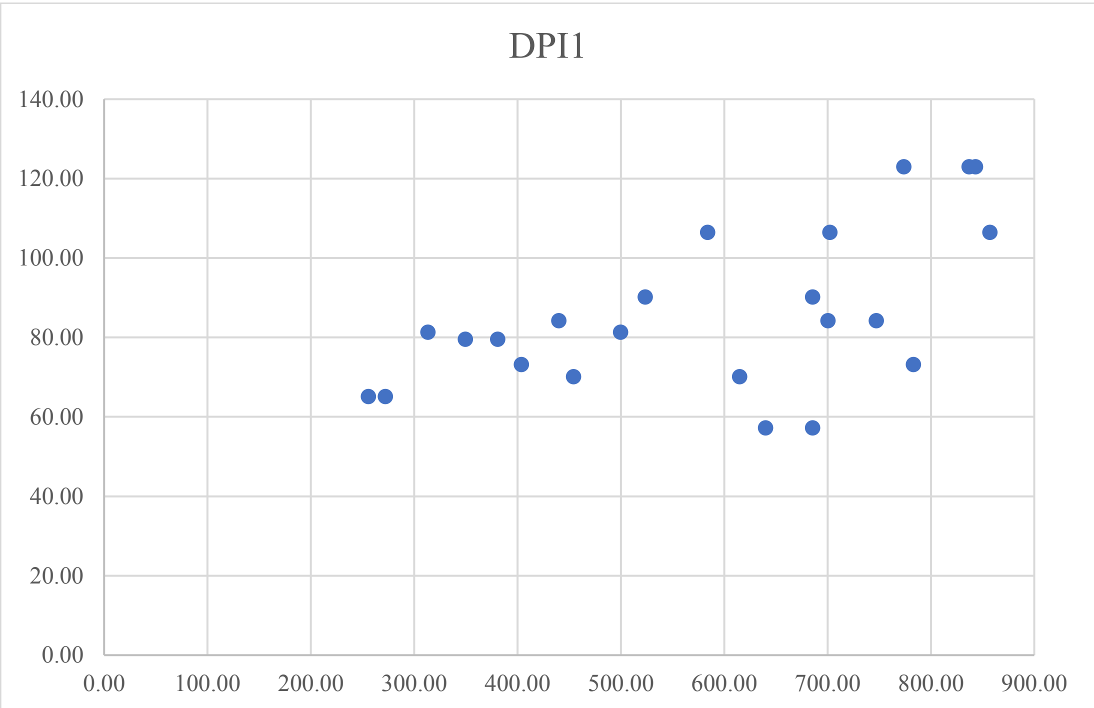

Figure A.4: Unit Cost with DPI1

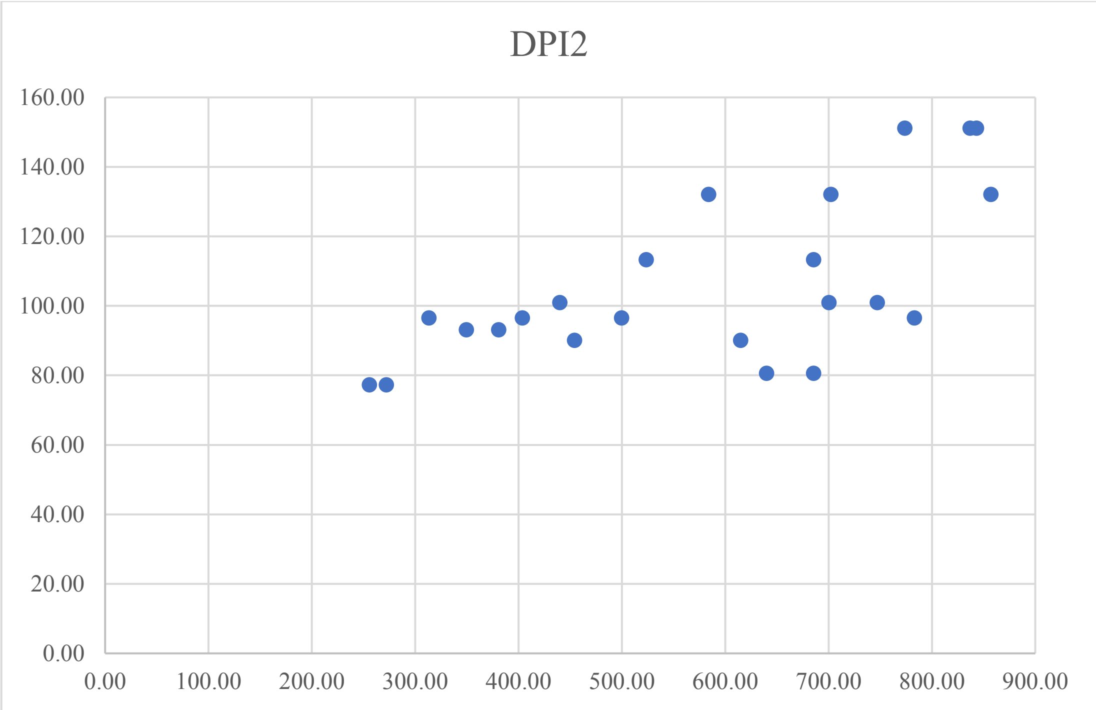

Figure A.5: Unit Cost with DPI2

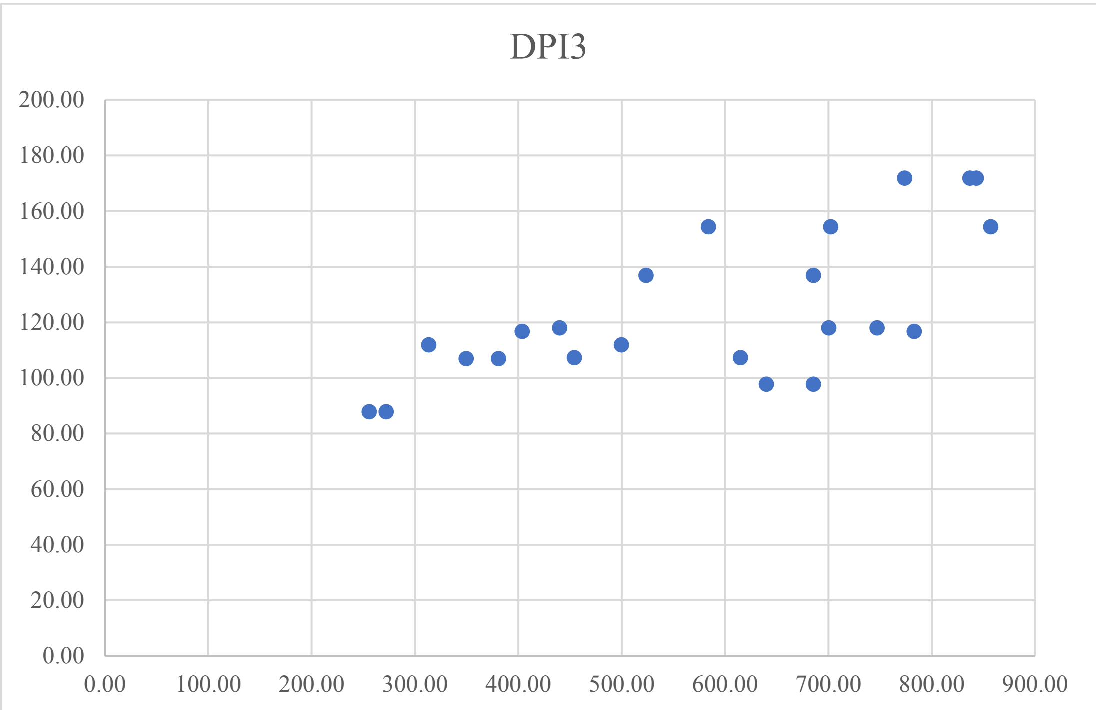

Figure A.6: Unit Cost with DPI3

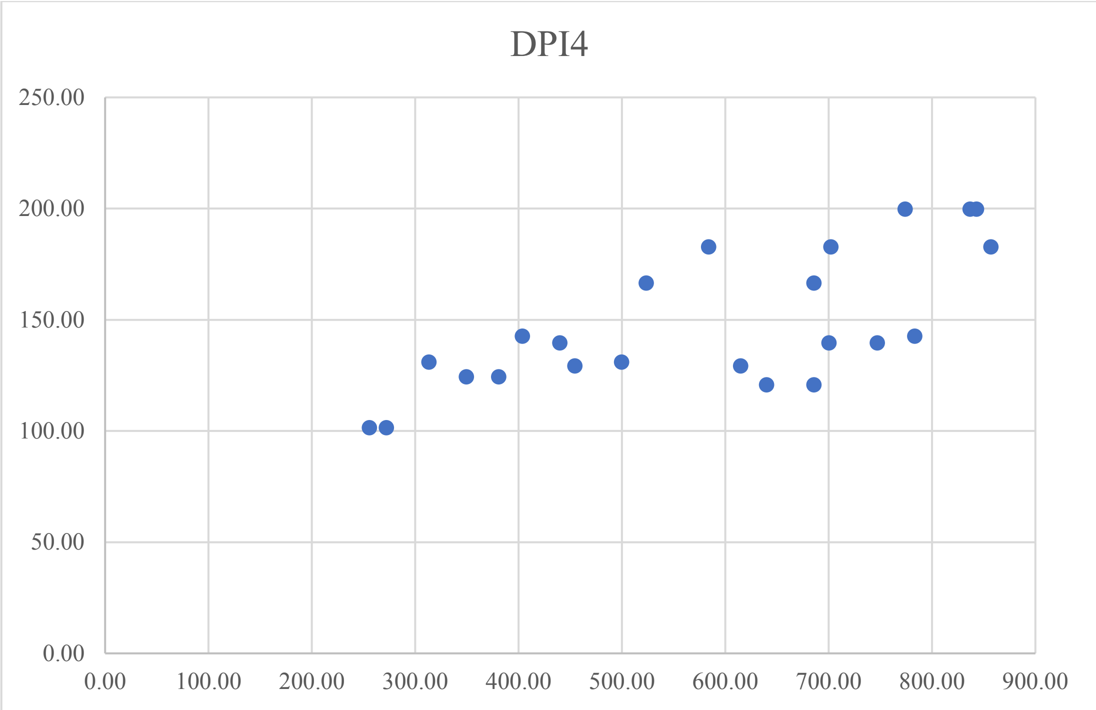

Figure A.7: Unit Cost with DPI4

Appendix B: Equation Values

Table B.1: Corresponding Predicted Values of Building Cost Index for each year

