EiABC
Ethiopian Institute of Architecture,
Building Construction and City Development
Addis Ababa University

ADDIS ABABA UNIVERSITY
ETHIOPIAN INSTITUTE OF ARCHITECTURE BUILDING CONSTRUCTION AND CITY DEVELOPMENT (EiABC)

Department of Construction Technology and Management

Program: MSc. in Construction Management

A study on Improving Price Adjustment Administration in Federal Road Projects

By
Simreteab Gebremedhin

Advisor: Wubishet Jekale (Dr. Eng.)

June, 2021

Addis Ababa, Ethiopia

A study on Improving Price Adjustment Administration in Federal Road Projects

By

Simreteab Gebremedhin

A Thesis Submitted to School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements of the Degree of Master of Science in Construction Management

Advisor: - Wubishet Jekale (Dr. Eng.)

June, 2021

Addis Ababa, Ethiopia

ADDIS ABABA UNIVERSITY
ETHIOPIN INSTITUTE OF ARCHITECTURE BUILDING CONTRUCTION AND CITY DEVELOPMENT
CHAIR OF CONSTRUCTION MANAGEMENT

A study on Improving Price Adjustment Administration in Federal Road Projects

By
Simreteab Gebremedhin

APPROVED BY BOARD OF EXAMINERS:

Dr. Eng. Wubishet Jekale ADVISOR	SIGNATURE	DATE
Dr. Asregedew Kassa___ INTERNAL EXAMINER	SIGNATURE	DATE
Dr. Bahiru Bewket_____ EXTERNAL EXAMINER	SIGNATURE	DATE
Dr. Asregedew Kassa CHAIRMAN	SIGNATURE	DATE
Dr. Dagnachew Adugna Postgraduate Director	SIGNATURE	DATE

Abstract

The degree of price variations referring to each specific type of construction shall be measured by specific price indices, in order to achieve more accurate results. In Ethiopian Road Authority, Price Index is commonly used for price adjustment administration in the escalation of road construction costs. This study aims to improve price adjustment administration in federal road projects. The objectives of the study report in this thesis are assessing current price indices determination practice when original source cease to publish indices, assessing reliable sources to minimize ceasing of publishing indices and developing guideline for price adjustment administration system when supplier cease to exist and replaced by new source. This research covered, the studies on improving price adjustment administration in federal road projects. Moreover, price adjustment administration when suppliers cease to published price indices were analyzed by trend, T-tests and regression analysis techniques, to obtain models to predict the future values of the new sources of indices, which was a way enabling the prediction of the future indices of a price adjustment in federal road projects. Using a detailed literature review, a quantitative data collection approach, data was collected from Ethiopian Road Authority payment certificates, to see the trend of price adjustments of key construction cost inputs (cement, bitumen, fuel and steel), National Bank of Ethiopia's website (currency exchange ETB to USD) and different local and international road construction material suppliers' websites. In this thesis, some descriptive statistical methods have been used for the analysis of Three DB case study projects that are completed under RSDP IV. The projects are Chole magna, Dire Dawa- Dewelle and Pawi-Junction. The result is analysed using trend, T-test and regression analysis methods. The analysis resulted that, NOC should be used as a new source for Chole magna and Dire Dawa-Dewelle projects. Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S should be used for Pawi Junction-Fendkia-Ayma project. Finally, based on the analysis of the results, this research developed guideline to enable professionals to determine the new source of index using a common guideline and help to create common understanding.

Key Words: Price Adjustment, Price Index Construction Price Index and Supplier cease to published price index.

Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university and that all sources of materials used for the thesis have been duly acknowledged.

Name: Simreteab Gebremedhin

Place: Addis Ababa, Ethiopia

Date of submission: June, 2021

Signature: _____

Title of the thesis:

"A Study on Improving Price Adjustment Administration in Federal Road Projects"

This thesis has been submitted for examination with my approval as university advisor

Name: Dr.-Eng. Wubishet Jekale

Signature: _____

Date: _____

Acknowledgments

This thesis could not have been possible without the support of many individuals who have endowed me with expert guidance, precious assistance, motivation and encouragement.

A great many thanks must firstly go to my Advisor Dr. Eng. Wubishet Jekale, for his excellent guidance, immense patience, pushing, coaxing, enlightenment and enthusiastic support throughout the entire length of this thesis.

I am immensely appreciative of Eng. Bekele Jebessa for supporting me as an academic advisor, guide and colleague who was always available to offer support and advice. I would also like to acknowledge the endless support of ERA team leaders, regional directos and senior advisors.

In the end, I have to express my love and respect to my wife and my lifeEdlye for her endless love, motivation, and supportand my parents who always supported me to pursue my education to the highest possible level.

Acronyms

ADB = Asian Development Bank

ANOVA = Analysis of Variance

CPA = Contract Price Adjustment

CPAPI = California Paving Asphalt Price Index

CPI = Consumer Price Indices

CSA = Central Statistics Agency

DB = Design Build

ER = Employer's Representative

ERA = Ethiopian Roar Authority

FHWA = Federal Highway Administration.

FIDIC = Fédération Internationale Des Ingénieurs Conseils

GDP = Growth Domestic Product

IPC = Interim Payment Certificate

MoFED = Ministry of Finance and Economic Development

MoWUD = Ministry of Works and Urban Development

NOC = National Oil Company

PAC = Price Adjustment Clause

PPA = Public Procurement Agency

PPPAA = Public Procurement and Property Administration Agency

PPI = Producer Price Indices

RSDP = Road Sector Development Program

SMEC=Snowy Mountains Engineering Corporation

Table of Contents

List of Table

List **Page**

List of Figure

List **Page**

Chapter 1

1.INTRODUCTION

1.1 Background of the study

Construction industry is the backbone of the economic activities in the development of the socio-economic change of a statein many developing countries. Construction project has their own unique product service, a time-bound (definite beginning and end time), high value and mission of making a construction service with the predetermined performance objectives defined in terms of time, cost and quality (Abukar Warsame, 2011).It has become an important actor andvital for the economic development of all nation.

It creates an important element of Ethiopian economy that and had a growing impact on GDP about 15% (National Bank of Ethiopia, 2018/19). Infrastructure construction sector takes the largest share among the other industry sectors. Ethiopian government spends around 60% of the capital budget on infrastructure (Wubishet, 2004). Road transportation is a key component of the economic and social development process, often absorbing a high proportion of the national budget. Most, not all, business, personal, and public economies are the result of this transportation system.

Ethiopian Road Authority is established in 1951 and currently responsible to construct federal road construction projects of the country in collaboration with regional road authorities to achieve the intended objectives of the sector (ERA, 2014). The context of Ethiopian geography pattern of economic activity, transportation plays vital role in facilitate an economic development. Ethiopia's transportation road master plans often have the objectives of accessibility, mobility and equity in addition to economic dimensions. Ethiopian road network provides the dominant mode of freight passenger transport and plays vital role growing the economy of the country. All sectors of the nation’s economy, service and people relay on the availability and satisfactory performance of road by acknowledge the importance of road transport in supporting social and economic development and its role as a facilitator to meet poverty reduction targets. The government has located increased emphasis on improvement of the quality and extent of road construction in the country. To address constraints in the road sector, related to restricted road network coverage and poor condition, the Government formulated the RSDP in 1997. Since then, four phases of RSDP were implemented over the period of 1997 - 2015 and the fifth phase; RSDP V has been implemented since July 2015.

- RSDP I - From July 1997 to June 2002 (5 years plan)
- RSDP II - From July 2002 to June 2007 (5 years plan)
- RSDP III - From July 2007 to June 2010 (3 years plan)
- RSDP IV - From July 2010 to June 2015 (5 years plan)
- RSDP V - From July 2015 to June 2020 (ongoing)

In joining, all earlier experiences associated with the financing and construction of roads in Ethiopia indicate that most projects face cost overrun and unnecessary delay due to unexpected

higher project cost earntthroughout the construction period. The problems related with the cost overrun and delays in most of the projects are: inflation, market fluctuations in currency exchange, and change in government legislation have significant impact in the increase of the construction cost in Ethiopia. Due to this reason, federal road construction project agreementsunified price adjustment provisions to compensate the contractor or the employer in the case of rise or fall in cost of labor, material, equipment or any other changes in legislation.

Price adjustment clauses are a contractual method that allow the contractor to be partially protected against material, equipment and labor prices increase that may occur between the contract award and execution the work. This is ready by having owner accept the risk for escalating prices by offering a price adjustment clause that pays the contractor for any rise above the contract agreement value. Many price adjustment clauses contain provision of the contractor to provides a discount to the owner in the occurrence to decrease price(Amaha Gebretsadik, 2012).

In general, the integration of PACs in construction contracts enables the contractor or the owner to be protected against price fluctuation that may occur between the contract signing and execution of the contract.

1.2 Problem statement

Ethiopian construction industriesarefaced by many problems which tends to confront the industry and thus making struggles at developing the construction sector. The major problems of construction industry are related to lacks and market price fluctuation of the inputs required for construction industry (Amaha Gebretsadik, 2012). The shortages and market fluctuation of construction inputs are also highly affecting the growth of construction industry. The unpredictable inflation occurring sharp construction material price increases lead contractors into failure to complete their projects within the budgeted costs and contract time for client.

The Ethiopian Road Authority projects are being completed by highly inflated prices mainly due to price fluctuation on construction inputs and improper contract administrations with respect to price adjustment formula in the case of inflation and deflation of market price. Practically, different contractors, consultants and experts are used different price adjustment approaches when original suppliers cease to publish price indices.

ERA contract document Sub-Clause 13.1[b], stated “if that original price source ceases to exist, the employer representative will consider the trend of increment of the material cost of the new supplier and compare it with the trend of the original supplier and determine a cost with a trend which could fairly represent the original increment trend” it doesn’t clearly define price adjustment calculation methods and guideline when the original suppliers cease to publish price indices and change by new sources. Because of these open clause contractors and employer’s representative calculate the new source index based on their interest. Specially, these different calculation techniques ERA doesn’t administer the correct compensation systemwhen the original suppliers cease to publish price indices and change by new sources.

Due to these problems, some projects have higher adjusted price and some projects have very low- adjusted price so, this research intends to clarify the confusions and develop a guideline to improve price adjustment administration system in federal road projects. The main problems of such types of study can be formulated as follows: What is needed for the establishment of a relevant price adjustmentmethods when the original suppliers cease to publish price indices and change by new sources for the Ethiopian Road Authority projects.

1.3 Objective of the research

1.3.1 General Objective

The general objective of this research is to minimize differences in administering price adjustment in federal road projects

1.3.2 Specific Objective

The specific objectives of this research are:

- Assessing current price indices determination practice when original source cease to publish indices.
- Assessing reliable sources to minimize ceasing of publishing indices.
- Developing guideline for price adjustment administration system when supplier cease to exist and replaced by new source.

1.4 Research Questions

- What are the current price indices determination practice when original source cease to publish indices?
- What are the reliable sources to minimize ceasing of publishing indices?
- How can we select a new reliable source when the supplier cease to exist?

1.5 Significance of the Study

The important of this research paper is expressed in the following ways. First, it may benefit the different stakeholders involving in road construction projects in general and particularly federal road construction projects related to price adjustment administration processes. Second, it helps ERA, contractors and consultants to knows and identify the factors of price indices, identify reliable source selection criteria and identify new reliable source selection criteria in price adjustment processes.

1.6ScopeoftheStudy

The study is bounded by only ERA RSDP IV Design and Build federal road projects. Other construction price adjustments like, Design Bid Build federal road projects, Regional and Rural roads, gravel roads, building and water works construction projects are not parts of the research.

1.7 Limitation of the study

Lack of access to get weight determination data was the major limitation because of COVID 19.

1.8 Research Process and Structure

The research is organized in five chapters as briefly described below.

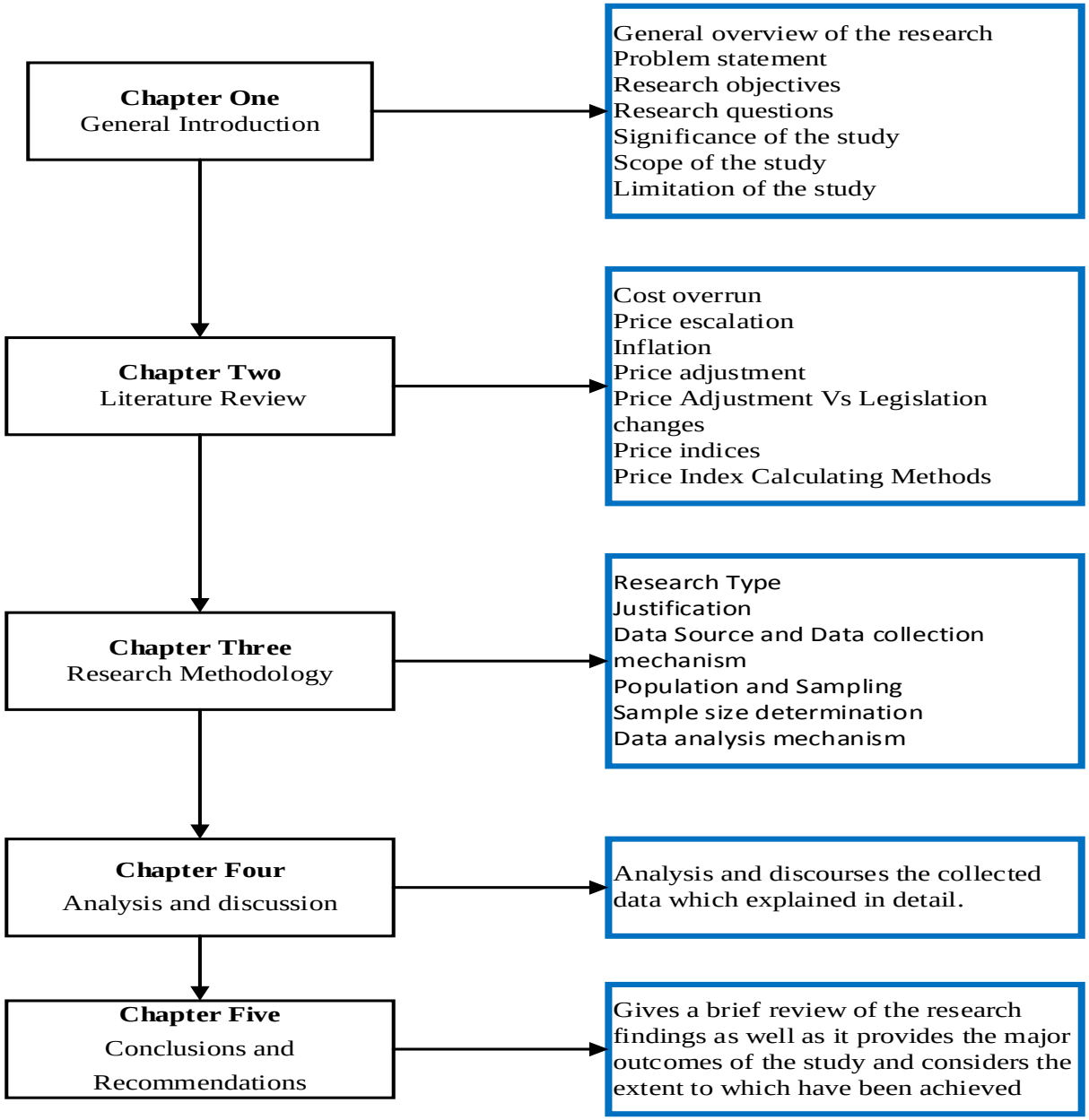


Figure 1.1:Research Process and Structure

Chapter 2

2. LITERATURE REVIEW

2.1 Introduction

In order to improve better understanding of the research objective, a broad literature review has been conducted. Hence, the purpose of this chapter is to discuss about the definition and concepts of price escalation, inflation, price adjustment and price indices. Several studies have been showed to develop different price indices for different types of construction projects(Serkhan Kahraman, 2005). Construction price index is broadly used in construction industry to measure the ratechange of construction costs as a combination of material, labor and equipment costs. Theindex is originated a base year in which a predetermined quantity ofcertain price elements adds up to a perpetual value(Mustafa Alptekin, 2007). Generally, the comprehensive literature review conducted and addressing the objective of the research through a brief argument on previous studiesand best practices related to price adjustment administration in road construction projects.

2.2 Construction industry

Construction industry is complex in nature because it involves different technology in a reasonable size of the projects, a high level of organizational complexity and different parties (client, contractor, consultant, Suppliers, Bank, Insurance, permitting agency and public). It has major role in an economic development of one society(Turkey, 2011). It opens an opportunity for the large employments; create a market for construction inputs providers and its services and the services delivered are an input for other sectors. Due to its great investment, it's considered as an economic inspiring of a country(Chantal C. Cantarelli, 2010). That is why developing countries also invest in infrastructure development to increase their infrastructure status that is used to compete in the world(Lee, 2008).

The development of infrastructure has positive significant effect for developed and developing countries, predominantly road construction projects in the aspects of creating the direct and indirect job opportunity, improve the standards of the country internationally as well as locally(Garry D. Creedy Martin Skitmore, 2010). This positive significance depends on the accomplishments of the objective of the project. Which is accomplishing the project within the available environment by putting together all the resources in bounded time, estimated project cost and specified quality(Chantal C. Cantarelli, 2010).

2.3 Construction industry in Ethiopia

Construction industry is one of the greatest important contributors for political, economic, social and technological development of one country(Turkey, 2011). Current facts show that about 60% of the federal capital budget of Ethiopia is routed to the development of physical infrastructure, from this nearly 33% were for the road construction projects(Sae-Hyun, 2011). Also, the involvement of private sector as the partners in the capital investment, increased capital investment in the field, as well as promote more advanced technologies and materials.

This sector significantly increases both in volume and density of work seen in Ethiopia. A number of studies in the public sector show that more than 80% of the construction projects are delayed, cost overrun, price escalation, inflation and lack the management(Thillai A. Rajan, 2013). Mostly, Ethiopian road construction project is affected by cost overrun, price escalation and inflation.

2.4 Cost overrun

Cost overrun is defined by different researchers. Some definitions that are most related for this study are,it is the difference between actual and estimated costs of a percentage of the estimated cost using all costs calculated in constant prices (Placeholder1) and (Abukar Warsame, 2011). Cost overruns is also defined when the project objectives have not been achieved within the estimated budgeted cost (Ghaleb J. Sweis *et al.* , 2013).

For the purposes of this research,cost overrun is the difference between the actual project completion cost and the contract amountagreed between the project owner and the contractor during signing of the contract period.Construction projects are affected bydifferent cost overrun causes.

2.4.1 Causes of cost overrun

According to (T.Subramani and P S Sruthi, 2014)and (Chitkara K.K., 2011)identified causes of cost overrun in construction projects are: construction material cost increases due to inflation, change orders which are initiated by the project owner, unexpected problem in supply of raw material, unpredictable weather conditions, insufficient project preparation, wrong material estimates, complexity of the projects, contractor's lack of geographical conditions, project type experience (lack of experience), poor organizational structure, labor unrest, foreign exchange, resources limitation (material, labor and equipment), natural disasters, labor productivity, changes in government regulations and laws, slow decision making and non-familiarity with local regulations.

Each cost overrun causes have different degree of occurrences and impact in the construction project costs at completion the work. Some causes may occur frequently but their impacts on project cost may be less severe. Whereas some cause of cost overrun may happen rarely but their impact may be severe. Therefore, it is necessary to identify cost overrun causes based on occurrences and their effect in order to rank their overall effects on construction project cost overrun (Fetene Nega, 2008). This helps to prioritize the factors and hence to determine the mitigation actions to be taken. Finally, the cause of cost overrun tends to price escalation.

2.5 Price escalation

Based on (Asian Development Bank, 2018)price escalation is defined as, the upward movement of prices and can be factored into a contract. Price escalation also defined as, the predicted rise in price of inputs (labour, material and equipment) over time due to inflation(Pravin Raniga, 2008). It refers to the increase in the amount of construction cost required to construct a project in excess of the original budgeted cost.

Price escalation in road projects currently become a headache for clients and contractors of these projects to cover resulting in late payments and disordering the country budgets. It is critical to derive methods both calculate and manage price escalation on individual projects for owner and contractor in order to ensures that sufficient funds to deliver the final construction project in budget and schedule (Joseph Ignatius *et al.*, 2015) and(H.M.S. Belmonte , 2013). As a result, price escalation exposed the construction industry to claims in related to cost overrun and inflation. The Ethiopian construction industries price escalation has familiar problem especially, in road construction projects. Price escalation occurs when actual costs exceed the original estimated values.

2.5.1 Price escalation factors

Price escalation factors are reached through understanding the forces driving each factor. With this understanding it is possible to design policies for dealing with these price escalation factors. Factors that contribute to price escalation and are manageable by the client or contractor are internal factors exist outside direct controls of the client or contractor are classified as external(Mr. P. G. Tamhankar, 2018). According to(Shane, 2009), there are two types of price escalation factors. These are:

i. **Internal price escalation factors:** can be directly organized by the client or contractor. Internal factors that lead to the incorrect estimation of project costs during the project planning process from poor project management, defective design, substandard contract documents (unclear contract provisions) and poor cost estimation. Each of these factors separately or in combination with others can cause significant project costs increases at the contract time.Some of the internal price escalation factors are: bias, delivery/procurement approach, change of project schedule, construction complexity, scope change, poor cost estimating, defective execution and unclear contract provisions.
ii. **External price escalation factors:** are those factors over which the client has little or no directcontrol over their impact. However, the owner needs to consider them when estimating project costs. During the planning and design phases of project development external factors such as local government concerns and requirements, fluctuations in the rate of inflation and market conditions can lead to underestimation of project costs.

Most of the time,Ethiopian construction industries including ERA projects are affected by internal and external price escalation. The main reasons are:poor project management, defective design, market inflation and supply and demand imbalanceon construction industry(Asteway Yigezu, 2008).

2.6Inflation

According to (Turochy, 2001)and (Asteway Yigezu, 2008)inflation is defined an increase of expenditure levels resulting from a considerable and continues rise in prices and other costs through time without changes in construction project scope. Since most of the road construction projects take on average between 3 up to 5 years to complete, inflation plays an important role in the planning process. But during this time, the value of foreign currency changes, the devaluation of local

currency, an increase cost of construction materials (such as: cement, fuel, bitumen, reinforcement bar and finishing materials).

The main differences between inflation and deflation are: Inflation is a loss in purchasing power of money over time. It means that, cost of an item to increase over time or to put it another way, the same money (Dollar/Birr) amount buys less of an item over time.Deflation is the reverse of inflation, in that prices decrease over time and hence a specified amount of money gains purchasing power(Park C. S., 2007).

2.6.1 Types of inflation

The natures of inflation are not identical in the economy for the time. It is wise to distinguished between different types of inflations are listed below. These are:

i. **Demand pull inflation:** is occurs when the total demand and its output is rising at unsustainable rate lead to increased pressure in scarce resources and positive output gap. When there are excess demands in the economy, producers are able to raise prices and achieve bigger profit margins because they know that demand is running ahead of supply(Asian Development Bank, 2008) and (Totonchi, 2011).
ii. **Cost-push inflation:** is the economy may increase from the overall rise cost of production. This type of inflation is called cost-push inflation. Cost of production may rise due to an increase in the prices of raw materials (Asian Development Bank, 2008) and (Totonchi, 2011).
iii. **Hyperinflation:** is defined as the beginning on month and rise in price exceeds 50% as an ending in a month before rise in costs drops the amount and stay below at least a year. Hyperinflation is the most social destructive economic occurrences (Amadou Dem, 2001).
iv. **Stagflation:** isdefine the periods of low or negative output growth, and inflation that is high by historical standards. A period of high inflation and unemployment at the same time. Stagflation can occur without a supply shock, as long as the inflation is amazing and the monetary policy follows a rule which prescribes a sharp contraction response to increases in inflation (Silje Gunlaug Yun, 2008) and (Robert B. Barsky, 2000).

The inflation of market price will be caused by different reasons some of the major causes of inflation are identified and clarified below.

2.6.2 Causes of Inflation

The price of any goodsand services are influenced by different market forces that can change the balance between supply and demand. Many of these forces come from domestic as well as global markets. Assumed the unique environment of each market and country, a good grasp of how individuals interact with markets are necessary to understanding the impact of price changes. According to (Adjusting Prices for Inflation and Creating Price Indices, 2009) there are different causes of inflation listed below. These are:

i. **Production Deficits (Shortages):** for locally produced materials, the differences in product prices reflect differences in local conditions of supply and demand. In general, prices are lower in regions when the materials are excess production and higher in the regions of deficits/shortage production where demand exceeds local production.
ii. **Effects of input markets:** if the cost of inputs used in production of material increases, this can cause rise in the costs of production. The rise in input costs can also result in a decreasematerial production, making an excess demand of the product in question and inducing an upward pressure on prices(Office of the Secretary of Defense , 2017).
iii. **Government policies:** can take many procedures and could potentially cause inflationary pressure. Invarious countries, the markets for construction materialsare subject to government price policies. The goals of these policies are often to stabilize construction industry prices. In this situation, prices of construction materials are no longer only a function of demand and supply. A consequence of price fixing policies can include shortages during years to the benefit of some consumer groups such as contractors, project owners and suppliers.

    Another government policy that often results in inflation is the devaluation of official exchange rate. Devaluation would, if local prices stay the same, means more local currency will be needed in order to buy the same amounts of imported materials. The devaluation of local currency will make the price of imported goods increase, which will also affect prices of locally produced materials. Countries that are oil energy dependent, it must be purchased using foreign currency, which often makes inflationary pressures in this way. The rise in fuel costs increase the price of construction materials (cement, sand, crushed aggregates, reinforcement bars and finishing materials) transportation from production areas to construction sites also increase(Adjusting Prices for Inflation and Creating Price Indices, 2009).

iv. **International trade and trade barriers:** According to(Adjusting Prices for Inflation and Creating Price Indices, 2009) the 2008 price crisis has highlighted how global construction material markets have majorly influence on local markets. The crisis in international market has resulted in high prices for imports and in many construction materials, has pushed upward the price of importedconstruction materialsbecause of limiting access to purchased consumers.

2.7 Price adjustment

According to(David E., *et al* ,2013)price adjustment is a contractual method, that agreecontractor to be partially protected against material,equipment and labor price increase that may arise between contract award and implementation of the construction work. This is done by having client tolerant the risk for price escalation by offering a price adjustment clause that pays the contractor for increases the market price in the contract period. Normally, there is minimum contract period and amount to which a price adjustment is applied although, there is not always the circumstance.

According to(Asian Development Bank, 2018)Price adjustment is an overall price of contract to take account of legitimate changes in cost of performing the contract. It is a mechanism to protect both clients and contractors from unexpected price fluctuations. Price adjustment provision is

planned during procurement and bid preparation stage of construction procurement cycle and used as necessary throughout the contract execution stage.

Contract price adjustment is used in construction industry to pay the contractors for price escalation for increasing and decreasing the value of construction material, equipment and labor prices. It is widely accepted in construction industry. It is an effective measures of price escalation it provides more representative measures of the rise and fall in costs of construction projects (H.M.S. Belmonte , 2013).

The provision of price adjustment accounts for rise or fall prices of goods and services in construction contract. It is practiced all over the world has more realistic competitive bid and implementation of contracts on reasonable just manner. Prices of material, equipment and labor are highly variable to increase and decrease in the exchange market (Pakistan Engineering Council, 2009). As a result, most engineering construction-based contracts contain provisions for adjustments to changes in cost (i.e. price escalation) utilization. The price adjustment formula needs take into consideration of increases or decreases cost of labor, equipment and material over the periods of contract.

2.7.1 Price adjustment parameters

A typical escalation clause should define the conditions, methods, and terms of price adjustment. These are timing (base date and periodicity), trigger and cap values (i.e. limit on the price changes that up to this point contractors cannot claim adjustments), value or the amount of work that is going to be adjusted and the calculation method. Contracting authorities should also determine a standard to calculate completed construction amounts for adjustment (i.e. actual construction rate or scheduled construction rate) and computation method to calculate the price changes (Seneviratne, P. N, 2013). Therefore, contracting authorities or the parties should be aware of the nature and structure of work, economic and other conditions in order to prepare the conditions, terms, timing and any other parameters of clause appropriately.

Considering the FIDIC formula that is either directly used for many countries or used as a basis for escalation formula, the form is:

$$Pn = a + b(Ln/ Lo) + c(En/Eo) + d(Mn/Mo)$$

Where:

Pn: It is adjustment multiplier to be applied the contract value of the related currency of the work carried out in period "n", if not otherwise specified in the contract data, this period will be a month.

a: It is a fixed coefficient specifies in the contract standing for the non-adjustable part of contractual payments.

b, c, d, etc.: Coefficients indicating the estimated weight of every cost element related to the implementation of the works, as specified in the contract; they represent the inputs such as labor, cement, materials etc.

Ln, En, Mn, etc.: They are the present cost/price index or reference price for period "n", and they are applied to the related cost elements.

Lo, Eo, Mo, etc.: They are the base costs/price indices or base reference prices, and they are applied to the related cost elements on the base date.

The contracting parties can state either one formula for escalating the total value of all the works that is completed in a given period or they can state different formulas for the different work packages. After deciding the formula, contracting parties should determine the parameters of formula such as the non-adjustable portion, coefficients of cost element, indices or reference prices etc. In FIDIC, the base date for Mo, Eo, Lo, etc. is stated as 28 days before the last day of submission of tender.

Mostly, clients state the parameters of escalation formula but if they are not stated every bidder has to propose their b, c, d values and other parameters. All of these data related to the adjustment clause are stated in the "adjustment data table" and also the particular conditions of contract in the tender document (Seneviratne, P. N, 2013).

Based on different countries procurement guidelines, the price adjustment provision is put in contracts according to the project duration. Some government agencies put the adjustment clause in their construction contracts regardless of the project duration and some multi development banks contract include the adjustment clause for a project that takes more than 18 months (Asian Development Bank, 2018) and (Seneviratne, P. N, 2013). After the decision for putting the price difference clause into the contract, clients and tenderers have to state the following terms, parameters, and conditions of escalation clause:

- Base date and Start Date
- Triggers and caps
- The non-adjustable portion (a);
- Cost elements (L, E, M, etc.)
- Weightings of the cost elements (b, c, d, ...)
- The source of the indices or reference prices for L, E, M...
- Computation method (formula for calculation)
- Computation of work rate for adjustment (scheduled or actual construction rate)
- Minimum elapsed period for escalation

Base date: the default base date in FIDIC is stated as 28 days before the last day of submission of tender.

Start date: This is the date of the first adjustment period. Start date is stated as commencement date in FIDIC escalation announcement.

Triggers and caps: Actually, most of the clients and contractors are not aware of the triggers and caps because many standard contracts do not state any triggers and caps value. Actually, a triggers value is determined for escalation clause of construction project contracts that they are executed in stable economic condition. Triggers value can be expressed that it is a minimum price increase level that enables for a contractor to request a price adjustment. The important point is that what will be the rate or the appropriate level of price changes for adjustment(Seneviratne, P. N, 2013).

Cost elements: One of the most important point in escalation clause is the determination of inputs elements that adjustment will be made. FIDIC determines the labor, equipment and materials as possible cost elements. However, formulation of FIDIC affords the opportunity to the parties to put additional cost inputs to the adjustment formula. In fact, the cost elements that price adjustment will be performed should be determined according to the nature, type and the work package of the project.

Weightings: Another key point in escalation clause is the determination of the weight of cost elements. Actually, either client can determine the weight of cost elements into the contract document or it can require the bidders to determine and offer them into their proposal. The weights of each cost element take time but it is essential to have a reasonable and useful price adjustment clause.

Non-Adjustable Portion: This can be defined as the risk sharing between clients and contractors due to changes in construction materials. It can also be viewed overheads and profits that deemed to be unaffected by inflation. There are different perspectives on the appropriate value of non-adjustable portion depending on whether it is considered the contractor's risk or its profit. When considering the escalation ruling in (Asian Development Bank, 2018) fixed the non-adjustable element weight 15%, but the actual figure will depend on the calculation and may vary between 10% and 20%. The adjustable elements weight are the remaining parts. (Pakistan Engineering Council, 2009) also determined or fixed the non-adjustable and adjustable weights. The non-adjustable elements shall never be less than 35% and the adjustable elements shall never be more than 65% of the Engineer’s estimate.

Ethiopian Road Authority price adjustment weight determination trend is varying from project to project. But most of the projects non-adjustable element weights have 30%.

2.7.2 Price adjustment in Ethiopian construction industry

In projects of reasonably long duration (greater than one year) undertaken in areas which suffer from continuous inflation. Project owners consider it reasonable to compensate contractors for losses which they might suffer as a result of increases the prices of labour, equipment and materials. There are a number of methods of calculating such CPA. Whichever method is used it usually arranges for both increase and decrease in prices and can as a result in either increase or decrease the contract price. Unfortunately, the norm is that CPA tends to be an escalation of the contract price (SMEC, 2019).

There are different methods presented for calculating the CPA. Each method is used it generally provides for both increase and decrease in price and can thus result in either increase or decrease the contract price. Normally, ERA uses two CPA methods. The two most common methods of calculating are: proven cost method and formula method.

2.7.2.1 Proven cost method

This method is used the contractor is requiredat tender stage, to list those elements of his costs which he wants to be subject to CPA. In provision of this he includes a list of the actual costs and suppliers of the various elements upon which he based his tender. When the contractor purchases these materials, he presents proof the actual prices paid and receive compensation for the difference the "basic cost" and the "actual" invoiced cost of those same items. It is important ensure that, all purchases are from the suppliers identified at the time of the tender. Any change in suppliers is probablyoutcomeunacceptable comparison of prices and accordingly over-compensation(SMEC, 2019). A typical month's price adjustment calculation using the proven cost method might be as follows:

Table 2.1:Example of Proven Cost Method

Description	Unit	Qty	Basic Price	Current Price	Difference (This IPC)	Price Adjustment
Cement	quintal	200	200.00	210.00	10.00	2, 000.00
Diesel	litre	5000	16.10	17.10	1.00	5, 000.00
Total Price Adjustment for this Month Ethiopian Birr (ETB)						7,000.00

2.7.2.2 Formula/Indices method

With this method the works, to be undertaken, are mathematically described in a formula. It contains several factors on behalf of the various elements of the project at the time of tender and a number of similar factors for the various elements of work at the time that the works are undertaken. By using these factors in the formula, a percentage increase in the tendered value of work done is obtained and the amount resulting from this represents the CPA due to the contractor. These is the preferred method, where such factors or indices are available (SMEC, 2019).

The formula is usually of the following type:

Pn= a + b Ln/Lo + c Mn/Mo + d En/Eo + etc.

Where:

Pn: is a price adjustment factor to be applied the amount in each specific currency for payment of the work carried out the subject month, determined in accordance with SubClause 60.1 (c), and Sub-Clauses 60.1 (d) and (e), where such variation and day work arenot otherwise subject to adjustment.

a: is a constant, representing the non-adjustable portion of contractual payments.

b, c, d, etc.: are weightings or coefficients represent the estimated proportion of each costelement (labour, materials, equipment usage, etc.) in the work or section.

Ln, Mn, En, etc.: are the current cost index or reference price of the cost elements in the specific currency for month "n" determined pursuant to Sub-Clause 70.5, applicable to each cost element; and

Lo, Mo, Eo, etc.: are the base cost index or reference price corresponding to the above cost elements at the date specified in Sub-Clause 70.5.

If price adjustment factor is applying to payment made in currency other than currency of source of index for particular index input, correction factor **Zo/Z** will be applied a respective component factors of Pn for the formula of the relevant currency. Zo is the number of units of currency of the country of the index, equivalent to one unit of the currency of payment on the date of the base index, and **Z** is the corresponding number of such currency units on the date of the current index.

Unfortunately, the indices for use in such a formula are not being generated in Ethiopia and it is therefore necessary to utilize representation indices from suppliers or the government in order to utilize the formula. Further explanation of the indices and weighting is included in CPA indices and weightings sources and types of representation indices could be a cement factory for cement, minimum labour rate for local labour, government published fuel price for fuel etc. or failing the existence of reliable indices a simplified form of the formula utilizing only the consumer price index, which is published, could be used (SMEC, 2019).

2.8 Price adjustment Vs Legislation changes

According to (SMEC, 2019)price adjustment inputs which rely on data from a particular supplier rather than indices, if that original price source ceases to exist, the employer representativewill consider the trend of increment of the material cost of the new supplier and compare it with the trend of the original supplier and determine a cost with a trend which could fairly represent the original increment trend.

Based on ERA contract document Sub-Clause13.1. [b], the source of indices shall be appropriate for their purpose and shall relate to the contractor's proposed source of supply of inputs the basis of which his contract price have been computed. As the proposed basis for price adjustment, the contractor shall have submitted with his bid the tabulation of weightings and source of indices, which shall be subject to approval by the ER's.

The contractor will not sign the agreement before he submits base indices from the approved sources. If the contractor desires to order materials from a supplier other than from whom he obtained his original quotations or indices because the original supplier ceases to exist, the ER's will look into the trend of increment of the material cost of the new supplier and compare with the trend of the original supplier, and determine a cost with a trend which could fairly represent the original increment trend. However, if the original supplier exists and the contractor proposes a new supplier

for any reason, the ER's will look into the current quotations or indices of the original supplier and the newly proposed supplier and will use the quotations or indices favorable to the employer.

The base cost index or price shall be those prevailing on the 28 days prior the latest date for submission of bid. Current index or price shall be those prevailing on the 28 days prior the last date of the period to which a particular Interim Payment Certificate (IPC) is related. If at any time current index is not available. Provisional indices determined by the ER's will be used subsequent correction the amount paid the contractor when current index become available.

2.9Price indices

Based on (Producer Price Index Manual, 2004)price index is measure the percentage changes in a set of prices over time. Theories of indices are located in the domain of microeconomic theories, which have been in existence for several periods within various industries. However, its usage and complexities are always misapplied or misinterpreted. According to Lippe (2001) index theory has to do with the evaluation of index formulas, although counting all the various index formulas that have been discovered in later. The basic variables required for the calculation of price indices are:

- Basket of goods and services
- Base year weights
- Base year prices
- Current prices

2.9.1 Basket of goods and services

According to (Statistics South African, 2017)and (Government of India Wholesale Price Index, 2011)basket of good and service list in which prices are focused periodically in order to calculate indices. In index, it is very hard to focus all the price movement of good and service. Therefore, they are limited with important goods and services according to a criterion and named as basket of good and service. The goods and services chosen are defined type, quantity and quality and update based on the purposes of index.

2.9.2 Base year weights

According to (IMF, 2004) and (A guide Producer Price Index, 2013) the PPI is calculated from many prices collected from all types of establishments, covering the selected economic activities and products. Because some products have greater production or sales than others, each product is given a weight to represent its importance in total output or sales during the reference (base) period for the weights. To reach at the collective index figure, the price relatives of the individual products are multiplied by these weights to derive a weighted average collective index.

Thus, the weights are key elements in construction PPI. They determine the impact that an individual price change will have on the overall index. Without weight, the relative price changes all

suppliers in the basket. It will get equal importance in calculation of index. If there will no dispersion of the price change, weights will be unimportant.

Preferably value weights are most appropriate as PPI is used as a deflator for output and a measure of inflation and the value weights that are most appropriate for these uses would be the value of output. If production values are not available, then sales or value of deliveries could be used. The value weights should reflect quantities produced valued at basic prices.

2.9.3 Base year prices

The well-known criteria for the selection of new base years are:a normal year, a year for which reliable source, price and other important data are available and a year as recent as possible and equivalent with other data series (Government of India Wholesale Price Index, 2011).For the construction of indices, a decision has to be made on a base period with which the indices can be compared at a particular time. (Statistics South African, 2017) stated that, normally for general purposes, the cost at the base period is usually given the chance value of 100 in order to allow for both increases, as well as decreases in the value of the data without having to deal with negative numbers, where values fall below the base index number (Serhan Kahraman, 2005).

(Statistics South African, 2017)further mentions that the chosen period should preferably cover a seasonal cycle typically a calendar year. Prism Economics and analysis (2001) calls this “normalization” of the index, i.e. the indices are normalized to baseline value of 100 that is assigned to a specific year. (Akintoye S.A., 1991) and (Flemming M.C. and Tysoe B.A., 1991)conclude that generally one should choose a base period of reasonable economic stability, as well as a period that is not too distant in the past. Such a "normal" year is explained a period of average steady inflation without any unusual occurrences.

2.9.4 Current prices

Current price is the existing price of the goods and services used to calculate the price indices. The indices are renewed periodically because (SSI Turkey, 2002) states that in Turkey, which is socially, economically, and culturally in continuous and in rapid change, the products and services also change in light of new technological advances. This in return, results in alterations in consumer behavior. There are changes in the structures and shares of the sectors, firms, and resources in production. Certain goods and services leave their positions to new ones and others lose their significance in production. Reflecting these changes to indices in the structure of consumption and production and updating the indices are mandatory. On the international platform, it is advised that the indexes are renewed every five years (SSI Turkey, 2002).