INDEX	Year	No Year	Exponential	Linear	Logarithmic	Quadratic	Cubic	Power
CCI	R squared		$R^2 = 0.962$	$R^2 = 0.9707$	$R^2 = 0.9337$	$R^2 = 0.9842$	$R^2 = 0.9844$	$R^2 = 0.9478$
	EQ		$y = 98.579e^{0.0337x}$	$y = 3.9632x + 97.457$	$y = 16.054\ln(x) + 95.005$	$y = -0.1847x^2 + 5.9953x + 93.393$	$y = -0.0106x^3 - 0.0097x^2 + 5.1881x + 94.303$	$y = 96.302x^{0.1383}$
	2009	1	101.95	101.42	95.01	99.20	99.47	96.30
	2010	2	105.45	105.38	106.13	104.64	104.55	105.99
	2011	3	109.06	109.34	112.64	109.71	109.49	112.11
	2012	4	112.80	113.31	117.26	114.42	114.22	116.67
	2013	5	116.67	117.27	120.84	118.75	118.67	120.32
	2014	6	120.67	121.24	123.77	122.72	122.79	123.40
	2015	7	124.81	125.20	126.25	126.31	126.51	126.07
	2016	8	129.08	129.16	128.39	129.54	129.76	128.42
	2017	9	133.51	133.13	130.28	132.39	132.48	130.53
	2018	10	138.08	137.09	131.97	134.88	134.62	132.44

Table B.1 (cont.)