2.10 Construction price indices

Construction price indices have always been used to evaluate the variations in material, equipment and labor costs (Wang C.H. and Mei Y.H., 1998).In other words, they represent the variations in the prices of material, equipment and labor which form in general the sub-items of construction costs.

Several price indices are calculated and published by governmental organizations to be used for several purposes; whereas various studies are conducted for different types of construction to achieve more accurate price indices to be used specifically for the type of constructions.

Construction price index is calculated by the statistical authority of the country to meet the demand arising from the need to assess actual change in the output from this activity which cannot be derived only through reference to regular construction statistics(Consumer Price Index, Sources and Methods, 1996) and (EUROSTAT, 1996).

According to (Kahraman, 2005)construction price index is developed to measure the price variation in construction material, equipment and labor costs. However, each specific types of construction project is a combination of unique set of materials, equipment and labor. This leads to the fact that cost variation is for different construction types shall be measured by different types of cost indices. Cost variations are developed by measuring the price variations regarding the specific sets of material, equipment and labor involved in different types of construction projects.

Price indices in construction industry offer a medium for inspection changes that occur in the pricing of construction goods and services at the entering and existing levels construction activities. However, the advantages of price indices are to understand the connections between the changes in real inputs and outputs of the construction industry over a period. The important reasons why price index is needed in the construction industries are follows:

- Computing the differences in prices of goods and service for construction activities
- Supervising the influence in difference of relation between total cost and selling price goods and services in construction industry
- Computing the cost of goods and services at continual prices
- Appraising the medium-term development of prices
- Forecasting the price of construction project
- Formulating the manufacture of goods and examine the effectiveness of commercial components and
- Enabling value for money.

2.10.1Types of construction price indices

According to (Louis Kincannon)there are different types of construction price indices. These are:

2.10.1.1Input price indices

According to(EUROSTAS, 1996)**,** input price index measure change in the price of input to the construction process by monitoring individually the cost of each element. This are usually implying the composition of a weighted index of the costs of earning and materials.(IMF, 2004) It should not be used to provide information on price activities for finished construction work as they generally do not reflect the whole range of influences that impact on market prices. These include changes in productivity, profit and trade margins of contractor and changes in actual market conditions. Its only

provide a reflection of changes in the prices of construction inputs. The indices produced are production cost rather than production price indices. As a result, the real trend of construction costs may differ substantially from the trend compiled solely the basis of wages and material costs. An input cost index is likely to overstate the price rise of completed construction work as it ignores gains in productivity reflected in price declines.

The applicable factor for the month under consideration is thus calculated using the formula:

$$Pc = \frac{It - Io}{Io}$$

Where:
Pc = fractional change in cost index
It = index at the time t, applicable month
Io= base month index

2.10.1.2 Output price indices

Output price indices measure and reflect the price index of construction material sold by producers. Major principle of index measures the price received by producers(EUROSTAS, 1996). It covers most of the items usually built into the price paid by contractors or clients to units involved in producing the completed output of the construction activity. These generally include materials, equipment, labour, overheads and profits.Several different techniques are used to include all these components. One method involves the inclusion in the index of all the individual factors involved in the construction projects. It includes overhead, profit and any other costs paid by the client. An alternative method involves basing the index on the price of actual finished constructions. Both methods are described in detail below in the typology of methods used to compile construction price indices.

2.10.1.3 Seller's price indices

According to (Kissi, 2017)and (Louis Kincannon)Seller's price index measure change in the price of construction output paid by the buyer or final owner of the output of the construction activity. The term "seller's price" is used to differentiate it from the "purchaser's price" which releases the land component in the ownership transfer. The relationship between the three may be shown as in the following table 2.2.

Table 2.2:Relationship between the three types of indices

Input price index	Output price index	Seller's price index
Elements paid by Contractor	Elements paid by Client	Elements paid by final Owner
Labor	Labor	Labor
Materials	Materials	Materials
Plant &Equipment	Plant &Equipment	Plant &Equipment
Transport	Transport	Transport
Energy	Energy	Energy
Other costs	Other costs	Other costs

	Contractor's profit margins	Contractor's profit margins
	Productivity	Productivity
	Overheads	Overheads
		VAT
		Land
		Architect'sfees
		Other costs
		Client's profit margins

2.11Sources of indices

Indices are typicallyprepared by governmental departments of statistics to represent the costs of those materials or groups of materials within the areas of influence of those sectors. The determination of price index that will be used to measure the price changes. Various price indices have been published by statistics institutions of countries(Asumadu, K., 2013). They are directly related to the economy and based on the rate of inflation, political stability and exchange rates of that particular country or area of influence. For the reason that indices are area specific they cannot be used as being representative of other areas i.e. fuel index from different country, todayreplicate the hyperinflation at this time being experienced in that country and would give no indication of what was trendy with the cost of fuel in Ethiopia(SMEC, 2019). If to customarbitrary indices, one would successfully import the inflation from that area into the project and above or belowpays the contractor for contract price adjustment. It is therefore, essential that the sources of indices coincide with the currencies of payment i.e. in the above example the contractor requested payment in ETB and USD. The source of the indices must therefore be the Ethiopia and United States of America.

All well developed countries produce such indices, which are up to date and readily available, usually via the internet(Asumadu, K., 2013). However, were these are not produced it becomes necessary to use proxy indices, which more often than not, are actual material or product prices from reliable manufacturers or producers e.g. a cement and reinforcement bar factory prices, government published fuel and bitumen prices.

In some country construction price indices have been published to measure price changes based on the type of construction projects such as: building, road and water works construction cost indices. Even in some countries, local price indices or locational factors to represent the price changes locally have been developed and published (Asumadu, K., 2013). One of the reasons behind developing construction cost index is that wholesale price index or PPI contain of many inputs which of them are irrelevant with construction resources. Therefore, wholesale price index or PPI do not reflect the actual price changes in construction materials truly. It is valuable to use such kinds of construction cost indices in price adjustment. On the other hands, it is important to note that, if the price adjustment will be calculated by using construction cost indices; these indices should be reliable, relevant to the project, easily accessible and published in a regular manner (Yadav *et al.*, 2011).

2.12Price index calculatingmethods

According to (Touran and Lopez, 2006) forecasting methods are used to produce numerical estimates of escalation, escalation factor or cost escalation range from the relatively simple to complex and sophisticated techniques.Also,reminder that the methods are used to forecasts one of the three periods:

- Short term (next 3 months)
- Medium term (4 months–2 years) and
- Long term (more than 2 years).

Estimating the increase in price over the long term is almost impossible because of many uncertainties beyond the control of all parties (Westney, 1997). Touran and Lopez claims that the same is true of long-term construction projects with multiyear schedules and start dates in the future. Despite this difficulty, the owners of large long-term projects need to come up with the estimated cost of these projects. The more prudent way to approach these problems is to calculate a range of possible costs rather than a single figure (Touran and Lopez, 2006). Forecasting methods for escalation factor can be group into two major categories: quantitative and qualitative methods.

2.12.1 Quantitative methods

Quantitative methods are used when sufficient quantitative information is available. Most of the forecasting techniques for escalation, escalation factor and cost escalation are quantitative methods. (Touran and Lopez, 1996). Different researchers are suggested two quantitative forecasting categories, the causal and time-series method (statistical method). The causal method assume that the predicted variable is controlled by one or more independent variables and the causal relationship is applied to predict a dependent variable.

2.12.1.1 Trend analysis

It is a technical analysis which attempt predict the future market price movement based on a recently observed trends data. Based on the ideas that has happened in the past and give traders the idea of what will happen in the future. It is a general direction of market which is taking during a specific period of time. Trend can be both upward and downward. It is a process of looking current trends in order to predict the future one and considered from the comparative analysis. It includes an attempt to determining whether current market trend is a gain in particular market sector and is likely to consider trends one market area and could result another one(Adam Hayes, 2019).

According to (Karama Kanoun and Jean-Claude Laprie, 2012) there are a number of trend analysis methods which can be used to help determine whether the system experiences the index increase or decrease. This method can be grouped into graphical and analytical methods. Graphical assessments consist of plotting some observed increase or decrease data such as the price indices versus time in order to visually obtain the trend showed by the data. The raw data are processed to

derive trend factors. It consists of calculating the descriptive statistics and correlation of the observed price indices.

2.12.1.2T-Test methods

According to (Graham Hole, 2009)this technique compute two-sample test and other two-sample test directly from mean, standard deviation and sample size. Confidence interval for the mean, mean difference and standard deviation can also be computed. a Hypothesis test include in this procedure can be produce for both one and two side test as well as, equivalence test. Use of t-test can aid to decide the difference between a condition is real or whether it due simply to chance fluctuation from one-time test to another. T-test enable to decide, mean of one situation truly different from another mean situation. There are two version of t-test.

- **Dependent-mean t-test**: use when the same subject participates in both condition of the experiment.
- **Independent-mean t-test:** use when you have two different group of subjects, one group performing one condition in the experiment, and the other group acting the other condition.

In both cases, we have one independent variable (the thing we operate in our test), with two levels (the two different conditions of our test). We have one dependent variable (Ronald E. Walpole, 2007). Commonly, there are two major ways to compare data:

- Compare the means of the two or more data sets.
- Compare the variation of two or more data sets.

In most comparative studies, mean is the most important piece of data. But there are also times when the variation also studied. This is particularly useful in studying the stability of marketing values.

In statistical works, t-test is used to compare the mean of two or more data sets. Microsoft excel perform this test easily and the procedure for T-test on excel sheet is comparing the specific data for select the fair price index of bitumen.

Reliability and Validity:

We do a two-tail test (inequality). If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis and -t Critical two-tail < t Stat <t critical two-tail, we do not reject the null hypothesis.

Mathematically, a T-test model is represented by the following equation:

$$t = \frac{(\overline{X} - \overline{Y}) - (\mu X - \mu Y)\text{hypothesised}}{\sqrt{\frac{\sum(X-\overline{X})^2+\sum(Y-\overline{Y})^2}{(NX-1)+(NY-1)} X \left(\frac{1}{NX}+\frac{1}{NY}\right)}}$$

Where:

X = Variable X

Y= Variable Y

NX = The number of subjects in condition X.

NY = The number of subjects in condition Y.

$\sum X$= Add together all the X scores, to get the sum of X

$\sum Y$ = Add together all the Y scores, to get the sum of Y

$\sum X^2$ = Square each X score, and then add together all these squared scores

$\sum Y^2$ = Square each Y score, and then add together all these squared scores

$(\sum X^2)$ = Add together all the X scores and then square this sum

$(\sum Y^2)$ = Add together all the Y scores and then square this sum

$\bar{X}$= Mean /Average, the sum of all the values of X divided by the number of X.

$\bar{Y}$= Mean /Average, the sum of all the values of Y divided by the number of Y.

$(\mu X - \mu Y)$ hypothesized is usually regarded as equaling 0

2.12.1.3Regression models

According to (Walter A. *et al,* 2008)it is a method for modeling and exploring a relationship between an outcome or response variable and one or more forecaster variables. The end result of a regression analysis is often to generate a model that can be used to forecast or predict future value of a response variable given specified values of the predictor variables. (Ronald E. Walpole, 2007)regression analysis identifies and evaluate the relationship between dependent and one/more independent variable which are also called predictor or explanatory variable. It is particularly useful to assess and adjust for confounding. Model of relationship is estimated based on their parameter value. It is used to develop estimated regression analysis. Various tests are applied to determine if the model is satisfactory. The estimated regression analysis is useful to predict the dependent variable to get their values.

Linear regression explores the relationship that can be described by straight lines. Surprisingly, large number of problems can be solved by linear regression and even more by means of transformation of the original variables that result in linear relationships among the transformed variables. When there is continuous a single dependent and independent variable is called simple linear regression analysis; it assumes that linear relationship between two variables.

Dependent variable is a representative whose value is depend the value of independent variables.

Independent variables are characteristics that can be measured directly; these variables are also called predictor or explanatory variables used to predict or to explain the behavior of the dependent variable.

Reliability and Validity:

- Does the model make intuitive sense? Is the model easy to understand and interpret?
- High R-square
- Low standard error
- P-values less than 0.05
- Are the signs associated with the coefficients as expected?
- Does the model predict values that are reasonably close to the actual values?

Simple regression model

Simple linear regression is a statistical method to allow summarize and study a relationship between two quantitative variables. In a cause-and-effect relationship, the independent variable is the cause and the dependent variable is the effect. Least square in linear regression is a method predict the value of dependent variable ***Y***, based on the value of an independent variable ***X***.

- One variable denoted (x), is regarded as the predictor, explanatory or independent variable.
- The other variable denoted (y), is regarded as the response, outcome or dependent variable.

Mathematically, the regression model is represented by the following equation:

$$y = \hat{y} = \beta o \pm \beta 1 X1 \pm \epsilon 1$$

$$\beta o = \overline{Y} - \beta 1 \overline{X}$$

$$\beta 1 = \frac{n\sum xy - \sum x \sum y}{n\sum x^2 - (\sum x)^2}$$

$$\overline{X} = \frac{\sum x}{n}$$

$$\overline{Y} = \frac{\sum y}{n}$$

Where:

X independent variable.

Y dependent variable.

***β*0** the intercept point of the regression line and the y axis.

$\beta 1$ the Slope of the regression line

$\boldsymbol{n}$ Number of cases or individuals.

$\sum \boldsymbol{xy}$ Sum of the product of dependent and independent variables.

$\sum \boldsymbol{x}$ = Sum of independent variable.

$\sum \mathbf{y}$ = Sum of dependent variable.

$\sum \boldsymbol{x^2}$ = Sum of square independent variable.

Test for significance of regression

The test for significance of regression is a test to determine whether there is a linear relationship between the response variable y and a subset of the predictor variables x1, x2, ..., xk. The appropriate hypotheses are

$$H_0 : \beta_1 = \beta_2 = \cdots = \beta_k = 0$$
$$H_1 : \text{ at least one } \beta_j \neq 0$$

Rejection of the null hypothesis H0 implies that at least one of the predictor variables x1, x2, ..., xk contributes significantly to the model. The test procedure involves an analysis of variance partitioning of the total sum of squares.

$$\text{SSR} = \sum_{\text{i=1}}^{\text{n}} (\hat{\text{y}}\text{i} - \overline{\text{Y}})^2$$

$$\text{SSE} = \sum_{\text{i=1}}^{\text{n}} (\text{Yi} - \hat{\text{y}})^2$$

$$\text{SST} = \sum_{\text{i=1}}^{\text{n}} (\text{Yi} - \overline{\text{Y}})^2$$

Into a sum of squares due to the regression model and a sum of squares due to residual (error), say,

$$\text{SST} = \text{SSR} + \text{SSE}$$

$$\sum_{\text{i=1}}^{\text{n}} (\text{Yi} - \overline{\text{Y}})^2 = \sum_{\text{i=1}}^{\text{n}} (\hat{\text{y}} - \bar{\text{y}})^2 + \sum_{\text{i=1}}^{\text{n}} (\text{Yi} - \hat{\text{y}})^2$$

$$MS_{reg} = \frac{SSR}{1}$$

$$MS_{res} = \frac{SSE}{(N-2)}$$

$$F = \frac{MS_{reg}}{MS_{res}}$$

$$R^2 = \frac{\text{Explained Variation}}{\text{Total Variation}} = \frac{SSR}{TSS}$$

$$R^2 = \frac{\sum(\hat{y}i - \overline{Y})^2}{\sum(Yi - \overline{Y})^2}$$

$$\text{Adjusted } R^2 = 1 - \frac{SSE/(n-p)}{SST/(n-1)}$$

$$e_i = Yi - \hat{y}$$

$$S_e = \sqrt{\frac{\sum(Yi - \hat{y}i)^2}{n-2}}$$

Where:

SSR= Regression Sum of Square
SSE = Residual Sum of Square
SST = Total Sum of Square
MS = Mean Square
e = error of estimate or error of prediction
Se = Standard error
n = the number of observations
(n – p)= denominator degrees of freedom

Chapter 3

3. METHODOLOGY

3.1 Introduction

A research methodology is the sequence that guides the researcher in the process of collecting, analyzing, and interpreting observations(Abiy Z., 2009). (Yin, 2003)considers it as an action plan for getting from here to there. Where is regarded the initial set of question to be answered and there, is some set of conclusions about the questions. This chapter includes the methodology used in this research. It provides research type, methods selected and the information about the research design from the research instrument.

Research Instrument: Document analysis from the selected projects, this instrument is used for answering question number one and two which are, what are the current price indices determination practice when original source cease to publish indices, what are the reliable sources to minimize ceasing of publishing indices and how can we select a new reliable source when the supplier ceased to exist? This part of the methodology will present, the rational for selection of case study projects, data gathering and analysis mechanisms to find the reliable new source, to develop a guideline and to draw a valid conclusion.

3.2Research type

The research methodology lead to accomplish the specified objectives of this study. As stated in the above statements, the major objectives of this research are assessing current price indices determination practice when original source cease to publish indices, assessing reliable sources to minimize ceasing of publishing indices and developing guideline for price adjustment administration system when supplier cease to exist and replaced by new source. The following diagram illustrates the research methodology followed for this particular research.

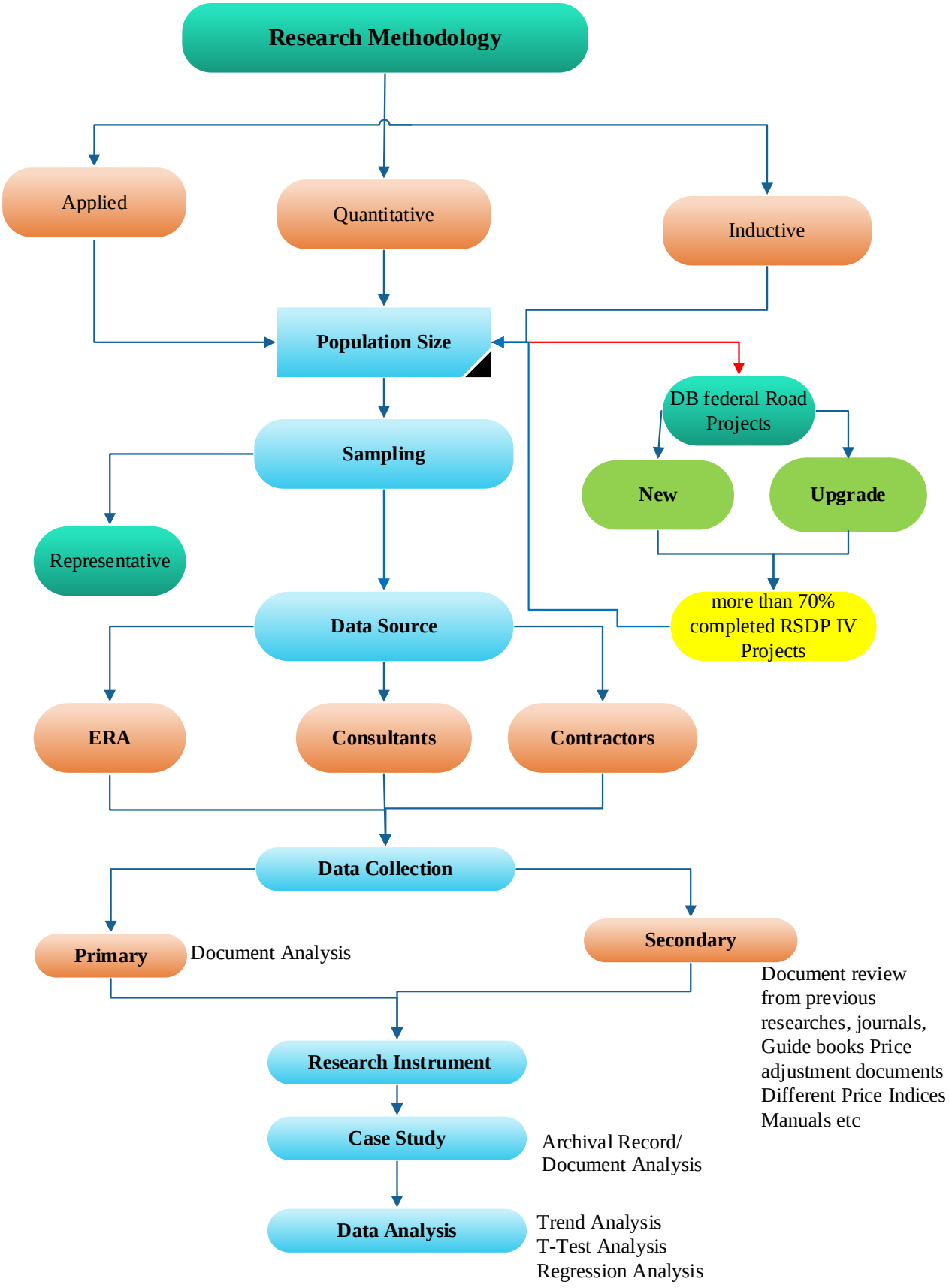


Figure 3.1:Research writing diagram

3.2.1 Justification of research methods

According to (Yin, 2003) a case study research used for exploratory, descriptive as well as explanatory studies and basically case study research should answer how? and why? questions raised by the researcher. The fundamental nature of this study is to answer questions about how to select reliable source in price adjustment process when the original suppliers cease to publish price Indices and change by new sources in ERA Design Build (DB) projects. These research asses theprice adjustment problems related to price indices determination andmaterial supplier source selection in the federal road projects. It also explores and analyze ERA DBprojects price adjustment new supplier source selection methods.

i. **Descriptive:** This research is descriptive and explanatory that it describes the factors of price indices determination andnew supplier source selection mechanisms in price adjustment on federal road projects and identifies the variables for the cause of the occurrence.
ii. **Applied:** This research is applied since; it solves the specific/particular problems of the Ethiopian road authority price adjustment administrationwhen supplier cease to publish and reliablenew supplier selection mechanisms.
iii. **Quantitative:**This research used quantitative approach. It describes, DB projects price adjustment problems when the original suppliers cease to publish price indices and change by new sourcesin ERA DB projects on the collection of numerical data in archival records in the ERA price adjustment documents support by statistical analysis. In quantitative approach data are collected and analysed based on document analysis. Hence, this technique aims to answer this research question what are the current price indices determination practice when original source cease to publish indices, what are the reliable sources to minimize ceasing of publishing indices and how can we select a new reliable source when the supplier ceases to exist?
iv. **Inductive:**This research used the inductive research method. It starts with research questions and objectives that need to be achieve during the research process. To check the effect of price index in federal road projects price adjustment methods can be access through finding answers to the following research questions. These are: what are the current price indices determination practice when original source cease to publish indices, what are the reliable sources to minimize ceasing of publishing indices and how can we select a new reliable source when the supplier ceases to exist?

3.2.2Data source and Data collection mechanism

The primary data sources for this research were primarily from ERA, consultants and contractors for the challenges and problems they have faced during construction period of different projects in related to price adjustment. Secondary sources were different manuals, guidelines, journals, thesis papers, books and reports which used for identifying factors which affect price indices determination and reliable source selection. The following tables 3.1 lists the projects are reported suppliers ceased to publish Price Indices and change by the new sources. The projects are:

Table 3.1:Projects suppliers ceased to publish Price Indices and replaced by the new sources.

No.	Name of Project	Proposal
1	Chole-Magna	❖ Contractor's proposal for changed source of Bitumen. ❖ Employer's Representative assessment report on Bitumen Price Index.
2	Dire Dawa-Dewelle	❖ Contractor's proposal for changed source of Bitumen, Reinforcement steel, labor and Equipment indices. ❖ Employer's Representative recommendation on Bitumen Price Index.
3	Pawi-Junction-Fendkia-Ayma	❖ Contractor's proposal for changed source of Bitumen. ❖ Employer's Representative recommendation on Bitumen Price Index.

Primary data were collected through document analysis from adjustable payment certificates, contract documents, contractors claim heads on when the original suppliers cease to publish Price Indices and change by new sources, employer representatives' analysis based on contractor documents for ERA's DBprojects. It involved in depth study of the most critical issues of ERA price adjustment practice when original source cease to publish indices and reliable new source selection criteria in federal road projects to monitor how they develop and how they are managed in price adjustment administration.Secondary data were collected from different manuals guidelines and literatures.

The data are collected from RSDP IV DB projects and above 70% completed federal rod projects. These data covered the proposed applicable and appropriate new sources of bitumen price indices, source of indices, base value date and price and percentage completion of these projects.

3.2.3 Population and Sampling

The population of the study falls to federal road construction DB projects whose constructions were started after July 2010 (RSDP IV projects) and their construction progress was more than 70% completed therefore, three projects are used for analysis. The basis of selecting these particular projects were based on the information and document availability as well as price adjustment techniques.

3.2.3.1Sample size determination

Sampling is the process of selecting representative unit of a population for the study in research investigation. Sample is a small proportion of a population selected for analysis.

- ❖ The total number of DB projects from RSDP IV, more than 70% complete are 29 projects. only three projects have faced supplier cease to exist problems. Therefore, all three projects used for analysis.

3.3 Data analysis mechanism

Collected datawere analyzed by using trend, T-test and regression analysis mechanisms. Data's from client (ERA), consultants and contractors price adjustment administration when supplier cease to publish price index and replaced by new source.

3.3.1 Trend analysis

The original source and different new data series related to bitumen prices are assessed. The trend analysis requires an appropriate representative price series for bitumen, i.e. a price that accurately captures general price trends in the global bitumen market. Trend analysis is checked by different statistical techniques like:

- Descriptive statisticsillustrates the range in price change among the selected suppliers
- Correlation analysis is carried out to find or observe any kind of association or correlation between these new suppliers with the original supplier as to bitumen pricing index and
- Tabular and graphical representation of the month-to-month percent changes for the original and new suppliers.

Through statistical analysis techniques, the trend of bitumen pricing index isexamining for the period between base date and end date when original supplier ceased to publish price index. Furthermore, theanalysis attempt to examine month to month change among this new supplier.

3.3.2T-Test analysis

Reliability and Validity: If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis and -t Critical two-tail < t tat <t critical two-tail, we do not reject the null hypothesis.Mathematically, a T-test model is represented by the following equation:

3.3.3 Regression analysis

This method fit the data effectively without using any erratic variable that creates noise. P-values as explained earlier are used to eliminate the unnecessary variables, while the R^2 is used for the determination of best fit.

Reliability and Validity:

- High R-square
- low standard error
- p-values less than 0.05
- the model predicts values that are reasonably close to the actual values

Prediction using regression models necessitates the forecast of the new supplier. Therefore, the regression process becomes a two-phase prediction. At the first phase, independent variables are predicted. In the second phase, dependent variable is predicted with the aid of prior defined independent variables.The results from the data analyses were then used to draw up a valid conclusion and recommendations as to improve price adjustment practices for ERA's projects.

Chapter 4
4. DATA ANALYSIS

4.1 Introduction

This chapter deals with the results and discussions of the data gathered from documents concerning about price adjustment on federal road construction projects when suppliers cease to publish Price Indices. In this part of research, the result of the data gathered is presented, interpreted and analyzed in detail to identify best price adjustment methods when suppliers ceased to publish Price Indices, explain current price adjustment methods when supplier cease to publish price index to administer in federal road projects.

This study aims to improve price adjustment method in federal road projects in terms of bitumen price indices when the original suppliers cease to publish price indices and changed by new sources in ERA DB projects. This section presents the steps of calculating several price indices using the data of RSDP IV DB projects compiled from proposed applicable and appropriate new sources of bitumen price indices.

4.2 General description of the projects

The selected projects are asphalt roads commencement date from November 2012 up to October 2014 with average cost per kilometer of 26.11million birr and contract completion period around four and one fourth (4.25) years, 3 years and four and half (4.5) years period. Currently, all the projects are 100% completed and provisionally accepted by the employer. Table 4.1 and 4.2 presents the general description of the selected DBprojects.

Table 4.1:Selected Ethiopian Road Authority Design and Build projects

Ethiopian Road Authority Design and Build Projects										
No.	Project Name	Contractor	Consultant	Description of index	Range of weighting	Bidder's Proposed		Source of Index	Base Value & Date	Percent Completion
						Local Currency	Foreign Currency			
1	Chole-Magna	CGC Overseas Construction Group Ltd	Road Design and Development Consultants PLC	Fixed/ Nonadjustable	30%	30%	30%		June/28/2012	100%
				Fuel	8 - 12%	12%	12%	NOC	18.03	
				Bitumen	15 - 30%	28%	28%	California PAPI	518.00	
				Steel Reinforcement Bar	2 - 5%	2%	2%	CEMAC, China	290.00	
				Cement	3- 8%	8%	8%	Mugher	121.40	
				Equipment	20- 30%	20%	20%	CEMAC, China	108.10	
				Total	100%	100%	100%			
No.	Project Name	Contractor	Consultant	Description of index	Range of weighting	Bidder's Proposed		Source of Index	Base Value & Date	Percent Completion
						Local Currency	Foreign Currency			
2	Dire Dawa - Dewelle	CGC Overseas Construction Group Co. Ltd.	Shandong Great Supervision and Consultation Co. Ltd.	Fixed/ Nonadjustable		25%	25%		**Sep, 2012**	100%
				Fuel		30%		TOTAL Ethiopia S.C.	16.89	
				Bitumen			15%	California PAPI	589.10	
				Steel Reinforcement Bar			10%	CEMAC, China	107.90	
				Cement		20%		Mugher	290.00	

				Equipment		25%	40%	CEMAC	108.30	
				Foreign Labor			10%	CEMAC, China	306.40	
				Total		100%	100%			
No.	Project Name	Contractor	Consultant	Description of index	Range of weighting	Bidder's Proposed		Source of Index	Base Value & Date	Percent Completion
						Local Currency	Foreign Currency			
3	Pawi Junction Fendkia-Ayma	CGC Overseas Construction Group Co. Ltd.	Ethio Infra Engineering in association with STADIA Engineering Works Consultant PLC	Fixed/Nonadjustable	30%	30%	30%		Sep, 2012	100%
				Fuel	10 – 20%	15%		Total Ethiopia	17.16	
				Bitumen	15 – 30%	25%	30%	California PAPI	589.10	
				Steel Reinforcement Bar	2 – 5%	2%	5%	CEMAC	107.90	
				Cement	3 -8%	8%	0%	Mugher	290.00	
				Equipment	25 -35%	20%	30%	CEMAC	108.30	
				Foreign Labor	0-5%		5%			
				Total	100%	100%	100%			

Table 4.2:General description of the selected Design Build projects

Project Description	Project Name		
	Chole-Magna	Dire Dawa-Dewelle	Pawi Junction-Fendkia-Ayma
Project Financer	GOE	China	GOE
Length in (km)	20	220	83
Commencement Date	Nov. 30/2012	Oct.1/2014	Dec.27/2012
Project starting date	11/30/2012	10/1/2014	12/27/2012
Contract cost with VAT	ETB 869,512,570.00	ETB 4,584,266,282.30	ETB 1,511,416,899.73
Contract Duration	1,547 Calendar date	1,095Calendar date	1,635 Calendar date
Original Completion Date	Feb.24/2017	Sep. 30/2017	May 30/2017
Revised Completion Date	Feb.24/2017	Nov. 15/2018	June 18/2017

4.3 Assessing current price indices determination practice when original source cease to publish indices.

According to ERA's contract document sub-clause 13.1 (b)(i) in the last paragraphquoted that, "If the contractor desires to order materials from a supplier other than from whom he obtained his original quotations or indices because the original supplier ceases to exist, the Employer's Representative will look into the trend of increment of the material cost of the new supplier and compare it with the trend of the original supplier and the newly proposed supplier and will use the quotations or indices most favorable to the Employer**".** This specific clausedoesn't clearly define the price adjustment calculation methods and guide the procedure when the original suppliers cease to publish price indices and change by new sources.

4.3.1 Current price index determination in Chole-Magna DB project

The contractor (CGC Overseas Construction Group Co. Ltd) addresses the reality that the original source of bitumen price index for calculation of price adjustments (California Paving Asphalt Price Index) has ceased to publish from the date after 1st March 2015.

Employer's representative of this project (Road Design and Development Consultant PLC) refers to contractor's letter ref.no. CGCOC/CM/15119 dated 20th January 2016, the contractor forwarded and proposed three alternatives. These are: National Oil Ethiopia, Virginia Roads and Kentucky KAPI asphalt as the new source of bitumen price index. Accordingly, the ER has assessed the contractor's proposed alternatives of sources of indices. The contractor's and ER proposed sources of indices are listed in the following table.

Table 4.3:Sources for bitumen price index in Chole-Magna DB project

No.	Name of Source	Proposed by
1	National Oil Ethiopia PLC	Contractor
2	Virginia Roads	Contractor
3	Kentucky KAPI Asphalt	Contractor
4	New Jersey	Employer's Representative
5	S.T. Wooten	Employer's Representative
6	Georgia	Employer's Representative

The employer representative has made the assessment as follows.

In order to look into the trend of change of the index value of the new sources and make comparisons with the original sources, they have considered data of the last four years from the month of the original source has ceased to publish the information (from January 2011 to February 2015). With the exception of NOC Ethiopia, all the other index data sources mentioned above including the original source (California) are based in the USA. Hence, in order to made the evaluation on a single currency basis, ER has converted monthly selling prices of NOC offered in ETB into USD, using the appropriate currency exchange rate, as published by National Bank of Ethiopia.

In order to evaluate the degree of relationship between the California and any one of the alternative sources, ER has calculated the coefficient of determination R^2. The assessment report shows that, the ERconsidered different trend and regression analysis (last 1 year from Mar 2014 to Feb 2015, last 1.5 years from Sep 2013 to Feb 2015, last 2 years from Mar 2013 to Feb 2015, last 2.5 years from Sep 2012 to Feb 2015, last 3 years from Mar 2012 to Feb 2015), last 3.5 years from Sep 2011 to Feb 2015 and last 4 years & 2 months from Jan 2011 to Feb 2015) for evaluating the strength of coefficient of determination, R^2. It arrived at an R^2 value of 0.89, 0.79,0.68, 0.60, 0.43,0.39 and 0.32 for analysis periods of 1,1.5,2, 2.5, 3,3.5 years and 4 years and 2 months, respectively. The ER finally recommended (last 2.5 years from Sep 2012 to Feb 2015) an R^2 value of 0.68 for predicted current index of California from current indices of NOC.

4.3.2 Current price index determination in Dire Dawa-Dewelle DBproject

The Contractor of Dire Dawa-Dewelle Design Build Road Project (CGC Overseas Construction Group Ltd), has submitted four proposals to the ER's (Shandong Great Supervision and Consultation Co. Ltd), declaring that its original sources of indices for bitumen, reinforcement steel, labour and equipment have ceased to publish and requested the ER's approval of its new proposed Georgia asphalt index.

Contractor declares that indices for equipment, steel and labour, from the original source, China Source Economic Monitoring & Analysis Center National Bureau of Statistics (CEMAC), has ceased to

exist since June 2015. Similarly, it declares that its original source of bitumen index, California Paving Asphalt Price Index (CPAPI), has ceased since March 2015.

Depends on Sub clause 13.1 (b) (i) of the contract, contractor therefore contends that the situation allows him change of the original supplier by a new supplier and he is entitled to replace his sources of indices for bitumen, Equipment, steel and labour.With such in consideration, the contractor choses the California bitumen price index during the bid time merely looking at the availability of the index and noting the experience of such index in other projects administered by the employer, and thus, allowing for ease of smooth administration of contracts by the ER and employer. However, there is no direct relationship the contract price with the original source of index of bitumen or any other sources from the US states, rather the contractor's rates are based on the world market prices.

In relation to bitumen index, contractor declares that he chose CPAPI during the bid time merely looking at the availability of the index and noting the experience of such index in other projects administered by the employer, and thus, allowing for ease of smooth administration of contracts by the ER and employer. Contractor further asserts that there is no direct relationship between itscontract price and the original source of index of bitumen or any other sources from the US states, rather the contractor's rates are based on the world market prices.

Contractor also states that, he chose the California bitumen index is only for the sake of ease of contract administration of the price adjustment, thinking that the supplier is in United States that has the world biggest and stable economy and he is of the view that any of other indexes in the same country, but different states, could be used for the price adjustment use.In relation to the facts of cease of the CPAPI index, contractor declares that he tried to communicate with the index publisher to find out the reason of cease of publishing but it failed to get reply.

Contractor proposed to select the new source of supplier with a reasonable trend, it made trend analysis of the following sources of indices from various department of transportation offices of US states, for the sake of similarity of economy and marketing with the original source of index.

- Department of transport the state of California – the original source
- Department of transport the state of Georgia
- Department of transport the state of North Carolina
- Department of transport the state of West Virginia
- Department of transport the state of New Jersey
- Department of transport the state of Oklahoma, and
- Department of transport the state of New York

The sources of the data sets used in this assessment are provided in the following table, which includes additional sources than the States department of transportation for the sake of understanding the global trend of bitumen index.

Table 4.4:Dire Dawa-Dewelle DB project sources of the data sets used in the assessment

Name of Source	Source Information
California Paving Asphalt Price Index (Base source)	California Department of Transportation http://www.dot.ca.gov/hq/esc/oe/ac_index.html
State of Georgia Department of Transportation Asphalt Cement Price Index	Georgia Department of Transportation http://www.dot.ga.gov/PS/Materials/AsphaltFuelIndex
State of North Carolina Department of Transportation Asphalt Price Index	State of North Carolina Department of Transportation https://connect.ncdot.gov/projects/construction/Pages/PavementConstruction-Prices.aspx
West Virginia Department of Transportation Asphalt Prices	West Virginia Department of Transportation http://www.transportation.wv.gov/highways/contractadmin/ Lettings /Pages/FuelandAsphaltPrices.aspx
State of New Jersey Department ofTransportation Asphalt Price Index	State of New Jersey Department of Transportation http://www.state.nj.us/transportation/business/trnsport/PriceIndex.shtm
State of Oklahoma Department of Transportation Asphalt Binder Price Index	State of Oklahoma Department of Transportation http://www.okladot.state.ok.us/contractadmin/pdfs/binderindex.pdf
National Oil Ethiopia (NOC)	As submitted by National Oil Ethiopia PLC
Canada - MTO AC Price Index	OHMPA Website http://www.ohmpa.org/mtopriceindex/

The contractor analysed the above alternative sources using T-test analysis and proposed Georgia asphalt index (published by Georgia department of transportation, USA) as the new source of index.Contractor also argued to support its claim for change of equipment, reinforcement steel and labour indices; declaring that the original source of the indices, CEMAC, has ceased to publication since June 2015. It accordingly proposed the following new sources of indices for each of the inputs:

- For equipment: PPI industry data for construction machinery manufacturing, bureau of labor statistics data, USA;
- For reinforcement steel: MEPS - World Carbon Steel Purchasing Price Index (WCSPPI)
- For labour: Wages and salaries for private industry workers in construction, bureau of labor statistics data, USA

Review of the Employer's Representative current price index determination

Employer's Representative of this project (Shandong Great Supervision and Consultation Co. Ltd) had continuation to his letter ref.no. SGHSBR-CGCOC/054/2018, dated 23rd September 2018 and refers to

contractor's letter CGCOC/DD/18228, dated 7th September 2018 andCGCOC/DD/180928, dated 28th September 2018 the ER's of the project has made an assessment on the contractor's proposal and agreed with the contractor's approach and methodology, determined adoption of the Georgia asphalt index (published by Georgia department of transportation, USA) as the new source of index.

The ER'sstates that, in forming his recommendation, he has analyzed the trends by comparing the number of monthly occasions where the California index and the indices in question both showed either increases or decrease in the selected 22months analysis period (Sep 2012 to June 2014), and he states that Georgia indices scored best by showing ten occasions out of 22 whereas the others scored nine out of 22.

The ER's determination has been communicated to the Contractor with copy to the employer, stating that the contractor shall use the Georgia bitumen index including the base index in place of California index with effect from March 2015. Though the ER is of view that, effective of March 2015, current indices of Georgia have to be used against base index of Georgia; it has not however elaborated on how that new index has to be incorporated in the price adjustment calculations.

4.3.3 Current price index determination in Pawi Junction-Fendkia-Ayma DBproject

The contractor of Pawi Junction-Fendkia-Ayma DBproject (CGC Overseas Construction Group Ltd) with letter ref.no. CGCOC/PJFA/15334 dated December 10, 2015 informedthe ER's that the original supplier for bitumen (i.e., CPAPI)ceased to published indices for bitumen as from March 2015and requested ER to changethe supplier to National Oil Ethiopia plc (NOC).

The contractor initially proposed to use NOC as alternative bitumen price index source. The ER vide his letter Cgc/12/2015/0211/kt dated December 16, 2015 instructed the Contractor to provide other sources in addition to NOC with a view to study the trend in price change as to this material (bitumen) globally. The contractor through its letter CGCOC/PJFA/16021 dated 16th January 2016 furnished another two sources for the ER further review and approval.

The ER, further looked into the matter and identified additionaltwo sources to strengthen the trend analysis. These additional sources are particularly important to adequately asses thesubject matter for the duration of the contract since fluctuation in petroleum prices hasan influence in increasing/decreasing in the costs of fuel and asphalt products.