INDEX	Year	No Year	Exponential	Linear	Logarithmic	Quadratic	Cubic	Power
CPPI	R squared		R^2=0.9712	R^2=0.9704	R^2=0.7951	R^2=0.9828	R^2=0.992	R^2=0.8117
	EQ		y=91.744e0.0388x	94.30	y=16.61ln(x)+89.204	y=0.1979x2+2.2661x+94.212	y=-0.071x3+1.3699x2-3.1395x+100.31	y=91.022x0.1465
	2009	1	95.37	94.30	89.21	96.68	98.48	91.02
	2010	2	99.15	98.74	100.72	99.54	98.95	100.76
	2011	3	103.07	103.19	107.45	102.79	101.31	106.93
	2012	4	107.15	107.63	112.23	106.44	105.14	111.53
	2013	5	111.39	112.07	115.94	110.49	110.00	115.24
	2014	6	115.79	116.52	118.97	114.93	115.46	118.37
	2015	7	120.37	120.96	121.53	119.77	121.12	121.07
	2016	8	125.14	125.40	123.74	125.01	126.53	123.46
	2017	9	130.09	129.84	125.70	130.64	131.27	125.61
	2018	10	135.23	134.29	127.45	136.66	134.92	127.57

Table B.1 (cont.)

INDEX	Year	No Year	Exponential	Linear	Logarithmic	Quadratic	Cubic	Power
TCI	R squared		R^2=0.9907	R^2=0.9986	R^2=0.9233	R^2=0.9992	R^2=0.9996	R^2=0.9538
	EQ		y=98.257e0.0488x	y=6.2432x+95.456	y=24.794ln(x)+92.344	y=-0.059x2+6.8921x+94.158	y=0.0212x3-0.4084x2+8.5036x+92.341	y=95.32x0.1979
	2009	1	103.17	101.70	92.34	100.99	100.46	95.32
	2010	2	108.33	107.94	109.53	107.71	107.89	109.34
	2011	3	113.75	114.19	119.58	114.30	114.75	118.48
	2012	4	119.44	120.43	126.71	120.78	121.18	125.43
	2013	5	125.41	126.67	132.25	127.14	127.30	131.09
	2014	6	131.68	132.92	136.77	133.39	133.24	135.91
	2015	7	138.27	139.16	140.59	139.51	139.13	140.12
	2016	8	145.18	145.40	143.90	145.52	145.09	143.88
	2017	9	152.44	151.65	146.82	151.41	151.25	147.27
	2018	10	160.07	157.89	149.43	157.18	157.74	150.38

Table B.1 (cont.)

INDEX	Year	No Year	Exponential	Linear	Logarithmic	Quadratic	Cubic	Power
DPI1	R squared		R^2=0.3844	R^2=0.4379	R^2=0.2877	R^2=0.7026	R^2=0.8711	R^2=0.2592
	EQ		y=62.841e0.0464x	y=4.2874x+59.461	y=14.354ln(x)+61.361	y=1.3174x2-10.204x+88.444	y=0.4346x3-5.8543x2+22.872x+51.151	y=63.948x0.1573
	2009	1	65.83	63.75	61.36	79.56	68.60	63.95
	2010	2	68.95	68.04	71.31	73.31	76.96	71.32
	2011	3	72.23	72.32	77.13	69.69	78.81	76.02
	2012	4	75.66	76.61	81.26	68.71	76.79	79.54
	2013	5	79.25	80.90	84.46	70.36	73.48	82.38
	2014	6	83.01	85.19	87.08	74.65	71.50	84.78
	2015	7	86.96	89.47	89.29	81.57	73.46	86.87
	2016	8	91.09	93.76	91.21	91.13	81.97	88.71
	2017	9	95.41	98.05	92.90	103.32	99.63	90.37
	2018	10	99.94	102.34	94.41	118.15	129.04	91.88

Table B.1 (cont.)