Table 4.5:Potential sources for bitumen price index in Pawi-Junction DB project

No.	Name of Source	Proposed by
1	National Oil Ethiopia PLC	Contractor
2	Kentucky	Contractor
3	Virginia	Contractor
4	Oklahoma	Employer's

		Representative
5	US Bureau of Labour Statistics (BLS) Producer Price Index (PPI)	Employer's Representative

ER plotted the trends of bitumen indices between the various sources, and determined that the PPI index from BLS shows a strong correlation / association with California paving asphalt price index. ERA accordingly considered a regression model, based on PPI values (US BLS) as input and analysis period of September 2012 through to February 2015. He used model to predict new determined index value of California index after March 2015. The correlation coefficient between California Paving Asphalt index and US BLS PPI was calculated as 0.972, whereas that between the CPAI and the other five sources were 0.14, -0.15, -0.05 and -0.08, respectively which all indicated a weak relationship.ERA noted that the PPI index of US BLS represents the trend of the original source of index, i.e., California paving asphalt price index and he recommended determination of "a cost with a trend" from the PPI index of US BLS which fairly represents the original increment trend.

4.4 Assessing reliable sources to minimize ceasing of publishing indices

4.4.1Statistical data analysis of the new bitumen price index in Chole-Magna DB project

- Trend analysis of the new sources
- T–Test to compare index of bitumen (the price) and
- Regression analysis

4.4.2.1Chole-Magna DB project trend analysis of the new sources

New sources were identified, which are provided by the States department of transports, as discussed in the above table 4.3. The trend analysis requires an appropriate representative price series for bitumen, i.e. a price that accurately captures general price trends in global bitumen market.

The international trend of bitumen indexes compared with the original supplier, selecting from US states and other international indexes; which are: California (original source), Virginia, Kentucky, NOC,New Jersey, S.T. Wooten and Georgia. Through statistical analysis techniques, the trend (time series) of bitumen pricing index is examined for the period between June 2012 and February 2015. Furthermore, the analysis attempted to examine the month-to month change among these new suppliers. Table 4.6 and 4.7 provide the trend of bitumen price index as from the contract base year (i.e. June 2012) and the statistics shown that there was a significant decline in bitumen price index.The descriptive statistics shown in Table 4.6 illustrates the range in price change is among these suppliers.

Table 4.6:Descriptive statistics for different sources for bitumen price index in Chole-Magna DB project

Descriptive statistics							
	California	Virginia	Kentucky	NOC	New Jersey	S.T. Wooten	Georgia
Mean	101.91	89.73	92.27	103.18	89.60	90.56	105.76
Standard Error	2.97	0.69	0.60	1.06	0.77	0.68	0.63
Median	106.20	88.66	91.43	103.10	89.33	89.62	104.68
Standard Deviation	17.06	3.99	3.47	6.09	4.41	3.91	3.60
Sample Variance	291.03	15.90	12.01	37.04	19.41	15.27	12.93
Range	69.75	16.11	13.52	27.26	16.21	14.47	15.38
Minimum	48.69	83.89	86.48	85.78	83.79	85.53	98.49
Maximum	118.44	100.00	100.00	113.04	100.00	100.00	113.88
Sum	3363.15	2961.17	3044.77	3404.88	2956.95	2988.62	3490.13
Count (months)	33	33	33	33	33	33	33

Correlation analysis was carried out to find or observe any kind of association or correlation between these new suppliers with the original supplier as to bitumen pricing index.

Table 4.7:Correlation analysis for different sources for bitumen price index in Chole-Magna DB project

Correlations							
	California	Virginia	Kentucky	NOC	New Jersey	S.T. Wooten	Georgia
California	1						
Virginia	-0.199	1					
Kentucky	-0.056	0.723	1				
NOC	**0.759**	-0.083	-0.244	1			
New Jersey	-0.253	0.942	0.823	-0.212	1		
S.T. Wooten	-0.252	0.967	0.824	-0.204	0.937	1	
Georgia	0.11	0.517	0.698	-0.022	0.561	0.613	1

The calculation shows in table 4.7 a strong positive correlation (0.759) between California and NOC bitumen price indices. This means that California bitumen price index increases the index of NOC also increase. The above table clearly describes that except the NOC Ethiopia price index all the other indices do not behave similarly throughout the time period (June 2012- Feb 2015) and have a very weak relationship with the CPAPI index.

Comparison of trends considering that both the CPAPI and NOC indices relate to have strong relationship (characterized by high correlation coefficient of 0.759). Based on the above table 4.6 and 4.7 output results recommend that the appropriate replacement price index that should be used is NOC which is of similar trend to CPAPI.

The bitumen price data for all sources is listed as from the period June 2012 (base date) to February 2015 (latest date of available information wherein the original source of index ceased to exist) in the trendanalysis are summarized in table 4.8 and figure 4.1; which analyses the month-to-month percent changes for the price index of all sources (using June 2012 as the base).

Table 4.8:Chole -Magna DB project month to month percent changes for the price index of all sources (June, 2012 as the base)

Month	California Paving Asphalt Price Index			Virginia			Kentucky Transportation Cabinet			New Jersey		
	Price (USD)	% Change	Price index Base June 2012 =100	Price (USD)	% Change	Price index Base June 2012 =100	Price (USD)	% change	Price index Base June 2012=100	Price (USD)	% Change	Price index Base June 2012 =100
12-Jun	518.00		100.00	712.82		100.00	605.63		100.00	632.50		100.00
12-Jul	520.80	0.54%	100.54	679.13	-4.73%	95.27	585.00	-3.41%	96.59	602.50	-4.74%	95.26
12-Aug	544.30	4.51%	105.08	651.58	-4.06%	91.41	568.75	-2.78%	93.91	585.00	-2.90%	92.49
12-Sep	589.10	8.23%	113.73	631.98	-3.01%	88.66	563.13	-0.99%	92.98	570.00	-2.56%	90.12
12-Oct	581.80	-1.24%	112.32	625.24	-1.07%	87.71	563.13	0.00%	92.98	567.50	-0.44%	89.72
12-Nov	554.70	-4.66%	107.08	626.47	0.20%	87.89	563.13	0.00%	92.98	572.50	0.88%	90.51
12-Dec	573.20	3.34%	110.66	617.9	-1.37%	86.68	563.13	0.00%	92.98	560.00	-2.18%	88.54
13-Jan	598.40	4.40%	115.52	606.81	-1.79%	85.13	558.13	-0.89%	92.16	542.50	-3.13%	85.77
13-Feb	613.50	2.52%	118.44	597.99	-1.45%	83.89	546.25	-2.13%	90.20	530.00	-2.30%	83.79
13-Mar	577.10	-5.93%	111.41	604.61	1.11%	84.82	546.25	0.00%	90.20	532.50	0.47%	84.19
13-Apr	607.90	5.34%	117.36	605.71	0.18%	84.97	546.25	0.00%	90.20	537.50	0.94%	84.98
13-May	548.80	-9.72%	105.95	620.04	2.37%	86.98	546.25	0.00%	90.20	545.00	1.40%	86.17
13-Jun	543.80	-0.91%	104.98	667.44	7.64%	93.63	546.25	0.00%	90.20	595.00	9.17%	94.07
13-Jul	559.20	2.83%	107.95	671.3	0.58%	94.18	542.50	-0.69%	89.58	590.00	-0.84%	93.28
13-Aug	592.30	5.92%	114.34	654.76	-2.46%	91.85	553.75	2.07%	91.43	565.00	-4.24%	89.33
13-Sep	596.00	0.62%	115.06	640.98	-2.10%	89.92	548.75	-0.90%	90.61	550.00	-2.65%	86.96
13-Oct	552.40	-7.32%	106.64	638.78	-0.34%	89.61	543.75	-0.91%	89.78	557.50	1.36%	88.14
13-Nov	523.90	-5.16%	101.14	638.22	-0.09%	89.53	536.88	-1.26%	88.65	555.00	-0.45%	87.75
13-Dec	538.30	2.75%	103.92	626.1	-1.90%	87.83	534.38	-0.47%	88.24	542.50	-2.25%	85.77
14-Jan	537.60	-0.13%	103.78	624.17	-0.31%	87.56	534.38	0.00%	88.24	537.50	-0.92%	84.98
14-Feb	547.30	1.80%	105.66	625.24	0.17%	87.71	534.38	0.00%	88.24	540.00	0.47%	85.38
14-Mar	583.70	6.65%	112.68	617.28	-1.27%	86.60	539.38	0.94%	89.06	535.00	-0.93%	84.58
14-Apr	553.30	-5.21%	106.81	602.76	-2.35%	84.56	545.63	1.16%	90.09	530.00	-0.93%	83.79
14-May	550.10	-0.58%	106.20	621.8	3.16%	87.23	557.50	2.18%	92.05	545.00	2.83%	86.17
14-Jun	564.40	2.60%	108.96	629.81	1.29%	88.35	565.00	1.35%	93.29	565.00	3.67%	89.33
14-Jul	572.90	1.51%	110.60	649.35	3.10%	91.10	577.50	2.21%	95.36	588.30	4.12%	93.01
14-Aug	532.50	-7.05%	102.80	670.9	3.32%	94.12	596.25	3.25%	98.45	599.15	1.84%	94.73

14-Sep	500.80	-5.95%	96.68	692.44	3.21%	97.14	597.50	0.21%	98.66	620.00	3.48%	98.02
14-Oct	477.50	-4.65%	92.18	686.18	-0.90%	96.26	595.00	-0.42%	98.24	612.00	-1.29%	96.76
14-Nov	411.70	-13.78%	79.48	665.23	-3.05%	93.32	586.88	-1.36%	96.90	591.00	-3.43%	93.44
14-Dec	349.90	-15.01%	67.55	654.21	-1.66%	91.78	571.88	-2.56%	94.43	586.00	-0.85%	92.65
15-Jan	252.20	-27.92%	48.69	632.16	-3.37%	88.68	553.75	-3.17%	91.43	568.00	-3.07%	89.80
15-Feb	253.70	0.59%	48.98	618.39	-2.18%	86.75	523.75	-5.42%	86.48	553.25	-2.60%	87.47

Month	National Oil Ethiopia (NOC)					S.T. Wooten			Georgia		
	Price (Birr)	Currency Exchange Rate (USD) to (ETB)	Price (USD)	% Change	Price index Base June 2012 =100	Price (USD)	% Change	Price index Base June 2012 =100	Price (USD)	% Change	Price index Base June 2012=100
12-Jun	21,500	17.78	1,209.22		100.00	639.00		100.00	598.00		100.00
12-Jul	21,500	17.91	1,200.45	-0.73%	99.27	614.33	-3.86%	96.14	673.00	12.54%	112.54
12-Aug	21,500	18.02	1,193.12	-0.61%	98.67	590.33	-3.91%	92.38	655.00	-2.67%	109.53
12-Sep	22,866	18.09	1,264.01	5.94%	104.53	568.67	-3.67%	88.99	635.00	-3.05%	106.19
12-Oct	22,866	18.14	1,260.53	-0.28%	104.24	563.33	-0.94%	88.16	629.00	-0.94%	105.18
12-Nov	22,866	18.21	1,255.68	-0.38%	103.84	559.33	-0.71%	87.53	627.00	-0.32%	104.85
12-Dec	22,866	18.29	1,250.19	-0.44%	103.39	557.33	-0.36%	87.22	626.00	-0.16%	104.68
13-Jan	22,866	18.37	1,244.75	-0.44%	102.94	551.56	-1.04%	86.32	625.00	-0.16%	104.52
13-Feb	22,866	18.44	1,240.02	-0.38%	102.55	546.56	-0.91%	85.53	623.00	-0.32%	104.18
13-Mar	22,866	18.51	1,235.33	-0.38%	102.16	553.75	1.32%	86.66	625.00	0.32%	104.52
13-Apr	25,521	18.67	1,366.95	10.65%	113.04	552.50	-0.23%	86.46	623.00	-0.32%	104.18
13-May	25,521	18.76	1,360.39	-0.48%	112.50	559.06	1.19%	87.49	623.00	0.00%	104.18
13-Jun	25,521	18.76	1,360.39	0.00%	112.50	590.31	5.59%	92.38	625.00	0.32%	104.52
13-Jul	25,521	18.84	1,354.62	-0.42%	112.02	593.44	0.53%	92.87	630.00	0.80%	105.35
13-Aug	25,521	18.90	1,350.32	-0.32%	111.67	588.44	-0.84%	92.09	635.00	0.79%	106.19
13-Sep	25,521	18.96	1,346.04	-0.32%	111.31	573.13	-2.60%	89.69	629.00	-0.94%	105.18
13-Oct	25,521	19.02	1,341.80	-0.32%	110.96	572.81	-0.06%	89.64	626.00	-0.48%	104.68
13-Nov	23,900	19.10	1,251.31	-6.74%	103.48	569.38	-0.60%	89.10	623.00	-0.48%	104.18

13-Dec	23,900	19.17	1,246.74	-0.37%	103.10	562.19	-1.26%	87.98	616.00	-1.12%	103.01
14-Jan	24,335	19.26	1,263.50	1.34%	104.49	561.07	-0.20%	87.80	614.00	-0.32%	102.68
14-Feb	24,335	19.33	1,258.92	-0.36%	104.11	559.29	-0.32%	87.53	615.00	0.16%	102.84
14-Mar	24,335	19.42	1,253.09	-0.46%	103.63	558.21	-0.19%	87.36	621.00	0.98%	103.85
14-Apr	24,335	19.51	1,247.31	-0.46%	103.15	556.33	-0.34%	87.06	621.00	0.00%	103.85
14-May	24,335	19.61	1,240.95	-0.51%	102.62	572.67	2.94%	89.62	630.00	1.45%	105.35
14-Jun	24,335	19.68	1,236.53	-0.36%	102.26	580.67	1.40%	90.87	640.00	1.59%	107.02
14-Jul	24,270	19.80	1,225.76	-0.87%	101.37	594.00	2.30%	92.96	657.00	2.66%	109.87
14-Aug	24,270	19.88	1,220.82	-0.40%	100.96	611.92	3.02%	95.76	670.00	1.98%	112.04
14-Sep	24,270	19.99	1,214.11	-0.55%	100.40	630.00	2.95%	98.59	681.00	1.64%	113.88
14-Oct	24,270	20.09	1,208.06	-0.50%	99.90	624.23	-0.92%	97.69	678.00	-0.44%	113.38
14-Nov	24,270	20.16	1,203.87	-0.35%	99.56	608.46	-2.53%	95.22	661.00	-2.51%	110.54
14-Dec	22,606	20.23	1,117.45	-7.18%	92.41	598.46	-1.64%	93.66	635.00	-3.93%	106.19
15-Jan	22,606	20.31	1,113.05	-0.39%	92.05	578.85	-3.28%	90.59	613.00	-3.46%	102.51
15-Feb	21,140	20.38	1,037.29	-6.81%	85.78	557.69	-3.66%	87.28	589.00	-3.92%	98.49

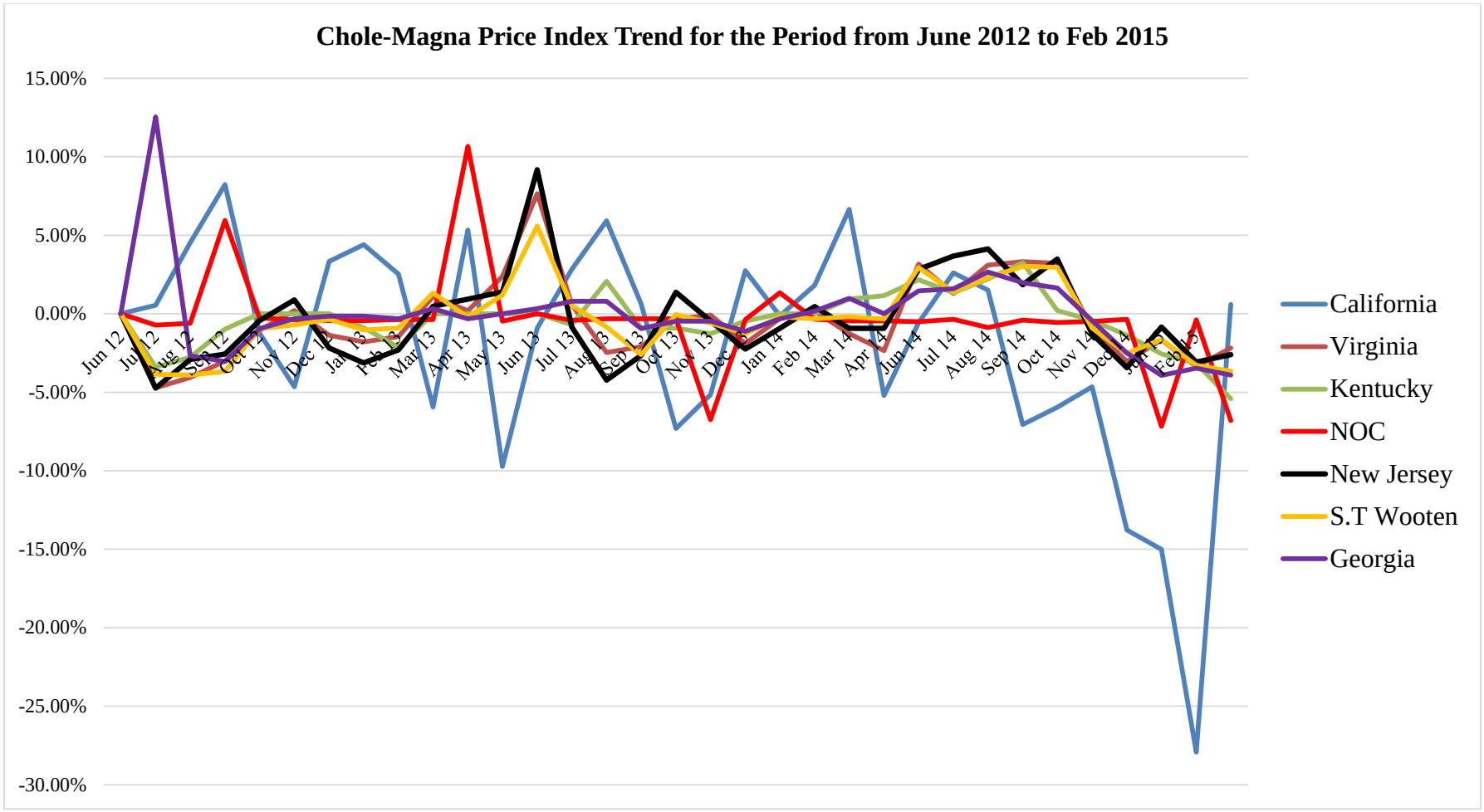


Figure 4.1:Chole-Magna price indexes trend for the period from June 2012 to February 2015

The above figure shows the trend in month-to-month price indices for the different sources. The Georgia index appears to have significantly steeper increases in the price index as compared to the other sources, especially in the earlier years. The California price index trend is observed to also have significantly steeper increases, as well as decreases in the price index. The increment and decrement trend for the California index appear to be comparatively erratic considering the similarity in trend for the other sources.

4.4.2.2 Chole-Magna DB project T-test analysis

Commonly, there are two major ways to compare data:

- Compare the means of the two or more data sets.
- Compare the variation of two or more data sets.

In most comparative studies, the mean is most important piece of data. But there are also times when the variation is also studied. This is particularly useful in studying the stability of marketing values. In statistical literature, a T-test is used to compare the mean of two data sets. ANOVA is used to compare the mean of two or more data sets.

4.4.2.2.1T–test to compare index of bitumen (setting June 2012 as base the price)

Microsoft excel perform this test easily, and the procedures for t-test on excel sheet is comparing the specific data for select the fair price index of bitumen.The comparison table of the indexes with the result of t-test using the price are stated below:

Comparison of department of transportation California and Virginia

A t-test is performed and found the result as shown below:

Table 4.9:T-test comparison of department of transportation California and Virginia

	California	Virginia
Mean	527.9121	639.6297
Variance	7809.154	808.05574
Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	-6.91345	
P(T<=t) one-tail	1.32E-09	
t Critical one-tail	1.669013	
P(T<=t) two-tail	2.64E-09	
t Critical two-tail	1.99773	

The result is interpreted as

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -6.91345< -1.99773). Therefore, we reject the null hypothesis.

Comparison of department of transportation of California and Kentucky

A t-test is performed and found the result as shown below:

Table 4.10:T-test comparison of department of transportation of California and Kentucky

	California	Kentucky
Mean	527.912	558.79
Variance	7809.15	440.4454
Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	-1.9529	
P(T<=t) one-tail	0.0276	
t Critical one-tail	1.66901	
P(T<=t) two-tail	0.0552	
t Critical two-tail	1.99773	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we do not reject the null hypothesis
t Stat < - t Criticaltwo-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This is not the case, -1.99773< -1.9529<1.99773. Therefore, we do not reject the null hypothesis. The observed difference between the sample means (558.79-527.912=30.878) is not convincing enough to say that the average bitumen Price Index of between Kentucky and California differ significantly.

Comparison of department of transportation of California and NOC

A t-test is performed and found the result as shown below:

Table 4.11:T-test comparison of department of transportation of California and NOC

	California	NOC
Mean	527.912	1247.654
Variance	7809.15	5415.759

Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	-35.9532	
P(T<=t) one-tail	1.8E-44	
t Critical one-tail	1.66901	
P(T<=t) two-tail	3.7E-44	
t Critical two-tail	1.99773	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail (-35.9532< -1.99773). Therefore, we reject the null hypothesis.

Comparison of department of transportation of California and New Jersey

A t-test is performed and found the result as shown below:

Table 4.12:T-test comparison of department of transportation of California and New Jersey

	California	New Jersey
Mean	527.912	566.748
Variance	7809.15	776.368
Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	-2.4078	
P(T<=t) one-tail	0.00947	
t Critical one-tail	1.66901	
P(T<=t) two-tail	0.01894	
t Critical two-tail	1.99773	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we do not reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This is not the case, -1.99773<-2.4078<1.99773. Therefore, we do not reject the null hypothesis. The observed difference between the sample means 566.748-527.912=38.836) is not convincing enough to say that the average bitumen Price Index of between New Jersey and California differ significantly.

Comparison of department of transportation of California and S.T Wooten

A t-test is performed and found the result as shown below:

Table 4.13:T-test comparison of department of transportation of California and S.T Wooten

	California	S.T. Wooten
Mean	527.912	578.706
Variance	7809.15	623.557
Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	-3.1775	
P(T<=t) one-tail	0.00114	
t Critical one-tail	1.66901	
P(T<=t) two-tail	0.00229	
t Critical two-tail	1.99773	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail (-3.1775< -1.99773). Therefore, we reject the null hypothesis.

Comparison of department of transportation of California and Georgia

A t-test is performed and found the result as shown below:

Table 4.14:T-test comparison of department of transportation of California and Georgia

	California	Georgia
Mean	527.912	632.455
Variance	7809.15	462.256
Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	-6.6033	
P(T<=t) one-tail	4.6E-09	
t Critical one-tail	1.66901	
P(T<=t) two-tail	9.2E-09	
t Critical two-tail	1.99773	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -6.6033< -1.99773). Therefore, we reject the null hypothesis.

Hence:

- Virginia, NOC, S.T. Wooten and Georgia index withCalifornia - We do a two-tail test (inequality). If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis; which means that the observeddifference between the sample means is convincing enough to say that theaverage data differ significantly.
- Kentucky and New Jersey index with California - we do not reject the null hypothesis; whichmeans that the observed difference between the sample means Kentucky and New Jersey index (558.79-527.912=30.878) and (566.748-527.912=38.836) are notconvincing enough to say that the data differs significantly.

Therefore, T–test to compare index of bitumen price indicesfrom Kentucky and New Jersey, comparing the Mean difference, Kentucky is the more similar trend than New Jersey, and statistically Kentucky is chosen as the best similar trend with the original supplier.

4.4.2.2.1 T–test to compare index of bitumen (setting June 2012 as base index)

The comparison table of the indexes with the results of the t-test for using theprice indexes are stated below:

Comparison of department of transportation California and Virginia

A t-test is performed and found the result as shown below:

Table 4.15:T-test comparison of department of transportation California and Virginia as base index

T-test: Two-sample assuming equal variances

	California	**Virginia**
Mean	1.019135	0.89732
Variance	0.029103	0.00159
Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	3.994144	
P(T<=t) one-tail	8.51E-05	
t Critical one-tail	1.669013	
P(T<=t) two-tail	0.00017	
t Critical two-tail	1.99773	

The result is interpreted as:

t Stat > t Critical two-tail	TRUE	we reject the null

t Stat < - t Critical two-tail	FALSE	hypothesis

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat >t Critical two-tail (3.994144> 1.99773). Therefore, we reject the null hypothesis.

Comparison of department of transportation California and Kentucky

A t-test is performed and found the result as shown below:

Table 4.16:T-test comparison of department of transportation California and Kentucky as base index

T-test: Two-sample assuming equal variances

	California	Kentucky
Mean	1.019135	0.92266
Variance	0.029103	0.0012
Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	3.183653	
P(T<=t) one-tail	0.001123	
t Critical one-tail	1.669013	
P(T<=t) two-tail	0.002246	
t Critical two-tail	1.99773	

The result is interpreted as:

t Stat > t Critical two-tail	TRUE	we reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat >t Critical two-tail (3.183653> 1.99773). Therefore, we reject the null hypothesis.

Comparison of department of transportation California and NOC

A t-test is performed and found the result as shown below:

Table 4.17:T-test comparison of department of transportation California and NOC as base index

T-test: Two-sample assuming equal variances

	California	NOC
Mean	1.01914	1.03178
Variance	0.0291	0.0037
Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	-0.4011	
P(T<=t) one-tail	0.34485	
t Critical one-tail	1.66901	

P(T<=t) two-tail	0.68971
t Critical two-tail	1.99773

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we do not reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This is not the case, -1.99773<-0.4011< 1.99773. Therefore, we do not reject the null hypothesis. The observed difference between the sample Variance(0.0291-0.0037=0.0254) is not convincing enough to say that the average bitumen price index of between California and NOC differ significantly.

Comparison of department of transportation California and New Jersey

A t-test is performed and found the result as shown below:

Table 4.18:T-test comparison of department of transportation California and New Jersey as base index

T-test: Two-sample assuming equal variances

	California	New Jersey
Mean	1.01914	0.89605
Variance	0.0291	0.00194
Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	4.01321	
P(T<=t) one-tail	8E-05	
t Critical one-tail	1.66901	
P(T<=t) two-tail	0.00016	
t Critical two-tail	1.99773	

The result is interpreted as:

t Stat > t Critical two-tail	TRUE	we reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat >t Critical two-tail (4.01321> 1.99773). Therefore, we reject the null hypothesis.

Comparison of department of transportation California and S.T Wooten

A t-test is performed and found the result as shown below:

Table 4.19:T-test comparison of department of transportation California and S.T Wooten index

T-test: Two-sample assuming equal variances

	California	S.T. Wooten
Mean	1.01914	0.90564
Variance	0.0291	0.00153
Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	3.72516	
P(T<=t) one-tail	0.00021	
t Critical one-tail	1.66901	
P(T<=t) two-tail	0.00041	
t Critical two-tail	1.99773	

The result is interpreted as:

t Stat > t Critical two-tail	TRUE	we reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat >t Critical two-tail (3.72516 > 1.99773). Therefore, we reject the null hypothesis.

Comparison of department of transportation California and Georgia

A t-test is performed and found the result as shown below:

Table 4.20:T-test comparison of department of transportation California and Georgia as base index

T-test: Two-sample assuming equal variances

	California	Georgia
Mean	1.01914	1.05762
Variance	0.0291	0.00129
Observations	33	33
Hypothesized Mean Difference	0	
Df	64	
t Stat	-1.2679	
P(T<=t) one-tail	0.10471	
t Critical one-tail	1.66901	
P(T<=t) two-tail	0.20942	
t Critical two-tail	1.99773	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we do not reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This is not the case, -1.99773< -1.2679 < 1.99773. Therefore, we do not reject the null hypothesis. The observed

difference between the sample Variance (0.0291-0.00129=0.02781) is not convincing enough to say that the average bitumen price index of between California and Georgia differ significantly.

Hence:

- Virginia, Kentucky, New Jersey and S.T Wooten index with California - We do a two-tail test (inequality). If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis; which means that the observed difference between the sample means is convincing enough to say that the average data differ significantly.
- NOC and Georgia index with California - we do not reject the null hypothesis; which means that the observed difference between the sample variance NOC and Georgia index with California (0.0291-0.0037=0.0254) and (0.0291-0.00129=0.02781) are not convincing enough to say that the data differs significantly.

Therefore, T–test to compare index of bitumen price indices from NOC and Georgia, comparing the Variance difference, NOC is the more similar trend than Georgia, and statistically NOC is chosen as the best similar trend with the original supplier.

Data analysis using; The number of occasions where the difference between the two indices in a month was less than 5%.When comparing the indices, it is found out that the NOC indices scored best in each of the criteria requested to be applied. On better occasions that index and CPAPI both showed either increases or decreases. Further, there were nineteen occasions where the difference between the NOC indices and CPAPI was less than 5%.

Table 4.21:Chole-Magna DB project number of occasions where the difference between the two indices in a month was less than 5%.

No.	Source of Index	Difference with California indices in a month was less than 5%
2	Virginia	15
3	Kentucky	17
4	NOC	**19**
5	New Jersey	14
6	S.T. Wooten	17
7	Georgia	17

Hence;

Under this methodology, the closest to the CPAPI indices is that of the NOC Ethiopia. Therefore, in consideration of the above three comparison t-test methods, the index from NOC Ethiopia satisfies the

statistical analysis on two of the methods, and proposes the use of the index from NOC Ethiopia as a new source of index, ofbitumen.

4.4.2.3 Chole-Magna DBproject Regression analysis

When there are continuous dependent and independent variable. It is called a simple linear regression analysis. This analysis assumes that a linear association between two variables. Table 4.22 periodic evaluation of correlation of the price indices between the original and the proposed 6 new sources (value of the coefficient of determination R^2, standard error and P-value).

Table 4.22:Chole-Magna DB project coefficient of R square, standard error and P-value

No.	Name of State	R Square	Standard Error	P-value
1	Virginia	0.03972	87.98243	0.01292
2	Kentucky	0.00312	89.64329	0.12855
3	NOC	**0.57630**	**58.44198**	**0.00154**
4	New Jersey	0.06384	86.87038	0.00369
5	S.T. Wooten	0.06349	86.88656	0.00631
6	Georgia	0.01210	89.23848	0.60601

As it can be seen from the above table the value of the coefficient of determination between California and NOC is the largest R square, low standard error and lass P-value ($P<0.05$), showing that the relation of the index data of California with NOC is the strongest of all the other sources.

In consideration of the observed relatively strong correlation between the index data of California and NOC, we have selected the data NOC to be used for producing a Linear Regression Model.

Table 4.23:Chole-Magna DB project regression result summary output

Regression Statistics	
Multiple R	0.7591448
R Square	0.57630
Adjusted R Square	0.5626331
Standard Error	58.44198
Observations	33

Table 4.24:Chole-Magna DB project ANOVA output

	df	SS	MS	F	Significance F
Regression	1	144013.508	144013.51	42.1651	3.038E-07
Residual	31	105879.427	3415.4654		
Total	32	249892.935			

Table 4.25:Chole-Magna DB project model summary

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-609.4303	175.447	-3.4736	0.00154	-967.26	-251.604	-967.26	-251.604
NOC	0.9115846	0.14038	6.49347	3E-07	0.62527	1.197901	0.62527	1.1979

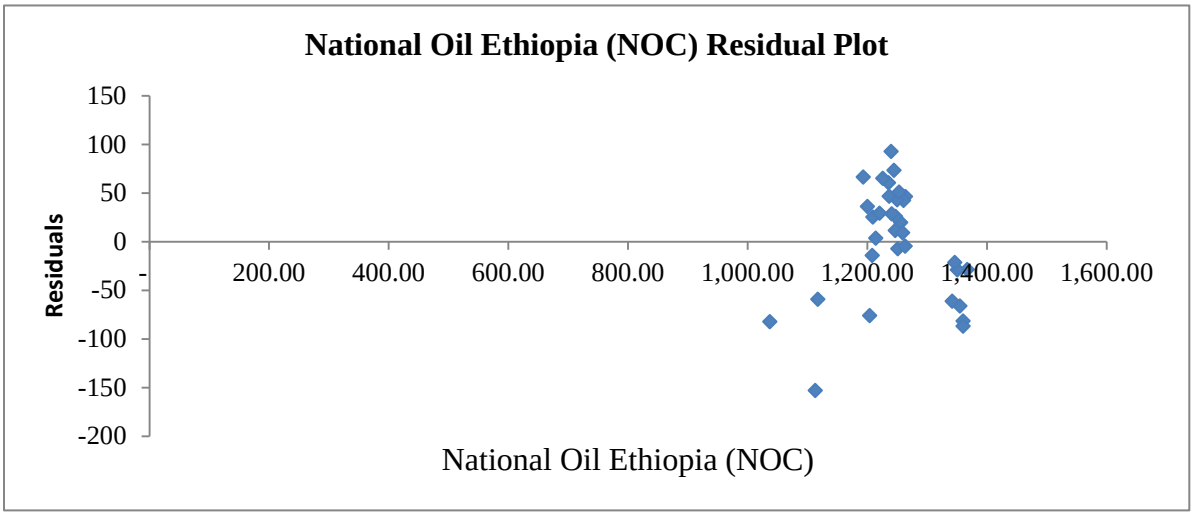


Figure 4.2:National Oil Ethiopia (NOC) residual plot

The model for forecasting the Californian paving assault price index using input or explanatory variable National Oil Ethiopia (NOC) is shown in table and figure

Table 4.26:Chole-Magna DB Project residual output

Observation/ months	Predicted California Paving Asphalt Price Index	Residuals	Standard Residuals
1	492.8795311	25.12046891	0.436713824
2	484.8783989	35.92160109	0.62448913
3	478.1983791	66.10162086	1.149162133
4	542.8247221	46.27527792	0.804485524
5	539.648716	42.15128403	0.732790797
6	535.2316083	19.4683917	0.338453706
7	530.2248859	42.97511408	0.747112901
8	525.2617714	73.13822864	1.27149201
9	520.954372	92.54562802	1.608885378
10	516.6795515	60.42044848	1.050396201
11	636.6623856	-28.7623856	-0.500027745
12	630.6843291	-81.8843291	-1.423541042
13	630.6843291	-86.8843291	-1.510464942
14	625.4184496	-66.2184496	-1.151193174
15	621.4982948	-29.1982948	-0.50760593
16	617.6029512	-21.6029512	-0.375562553
17	613.7321839	-61.3321839	-1.06624652

18	531.2436174	-7.34361737	-0.127667172
19	527.0784022	11.22159775	0.195085008
20	542.3563625	-4.75636249	-0.082688315
21	538.1853813	9.114618679	0.15845564
22	532.8668741	50.83312593	0.883722708
23	527.5974356	25.70256443	0.446833427
24	521.7992319	28.30076805	0.492002625
25	517.7755497	46.62445031	0.810555809
26	507.9514234	64.94857656	1.129116711
27	503.4549175	29.04508247	0.504942367
28	497.3309869	3.469013101	0.060308029
29	491.8219711	-14.3219711	-0.248984315
30	487.9981785	-76.2981785	-1.326427043
31	409.219298	-59.319298	-1.031252942
32	405.2068919	-153.006892	-2.659991146
33	336.1486185	-82.4486185	-1.433351089

Table 4.27:Chole-Magna DB project probability output

Observation/ months	Percentile	California Paving Asphalt Price Index
1	1.51515	252.200
2	4.54545	253.700
3	7.57576	349.900
4	10.60606	411.700
5	13.63636	477.500
6	16.66667	500.800
7	19.69697	518.000
8	22.72727	520.800
9	25.75758	523.900
10	28.78788	532.500
11	31.81818	537.600
12	34.84848	538.300
13	37.87879	543.800
14	40.90909	544.300
15	43.93939	547.300
16	46.96970	548.800
17	50.00000	550.100
18	53.03030	552.400
19	56.06061	553.300
20	59.09091	554.700
21	62.12121	559.200
22	65.15152	564.400
23	68.18182	572.900
24	71.21212	573.200

25	74.24242	577.100
26	77.27273	581.800
27	80.30303	583.700
28	83.33333	589.100
29	86.36364	592.300
30	89.39394	596.000
31	92.42424	598.400
32	95.45455	607.900
33	98.48485	613.500

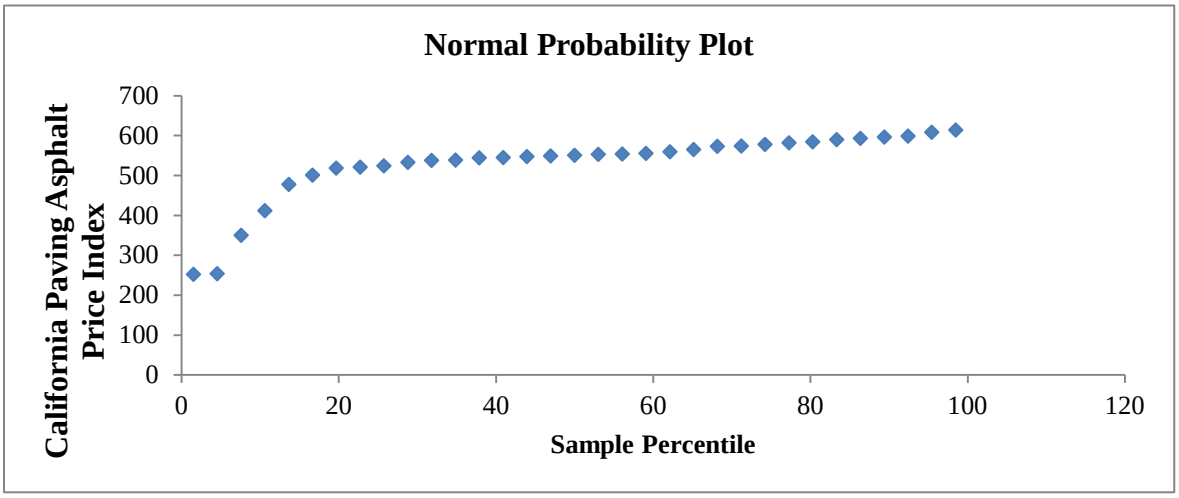


Figure 4.3:Chole-Magna DB project normal probability plot

Therefore, the predicating model is:

$$\mathbf{Y} = 0.9115846\mathbf{X} - 609.4303$$

Where:

Y = California paving asphalt price index

X = National Oil Ethiopia (NOC)

As it can be seen, the result reveals strong/perfect positive correlation between California paving asphalt price index and NOC Ethiopia (Multiple R=0.7591448, ρ<0.00154). Based on the regression model summary (see table 4.25) the predictor NOC Ethiopia is significant (ρ=0.00154). The model predictor discovered adjusted R Square= 0.5626331, F (1,31) = 42.1651, ρ<0.00154 that illustrates sound model for forecasting or predicating relationship between California paving asphalt price index and NOC Ethiopia based on the dataset as from the base period June 2012 until February 2015. Furthermore, the model predicator NOCEthiopia is available in detailed manner and can be applied until completion date of the contract.

New source selection:

- **Trend analysis:** the result from descriptive and correlation analysis for appropriate replacement price index indicated that, NOC Ethiopia is the new source. It has similar trend with the original source of index (CPAPI).
- **T-test analysis:** Comparing the mean difference, Kentucky has more similar trend than other sources, and statistically Kentucky is chosen as the best similar trend with the original supplier.
  Comparing the variance difference, NOC has more similar trend than other sources, and statistically NOC is selected as the best similar trend with the original supplier.
  The number of occasions where the difference between two indices in a month was less than 5%. When comparing the indices, it is found out that NOC indices scored best in each of the criteria requested to be applied.
  Therefore, based on the analysis result of the above three T-test comparison methods, the index from NOC Ethiopia satisfies the statistical analysis from the two methods. This research proposes the use of index from NOC Ethiopia as a new source of index.
- **Regression analysis:** As can be seen from the analysis, the value of the Coefficient of determination between California and NOC, NOC has the largest R square, low standard error and less P-value ($P<0.05$), showing that the relation of the Index Data of California with NOC is the strongest of all the other sources. Therefore, statistically NOC is picked as the best similar with the original source.

Based on the above three (trend, T-test and regression) analytical methods, in consideration of the observed relatively strong relationship between the index data of the original source, NOC Ethiopia is selected a new source of index.

4.4.2 Statistical data analysis of the new bitumen price index in Dire Dawa-Dewelle DB project

- Trend analysis of the new sources
- T – test to compare index of bitumen (the price) and
- Regression analysis

4.5.2.1 Dire Dawa-Dewelle DB project trend analysis of the new sources

New sources were identified, which are provided by the state's department of transports, as discussed in the above table 4.4. The temporal analysis requires an appropriate representative price series for bitumen, i.e., a price that accurately captures general price trends in global bitumen market.