INDEX	Year	No Year	Exponential	Linear	Logarithmic	Quadratic	Cubic	Power
DPI2	R squared		R^2=0.6278	R^2=0.6311	R^2=0.4618	R^2=0.8099	R^2=0.93	R^2=0.487
	EQ		y=74.763e0.0548x	y=6.0525x+69.864	y=21.384ln(x)+70.853	y=1.2734x2-7.955x+97.879	y=0.4315x3-5.8466x2+24.883x+60.855	y=74.784x0.1993
	2009	1	78.97	75.92	70.85	91.20	80.32	74.78
	2010	2	83.42	81.97	85.68	87.06	90.69	85.87
	2011	3	88.12	88.02	94.35	85.48	94.54	93.10
	2012	4	93.09	94.08	100.50	86.43	94.46	98.60
	2013	5	98.33	100.13	105.27	89.94	93.04	103.08
	2014	6	103.87	106.18	109.17	95.99	92.88	106.90
	2015	7	109.72	112.23	112.47	104.59	96.56	110.24
	2016	8	115.90	118.29	115.32	115.74	106.67	113.21
	2017	9	122.43	124.34	117.84	129.43	125.79	115.90
	2018	10	129.32	130.39	120.09	145.67	156.53	118.36

Table B.1 (cont.)

INDEX	Year	No Year	Exponential	Linear	Logarithmic	Quadratic	Cubic	Power
DPI3	R squared		R^2=0.6278	R^2=0.6311	R^2=0.4618	R^2=0.8099	R^2=0.93	R^2=0.487
	EQ		y=74.763e0.0548x	y=6.0525x+69.864	y=21.384ln(x)+70.853	y=1.2734x2-7.955x+97.879	y=0.4315x3-5.8466x2+24.883x+60.855	y=74.784x0.1993
	2009	1	91.57	88.25	80.92	102.23	91.69	85.50
	2010	2	96.99	95.52	99.30	100.19	103.69	99.38
	2011	3	102.73	102.79	110.05	100.47	109.24	108.51
	2012	4	108.81	110.07	117.68	103.09	110.85	115.50
	2013	5	115.25	117.34	123.60	108.03	111.03	121.23
	2014	6	122.07	124.61	128.43	115.30	112.28	126.12
	2015	7	129.29	131.88	132.52	124.90	117.11	130.40
	2016	8	136.94	139.15	136.06	136.83	128.03	134.24
	2017	9	145.05	146.43	139.18	151.09	147.55	137.71
	2018	10	153.63	153.70	141.98	167.68	178.16	140.89

Table B.1 (cont.)

INDEX	Year	No Year	Exponential	Linear	Logarithmic	Quadratic	Cubic	Power
DPI4	R squared		R^2=0.6278	R^2=0.6311	R^2=0.4618	R^2=0.8099	R^2=0.93	R^2=0.487
	EQ		y=74.763e0.0548x	y=6.0525x+69.864	y=21.384ln(x)+70.853	y=1.2734x2-7.955x+97.879	y=0.4315x3-5.8466x2+24.883x+60.855	y=74.784x0.1993
	2009	1	107.44	103.67	93.46	116.30	106.11	99.04
	2010	2	114.14	112.59	116.56	116.80	120.19	116.50
	2011	3	121.26	121.51	130.07	119.42	127.89	128.11
	2012	4	128.82	130.42	139.66	124.13	131.63	137.04
	2013	5	136.85	139.34	147.10	130.94	133.84	144.40
	2014	6	145.39	148.26	153.18	139.86	136.94	150.70
	2015	7	154.46	157.18	158.32	150.88	143.36	156.24
	2016	8	164.09	166.09	162.77	164.01	155.51	161.21
	2017	9	174.32	175.01	166.69	179.23	175.82	165.72
	2018	10	185.19	183.93	170.20	196.56	206.71	169.86