The international trend of bitumen indexes compared with the original supplier, selecting from US states and other international indexes; which are: California (original source), Georgia, North Carolina, Canada,West Virginia, New Jersey, Oklahoma and NOC. Through statistical analysis techniques, the trend (time series) of bitumen pricing index is examined for the period between September 2012 and February 2015. Furthermore, the analysis attempted to examine the month-to month change among these new suppliers. Table 4.28 and 4.29 provide the trend of bitumen price index as from the contract base year (i.e., September 2012) and the statistics shown that there was a significant decline in bitumen price index.The descriptive statistics shown in table4.28 illustrates the range in price change is among these suppliers.

Table 4.28:Descriptive statistics for different sources for bitumen price index in Dire Dawa- Dewelle DB project

Descriptive statistics								
	California	Georgia	North Carolina	Canada	West Virginia	New Jersey	Oklahoma	NOC
Mean	89.62	99.37	101.13	102.51	99.01	98.73	99.08	98.94
Standard Error	2.87	0.53	0.72	1.44	0.59	0.81	0.67	1.15
Median	93.85	98.61	100.06	99.74	99.03	98.03	98.86	98.79
Standard Deviation	15.74	2.93	3.94	7.86	3.22	4.42	3.69	6.29
Sample Variance	247.89	8.56	15.49	61.83	10.36	19.56	13.61	39.57
Range	61.33	14.06	14.67	24.26	11.80	15.79	15.00	26.08
Minimum	42.81	92.71	96.11	92.68	94.89	92.98	93.18	82.06
Maximum	104.14	106.77	110.78	116.94	106.69	108.77	108.18	108.14
Sum	2688.51	2981.08	3034.03	3075.29	2970.25	2961.89	2972.27	2968.09
Count (months)	30	30	30	30	30	30	30	30

Correlation analysis was carried out to find or observe any kind of association or correlation between these new suppliers with the original supplier as to bitumen pricing index.

Table 4.29:Correlation analysis for different sources for bitumen price index in Dire Dawa-Dewelle DB project

Correlations								
	California	Georgia	North Carolina	Canada	West Virginia	New Jersey	Oklahoma	NOC
California	1							
Georgia	0.138	1						
North Carolina	-0.285	0.815	1					
Canada	-0.619	0.531	0.654	1				

West Virginia	-0.146	0.876	0.922	0.583	1			
New Jersey	-0.285	0.739	0.915	0.615	0.938	1		
Oklahoma	-0.1	0.855	0.753	0.574	0.852	0.759	1	
NOC	**0.808**	0.061	-0.136	-0.656	-0.071	-0.145	-0.124	1

The calculation shows in table 4.29strong positive correlation (0.808) between CPAPI and NOC Ethiopia bitumen price indices. This means that California bitumen price index increases the index of NOC Ethiopia also increase. The above table clearly describes that except the NOC Ethiopia price index all the other indices do not behave similarly throughout the time period (Sep 2012- Feb 2015) and have a very weak relationship with the CPAPI index.

Comparison of trends considering that both the CPAPIand NOC Ethiopia indices relate to have strong relationship (characterized by high correlation coefficient of 0.808). This research recommends that the appropriate replacement index that should be used is NOC Ethiopiawhich is of similar trend to CPAPI.

The bitumen price data for all sources is listed as from the period September 2012 (base date) to February 2015 (latest date of available information wherein the original source of index ceased to exist) in the trend analysis are summarized in table 4.30 and figure 4.4; which analyses the month-to-month percent changes for the price index of all sources (using September 2012 as the base).

Table 4.30:Dire Dawa-Dewelle DB project month to month percent changes for the price index of all sources (September 2012 as the base)

Month	California Paving Asphalt Price Index			Georgia			North Carolina			Canada - MTO AC Price Index		
	Price (USD)	% Change	Price index Base Sep 2012=100	Price (USD)	% Change	Price index Base Sep 2012 =100	Price (USD)	% Change	Price index Base Sep 2012=100	Price (USD)	% Change	Price index Base Sep 2012 =100
12-Sep	589.1		100.00	576.00		100.00	626.84		100.00	733.2		100.00
12-Oct	581.8	-1.24%	98.76	571.00	-0.87%	99.13	620.95	-0.94%	99.06	723.8	-1.28%	98.72
12-Nov	554.7	-4.66%	94.16	569.00	-0.35%	98.78	616.54	-0.71%	98.36	723.8	0.00%	98.72
12-Dec	573.2	3.34%	97.30	568.00	-0.18%	98.61	614.34	-0.36%	98.01	723.8	0.00%	98.72
13-Jan	598.4	4.40%	101.58	567.00	-0.18%	98.44	607.98	-1.04%	96.99	723.8	0.00%	98.72
13-Feb	613.5	2.52%	104.14	565.00	-0.35%	98.09	602.47	-0.91%	96.11	723.8	0.00%	98.72
13-Mar	577.1	-5.93%	97.96	567.00	0.35%	98.44	610.39	1.31%	97.38	723.8	0.00%	98.72
13-Apr	607.9	5.34%	103.19	565.00	-0.35%	98.09	609.02	-0.22%	97.16	731.6	1.08%	99.78
13-May	548.8	-9.72%	93.16	565.00	0.00%	98.09	616.25	1.19%	98.31	731.3	-0.04%	99.74
13-Jun	543.8	-0.91%	92.31	567.00	0.35%	98.44	650.59	5.57%	103.79	731.3	0.00%	99.74
13-Jul	559.2	2.83%	94.92	572.00	0.88%	99.31	654.15	0.55%	104.36	707.5	-3.25%	96.49
13-Aug	592.3	5.92%	100.54	576.00	0.70%	100.00	648.63	-0.84%	103.48	699.5	-1.13%	95.40
13-Sep	596	0.62%	101.17	571.00	-0.87%	99.13	631.76	-2.60%	100.78	709.6	1.44%	96.78
13-Oct	552.4	-7.32%	93.77	568.00	-0.53%	98.61	631.4	-0.06%	100.73	693.2	-2.31%	94.54
13-Nov	523.9	-5.16%	88.93	565.00	-0.53%	98.09	627.62	-0.60%	100.12	679.5	-1.98%	92.68
13-Dec	538.3	2.75%	91.38	559.00	-1.06%	97.05	619.7	-1.26%	98.86	679.5	0.00%	92.68
14-Jan	537.6	-0.13%	91.26	557.00	-0.36%	96.70	618.46	-0.20%	98.66	679.5	0.00%	92.68
14-Feb	547.3	1.80%	92.90	558.00	0.18%	96.88	616.58	-0.30%	98.36	679.5	0.00%	92.68
14-Mar	583.7	6.65%	99.08	563.00	0.90%	97.74	615.31	-0.21%	98.16	747	9.93%	101.88
14-Apr	553.3	-5.21%	93.92	563.00	0.00%	97.74	613.24	-0.34%	97.83	759.8	1.71%	103.63
14-May	550.1	-0.58%	93.38	572.00	1.60%	99.31	631.25	2.94%	100.70	769.6	1.29%	104.96
14-Jun	564.4	2.60%	95.81	581.00	1.57%	100.87	640.07	1.40%	102.11	788.5	2.46%	107.54
14-Jul	572.9	1.51%	97.25	596.00	2.58%	103.47	654.76	2.30%	104.45	811.8	2.95%	110.72
14-Aug	532.5	-7.05%	90.39	608.00	2.01%	105.56	674.52	3.02%	107.61	834.2	2.76%	113.78
14-Sep	500.8	-5.95%	85.01	601.00	-1.15%	104.34	694.44	2.95%	110.78	850.5	1.95%	116.00
14-Oct	477.5	-4.65%	81.06	615.00	2.33%	106.77	688.08	-0.92%	109.77	857.4	0.81%	116.94
14-Nov	411.7	-13.78%	69.89	600.00	-2.44%	104.17	670.7	-2.53%	107.00	832.8	-2.87%	113.58
14-Dec	349.9	-15.01%	59.40	576.00	-4.00%	100.00	659.68	-1.64%	105.24	832.8	0.00%	113.58

15-Jan	252.2	-27.92%	42.81	556.00	-3.47%	96.53	638.06	-3.28%	101.79	832.8	0.00%	113.58
15-Feb	253.7	0.59%	43.07	534.00	-3.96%	92.71	614.74	-3.65%	98.07	832.8	0.00%	113.58

Month	West Virginia Department of Transportation Asphalt Price Index			New Jersey Department of Transportation Asphalt Price Index			Oklahoma			National Oil Ethiopia (NOC)				
	Price (USD)	% Change	Price index Base Sep 2012 =100	Price (USD)	% Change	Price index Base Sep 2012 =100	Price (USD)	% Change	Price index Base Sep 2012 =100	Price (Birr)	Currency Exchange Rate (USD) to (ETB)	Price (USD)	% Change	Price index Base Sep 2012 =100
12-Sep	568		100.00	570.00		100.00	550.00		100.00	22866	18.09	1,264.01		100.00
12-Oct	567	-0.18%	99.82	567.50	-0.44%	99.56	545.00	-0.91%	99.09	22866	18.14	1,260.53	-0.28%	99.72
12-Nov	567	0.00%	99.82	572.50	0.88%	100.44	545.00	0.00%	99.09	22866	18.21	1,255.68	-0.38%	99.34
12-Dec	564	-0.53%	99.30	560.00	-2.18%	98.25	545.00	0.00%	99.09	22866	18.29	1,250.19	-0.44%	98.91
13-Jan	554	-1.77%	97.54	542.50	-3.13%	95.18	545.00	0.00%	99.09	22866	18.37	1,244.75	-0.44%	98.48
13-Feb	539	-2.71%	94.89	530.00	-2.30%	92.98	545.00	0.00%	99.09	22866	18.44	1,240.02	-0.38%	98.10
13-Mar	541	0.37%	95.25	532.50	0.47%	93.42	545.00	0.00%	99.09	22866	18.51	1,235.33	-0.38%	97.73
13-Apr	545	0.74%	95.95	537.50	0.94%	94.30	545.00	0.00%	99.09	25521	18.67	1,366.95	10.65%	108.14
13-May	550	0.92%	96.83	545.00	1.40%	95.61	540.00	-0.92%	98.18	25521	18.76	1,360.39	-0.48%	107.63
13-Jun	569	3.45%	100.18	595.00	9.17%	104.39	540.00	0.00%	98.18	25521	18.76	1,360.39	0.00%	107.63
13-Jul	568	-0.18%	100.00	590.00	-0.84%	103.51	540.00	0.00%	98.18	25521	18.84	1,354.62	-0.42%	107.17
13-Aug	569	0.18%	100.18	565.00	-4.24%	99.12	542.50	0.46%	98.64	25521	18.90	1,350.32	-0.32%	106.83
13-Sep	564	-0.88%	99.30	550.00	-2.65%	96.49	532.50	-1.84%	96.82	25521	18.96	1,346.04	-0.32%	106.49
13-Oct	563	-0.18%	99.12	557.50	1.36%	97.81	532.50	0.00%	96.82	25521	19.02	1,341.80	-0.32%	106.15
13-Nov	554	-1.60%	97.54	555.00	-0.45%	97.37	532.50	0.00%	96.82	23900	19.10	1,251.31	-6.74%	98.99
13-Dec	549	-0.90%	96.65	542.50	-2.25%	95.18	532.50	0.00%	96.82	23900	19.17	1,246.74	-0.37%	98.63
14-Jan	548	-0.18%	96.48	537.50	-0.92%	94.30	532.50	0.00%	96.82	24335	19.26	1,263.50	1.34%	99.96

14-Feb	546	-0.36%	96.13	540.00	0.47%	94.74	532.50	0.00%	96.82	24335	19.33	1,258.92	-0.36%	99.60
14-Mar	544	-0.37%	95.77	535.00	-0.93%	93.86	527.50	-0.94%	95.91	24335	19.42	1,253.09	-0.46%	99.14
14-Apr	542	-0.37%	95.42	530.00	-0.93%	92.98	517.50	-1.90%	94.09	24335	19.51	1,247.31	-0.46%	98.68
14-May	551	1.66%	97.01	545.00	2.83%	95.61	512.50	-0.97%	93.18	24335	19.61	1,240.95	-0.51%	98.18
14-Jun	562	2.00%	98.94	565.00	3.67%	99.12	542.50	5.85%	98.64	24335	19.68	1,236.53	-0.36%	97.83
14-Jul	578	2.85%	101.76	588.30	4.12%	103.21	567.50	4.61%	103.18	24270	19.80	1,225.76	-0.87%	96.97
14-Aug	593	2.60%	104.40	599.20	1.85%	105.12	567.50	0.00%	103.18	24270	19.88	1,220.82	-0.40%	96.58
14-Sep	606	2.19%	106.69	620.00	3.47%	108.77	590.00	3.96%	107.27	24270	19.99	1,214.11	-0.55%	96.05
14-Oct	603	-0.50%	106.16	612.00	-1.29%	107.37	595.00	0.85%	108.18	24270	20.09	1,208.06	-0.50%	95.57
14-Nov	591	-1.99%	104.05	591.00	-3.43%	103.68	590.00	-0.84%	107.27	24270	20.16	1,203.87	-0.35%	95.24
14-Dec	578	-2.20%	101.76	586.00	-0.85%	102.81	557.50	-5.51%	101.36	22606	20.23	1,117.45	-7.18%	88.40
15-Jan	559	-3.29%	98.42	568.00	-3.07%	99.65	545.00	-2.24%	99.09	21535	20.31	1,060.32	-5.11%	83.88
15-Feb	539	-3.58%	94.89	553.30	-2.59%	97.07	512.50	-5.96%	93.18	21140	20.38	1,037.29	-2.17%	82.06

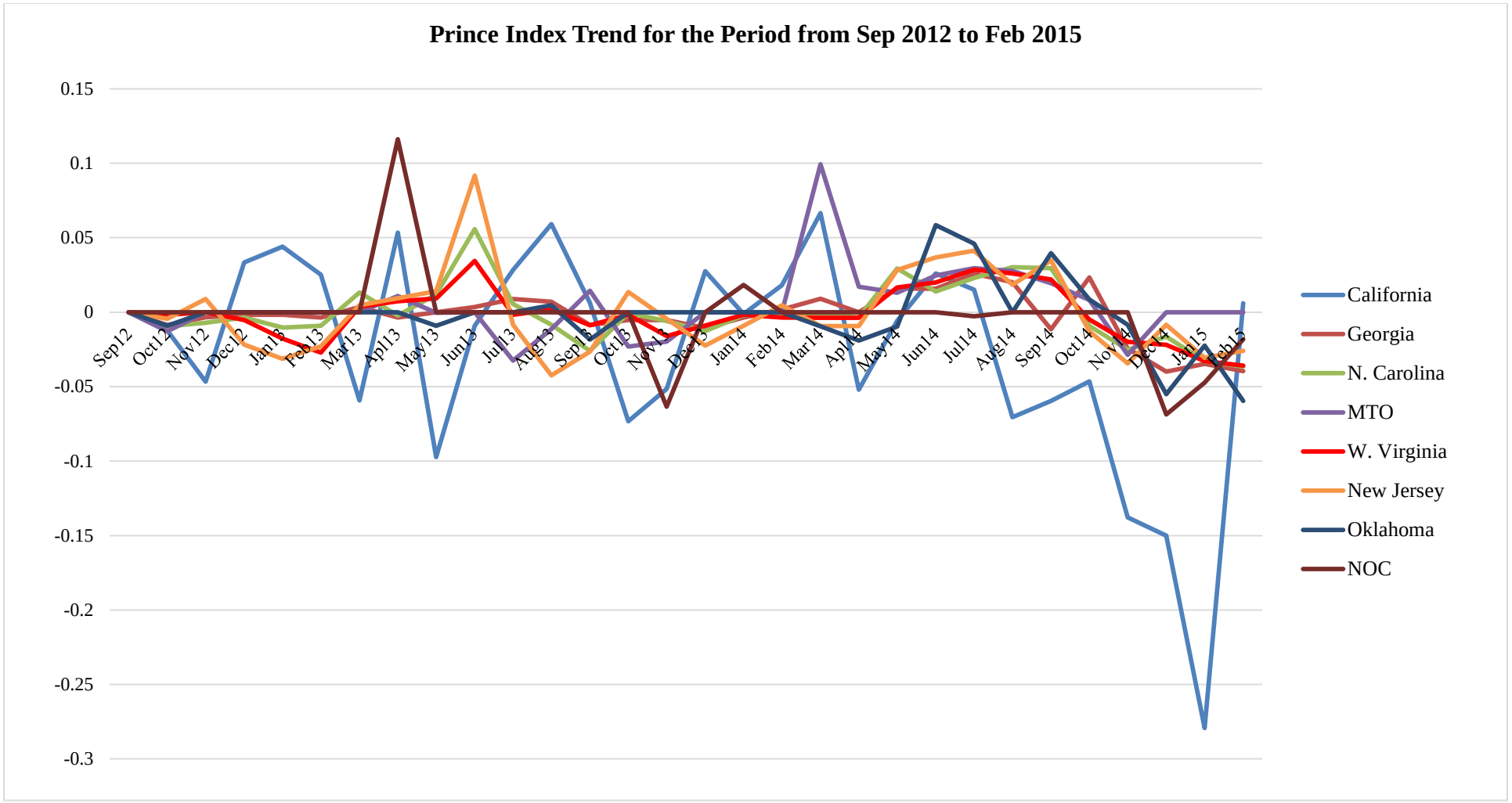


Figure 4.4:Dire Dawa-Dewelle price indexes trend for the period from September 2012 to February 2015

The above figure demonstrates the trend in month-to-month price indices for the different sources. The NOC Ethiopia appears to have significantly increases in the price index as compared to the other sources, especially in the earlier years. The CAPAPI price index trend is observed to also have significantly steeper increases, as well as decreases in the price index. The increment and decrement trend for the CAPAPI index appear to be comparatively erratic considering the similarity in trend for the other sources.

4.5.2.2 Dire Dawa-Dewelle DB project T-test analysis

Commonly, there are two major ways to compare data:

- Compare the means of the two or more data sets.
- Compare the variation of two or more data sets.

In most comparative studies, the mean is most important piece of data. But there are also times when the variation is also studied. This is particularly useful in studying the stability of marketing values. In statistical literature, a t-test is used to compare the mean of two data sets. ANOVA is used to compare the mean of two or more data sets.

4.5.2.2.1 Dire Dawa-Dewelle DB project T–test to compare index of bitumen (setting June 2012 as base the price)

Microsoft excel perform this test easily, and the procedures for t-test on excel sheet is comparing the specific data for select the fair price index of bitumen. The comparison of the indexes with the results of the t-test using the price are stated below

Comparison of department of transportation California and Georgia

A t-test is performed and found the result as shown below:

Table 4.31:T-test comparison of department of transportation California and Georgia

	California	Georgia
Mean	527.933	572.367
Variance	8602.6	284.033
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-2.5817	
P(T<=t) one-tail	0.00619	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.01238	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical	FALSE	we reject the null hypothesis
t Stat < - t Critical	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -2.5817< -2.00172). Therefore, we reject the null hypothesis.

Comparison of department of transportation of California and North Carolina

A t-test is performed and found the result as shown below:

Table 4.32:T-test comparison of department of transportation California and North Carolina

	California	North Carolina
Mean	527.933	633.9506667
Variance	8602.6	608.5075444
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-6.0504	
P(T<=t) one-tail	5.6E-08	
t Critical one-tail	1.67155	
P(T<=t) two-tail	1.1E-07	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical	FALSE	we reject the null hypothesis
t Stat < - t Critical	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -6.0504< -2.00172). Therefore, we reject the null hypothesis.

Comparison of department of transportation of California and Canada - MTO AC

A t-test is performed and found the result as shown below:

Table 4.33:T-test comparison of department of transportation California and Canada-MTO AC

	California	Canada - MTO AC
Mean	527.933	751.6
Variance	8602.6	3324.021379
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-11.218	

P(T<=t) one-tail	1.9E-16
t Critical one-tail	1.67155
P(T<=t) two-tail	3.7E-16
t Critical two-tail	2.00172

The result is interpreted as:

t Stat > t Critical	FALSE	we reject the null hypothesis
t Stat < - t Critical	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -11.218< -2.00172). Therefore, we reject the null hypothesis.

Comparison of department of transportation of California and West Virginia

A t-test is performed and found the result as shown below:

Table 4.34:T-test comparison of department of transportation California and West Virginia

	California	West Virginia
Mean	527.933	562.3666667
Variance	8602.6	334.1712644
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-1.995	
P(T<=t) one-tail	0.02537	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.05075	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical	FALSE	we do not reject the null hypothesis
t Stat < - t Critical	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This is not the case, -2.00172< -1.995<2.00172. Therefore, we do not reject the null hypothesis. The observed difference between the sample means (562.367-527.933=34.434) is not convincing enough to say that the average bitumen price index of between West Virginia and California differ significantly.

Comparison of department of transportation of California and New Jersey

A t-test is performed and found the result as shown below:

Table 4.35:T-test comparison of department of transportation California and New Jersey

	California	New Jersey
Mean	527.933	562.76
Variance	8602.6	635.651448

Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-1.9846	
P(T<=t) one-tail	0.02596	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.05192	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we do not reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This is not the case, -2.00172< -1.9846< 2.00172. Therefore, we do not reject the null hypothesis. The observed difference between the sample means (562.76 - 527.933=34.827) is not convincing enough to say that the average bitumen price index of between New Jersey and California differ significantly.

Comparison of department of transportation of California and Oklahoma

A t-test is performed and found the result as shown below:

Table 4.36:T-test comparison of department of transportation California and Oklahoma

	California	Oklahoma
Mean	527.933	544.917
Variance	8602.6	411.846
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-0.9797	
P(T<=t) one-tail	0.16564	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.33128	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we do not reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This is not the case, -2.00172< -0.9797< 2.00172. Therefore, we do not reject the null hypothesis. The observed difference between the sample means (544.917- 527.933=16.984) is not convincing enough to say that the average bitumen price index of between Oklahoma and California differ significantly.

Comparison of department of transportation of California and NOC

A t-test is performed and found the result as shown below:

Table 4.37:T-test comparison of department of transportation California and NOC

	California	NOC
Mean	527.933	1250.57
Variance	8602.6	6322.31
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-32.398	
P(T<=t) one-tail	3.8E-39	
t Critical one-tail	1.67155	
P(T<=t) two-tail	7.6E-39	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -32.398< -2.00172). Therefore, we reject the null hypothesis.

Hence:

- Georgia, North Carolina and NOC index withCalifornia-we reject the null hypothesis; which means that the observeddifference between the sample means is convincing enough to say that theaverage data differ significantly.

- West Virginia, New Jersey and Oklahoma index with California - we do not reject the null hypothesis; whichmeans that the observed difference between the sample means of West Virginia, New Jersey and Oklahoma index with California (562.367-527.933=34.434), (562.76 - 527.933=34.827) and (544.917- 527.933=16.984) respectively are notconvincing enough to say that the data differs significantly.

Therefore, t–test to compare index of bitumen price indices from West Virginia, New Jersey and Oklahomacomparing the mean difference Oklahoma is the more similar trend than West Virginia and New Jersey, and statistically Oklahoma ischosen as the best similar trend with the original supplier.

4.5.2.2.2 T–test to compare index of bitumen (setting September 2012 as base index)

The comparison table of the indexes with the results of the t-test for using theprice indexes are stated below:

Comparison of department of transportation California and Georgia

A t-test is performed and found the result as shown below:

Table 4.38:T-test comparison of department of transportation California and Georgia as an index

T-test: Two-sample assuming equal variances

	California	Georgia
Mean	0.89617	0.99369
Variance	0.02479	0.00086
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-3.3356	
P(T<=t) one-tail	0.00074	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.00149	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -3.3356< -2.00172). Therefore, we reject the null hypothesis.

Comparison of department of transportation California and North Carolina

A t-test is performed and found the result as shown below:

Table 4.39:T-test Comparison of department of transportation California and North Carolina as an index

T-test: Two-sample assuming equal variances

	California	North Carolina
Mean	0.89617	1.011343671
Variance	0.02479	0.001548647
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-3.8872	
P(T<=t) one-tail	0.00013	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.00026	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -3.8872< -2.00172). Therefore, we reject the null hypothesis

Comparison of department of transportation California and Canada - MTO AC

A t-test is performed and found the result as shown below:

Table 4.40:T-test comparison of department of transportation California and Canada - MTO AC as an index

T-test: Two-sample assuming equal variances

	California	Canada-MTO AC
Mean	0.89617	1.025066667
Variance	0.02479	0.006183168
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-4.0116	
P(T<=t) one-tail	8.7E-05	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.00017	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -4.0116< -2.00172). Therefore, we reject the null hypothesis

Comparison of department of transportation California and West Virginia

A t-test is performed and found the result as shown below

Table 4.41:T-test comparison of department of transportation California and West Virginia as an index

T-test: Two-sample assuming equal variances

	California	West Virginia
Mean	0.89617	0.99008216
Variance	0.02479	0.001035792
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-3.2009	
P(T<=t) one-tail	0.00111	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.00222	

t Critical two-tail	2.00172

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -3.2009< -2.00172). Therefore, we reject the null hypothesis

Comparison of department of transportation California and New Jersey

A t-test is performed and found the result as shown below

Table 4.42:T-test comparison of department of transportation California and New Jersey as an index

T-test: Two-sample assuming equal variances

	California	New Jersey
Mean	0.89617	0.9872982
Variance	0.02479	0.0019565
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-3.0521	
P(T<=t) one-tail	0.00171	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.00343	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -3.0521< -2.00172). Therefore, we reject the null hypothesis

Comparison of department of transportation California and Oklahoma

A t-test is performed and found the result as shown below

Table 4.43:T-test comparison of department of transportation California and Oklahoma as an index

T-test: Two-sample assuming equal variances

	California	Oklahoma
Mean	0.89617	0.99076
Variance	0.02479	0.00136
Observations	30	30
Hypothesized Mean Difference	0	

Df	58
t Stat	-3.2038
P(T<=t) one-tail	0.0011
t Critical one-tail	1.67155
P(T<=t) two-tail	0.0022
t Critical two-tail	2.00172

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -3.2038< -2.00172). Therefore, we reject the null hypothesis

Comparison of department of transportation California and NOC

A t-test is performed and found the result as shown below:

Table 4.44:T-test comparison of department of transportation California and NOC as an index

T-test: Two-sample assuming equal variances

	California	NOC
Mean	0.89617	0.98936
Variance	0.02479	0.00396
Observations	30	30
Hypothesized Mean Difference	0	
Df	58	
t Stat	-3.0107	
P(T<=t) one-tail	0.00193	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.00386	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail -3.0107< -2.00172). Therefore, we reject the null hypothesis

Hence:

- Georgia, North Carolina,Canada - MTO AC, West Virginia, New Jersey, Oklahoma and NOC index with California - t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis; which means that all the results fulfil one of the two.

Data analysis using; The number of occasions where the difference between two indices in a month was less than 5%. When comparing the indices, it is found out that the NOC indices scored best in each of the criteria requested to be applied. On better occasions that index and CPAPI both showed either increases or decreases further, there were eighteen occasions where the difference between the NOC indices and CPAPI was less than 5%.

Table 4.45:Dire Dawa-Dewelle DB project number of occasions where the difference between the two indices in a month was less than 5%.

No.	Source of Index	Difference with California indices in a month was less than 5%
1	Georgia	17
2	North Carolina	16
3	Canada - MTO	17
4	West Virginia	17
5	New Jersey	14
6	Oklahoma	15
7	NOC	**18**

Hence;

Under this methodology, the closest correlation to the CPAPI indices is that of the NOC Ethiopia.

Therefore, in consideration of the above three comparison methods, the index from NOC Ethiopia satisfies the statistical analysis on one of the methods, and proposes the use of the index from NOC Ethiopia as a new source of index of bitumen.

4.5.2.3 Dire Dawa Dewelle DB project regression analysis

A regression model has been produced to estimate the price of the original supplier by using the prices of the input parameters or new suppliers that have strong / perfect correlation with the original supplier. The CPAPI is taken to be dependent variable and the others new sources is taken as independent or explanatory variable. The regression model is used to forecast the indices of CPAPI.Periodic evaluation of correlation of the price indices between the original and the proposed 7 new sources (value ofcoefficient of determination R^2, standard error and P-value).

Table 4.46:Dire Dawa Dewelle DB project coefficient of R square, standard error and P-value

No.	Name of State	R Square	Standard Error	P-value
1	Georgia	0.01912	93.48525	0.87666
2	North Carolina	0.08099	90.48893	0.00935
3	Canada - MTO	0.38351	74.11362	0.00000
4	West Virginia	0.02139	93.37687	0.08742
5	New Jersey	0.08110	90.48358	0.00595
6	Oklahoma	0.00997	93.92022	0.10863
7	NOC	**0.65202**	**55.68155**	**0.00043**

As can be seen from table above the value of the coefficient of determination between California and NOC is the largest R square, low standard error and lass P-value (P<0.05), showing that the relation of the index data of California with NOC is the strongest of all the other sources.

As such, in consideration of the observed relatively strong correlation between the index data of California and NOC, we have selected the data NOC to be used for producing a linear regression model.

Table 4.47:Dire Dawa-Dewelle DB project regression result summary output

Regression Statistics	
Multiple R	0.80748
R Square	0.65202
Adjusted R Square	0.63959
Standard Error	55.68155
Observations	30

Table 4.48:Dire Dawa-Dewelle DB project ANOVA

	df	SS	MS	F	Significance F
Regression	1	162,663.34	162,663.34	52.46	6.94484E-08
Residual	28	86,812.19	3,100.44		
Total	29	249,475.53			

Table 4.49:Dire Dawa-Dewelle DB project model summary

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-649.9865	162.941	-3.989	0.00043	-983.76	-316.22	-983.76	-316.22
NOC Ethiopia	0.9419071	0.13004	7.243	6.9E-08	0.6755	1.20828	0.67553	1.20828

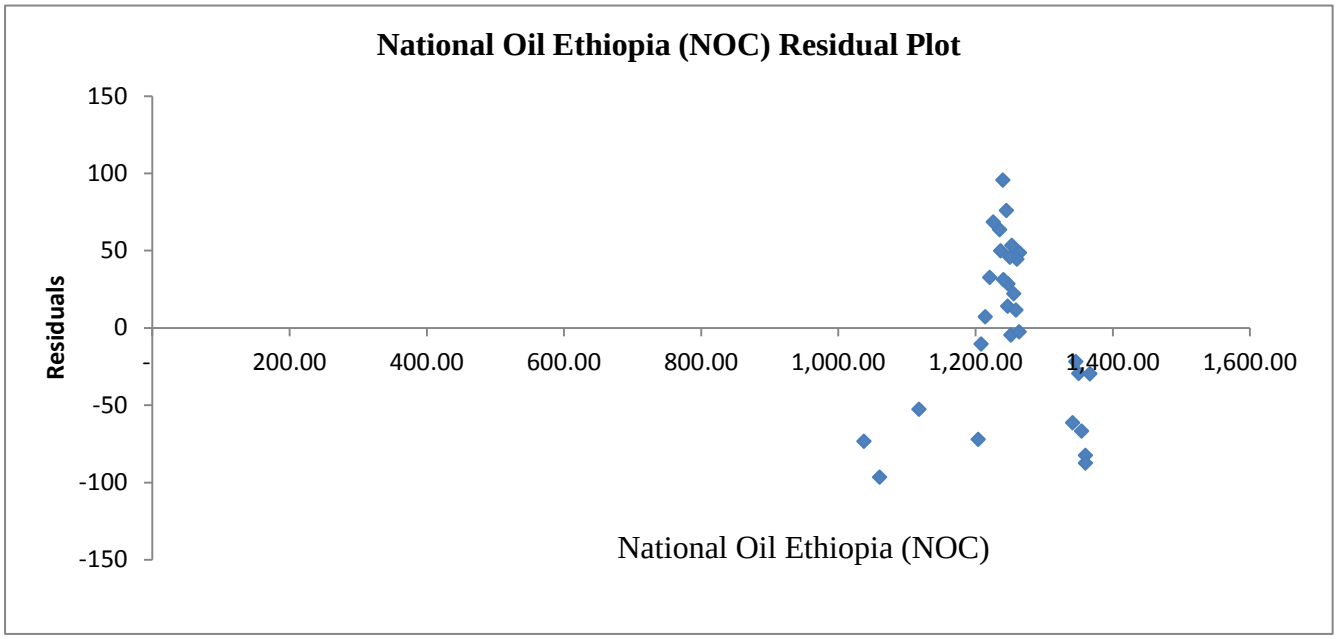


Figure 4.5:National Oil Ethiopia (NOC) residual plot

The model for forecasting the CPAPI using input or explanatory variable NOC Ethiopia is shown in table.

Table 4.50:Dire Dawa-Dewelle DB project residual output

Observation/ months	Predicted California Paving Asphalt Price Index	Residuals	Standard Residuals
1	540.59661	48.50339401	0.886504145
2	537.31495	44.48504529	0.813060155
3	532.75092	21.94908154	0.401166808
4	527.57765	45.62234516	0.833846763
5	522.44945	75.95055041	1.388160131
6	517.99877	95.50122909	1.745490954
7	513.58175	63.51824516	1.160932937
8	637.55564	-29.65564122	-0.542020809
9	631.37873	-82.5787334	-1.509304472
10	631.37873	-87.5787334	-1.600690257
11	625.93769	-66.73769217	-1.219775275
12	621.88714	-29.58713926	-0.540768788
13	617.86222	-21.86222275	-0.399579277
14	613.8627	-61.46270004	-1.123363416
15	528.63027	-4.730272885	-0.08645594
16	524.32651	13.97349198	0.255395706
17	540.11267	-2.512667106	-0.045924411
18	535.80294	11.49705561	0.21013349
19	530.30752	53.39247517	0.975862649
20	524.86281	28.43719378	0.519751054
21	518.87173	31.22826611	0.570763921
22	514.71421	49.68579023	0.908114987
23	504.5633	68.33670157	1.249000621
24	499.91722	32.58277712	0.595520532
25	493.58959	7.210411287	0.131785819
26	487.89732	-10.39732358	-0.190033515
27	483.94634	-72.24633816	-1.320457662
28	402.54699	-52.64699425	-0.962237378
29	348.73187	-96.5318691	-1.764328123
30	327.04573	-73.34572619	-1.34055135

Table 4.51:Dire Dawa-Dewelle DB project probability output

Observation/ months	Percentile	California Paving Asphalt Price Index
1	1.666667	252.20
2	5.000000	253.70
3	8.333333	349.90
4	11.666667	411.70
5	15.000000	477.50
6	18.333333	500.80

7	21.666667	523.90
8	25.000000	532.50
9	28.333333	537.60
10	31.666667	538.30
11	35.000000	543.80
12	38.333333	547.30
13	41.666667	548.80
14	45.000000	550.10
15	48.333333	552.40
16	51.666667	553.30
17	55.000000	554.70
18	58.333333	559.20
19	61.666667	564.40
20	65.000000	572.90
21	68.333333	573.20
22	71.666667	577.10
23	75.000000	581.80
24	78.333333	583.70
25	81.666667	589.10
26	85.000000	592.30
27	88.333333	596.00
28	91.666667	598.40
29	95.000000	607.90
30	98.333333	613.50

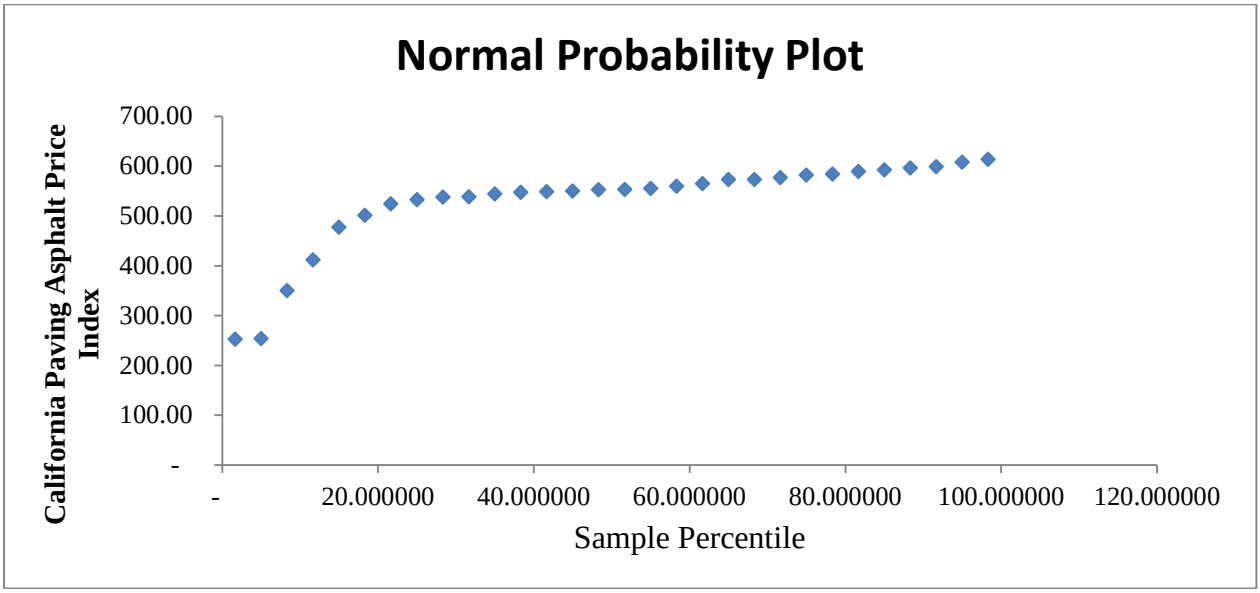


Figure 4.6:Dire Dawa-Dewelle DB project normal probability plot

Therefore, the predicating model is:

$$\mathbf{Y} = 0.9419071\mathbf{X} - 649.9865$$

Where:

Y = California paving asphalt price index

X = National Oil Ethiopia (NOC)

As it can be seen from the result, it reveals strong/perfect positive correlation between CPAPI and NOC Ethiopia (Multiple R=.0.80748, $\rho<0.00043$). Based on the regression model summary (see table 4.50) the predictor NOC Ethiopia) is significant ($\rho=0.00043$). The model predictor discovered adjusted R square=0.63959, F (1,28) =52.46, $\rho<0.00043$ that illustrates sound model for forecasting or predicating relationship between CPAPI and NOC Ethiopiabased on the dataset as from the base period September 2012 until February 2015. Furthermore, the model predicator NOC Ethiopia is available in detailed manner and can be applied until completion date of the contract.

New Source Selection:

- **Trend analysis:** the result from descriptive and correlation analysis for appropriate replacement price index indicated that, NOC Ethiopia is the new source. It has similar trend with the original source of index (CPAPI).
- **T-test analysis:** Comparing the mean difference, Oklahoma has more similar trend than other sources, and statistically Oklahoma is chosen as the best similar trend with the original Supplier.
  Comparing the Variance difference, all the results fulfil one of the two.
  The number of occasions where the difference between two indices in a month was less than 5%. When comparing the indices, it is found out that the NOC indices scored best in each of the criteria requested to be applied.
  Therefore, in consideration of the above three t-test comparison methods, the index from Oklahoma and NOC Ethiopia satisfies the Statistical analysis.
- **Regression analysis:** As can be seen from the analysis, the value of the Coefficient of determination between California and NOC, NOC has the largest R square, low standard error and less P-value ($P<0.05$), showing that the relation of the index data of California with NOC is the strongest of all the other sources. Therefore, statistically NOC Ethiopia is picked as the best similar with the original source.

Based on the above three (trend, t-test and regression) analytical methods, in consideration of the observed relatively strong relationship between the index data of the original source, NOC Ethiopia is selected a new source of index.

4.4.3 Statistical data analysis of the new bitumen price index in Pawi Junction-Fendkia-Ayma DB project

- Trend analysis of the new sources
- T–test to compare index of bitumen (the price) and
- Regression analysis

4.6.2.1 Pawi-Junction DB project trend analysis of the new sources

New sources were identified, which are provided by the state's department of transports, as discussed in the above table 4.5. The trend analysis requires an appropriate representative price series for bitumen, i.e. a price that accurately captures general price trends in global bitumen market.

The international trend of bitumen indexes compared with the original supplier, selecting from US states and other international indexes; which are: California (original source), Kentucky, Virginia, NOC,Oklahoma and PPI; Petroleum. Through statistical analysis techniques, the trend (time series) of bitumen pricing index is examined for the period between September 2012 and February 2015. Furthermore, the analysis attempted to examine the month-to month change among these new suppliers.

Table 4.52 and 4.53 provide the trend of bitumen price index as from the contract base year (i.e. September 2012) and the statistics shown that there was a significant decline in bitumen price index.

The descriptive statistics shown in table 4.52 illustrates the range in price change is among these suppliers.

Table 4.52:Descriptive statistics for different sources for bitumen price index in Pawi-Junction DB project

Descriptive statistics						
	California	Kentucky	Virginia	NOC	Oklahoma	PPI; Petroleum
Mean	89.62	98.74	100.55	104.84	99.08	88.42
Standard Error	2.87	0.63	0.73	0.96	0.67	2.07
Median	93.85	97.89	99.39	106.14	98.86	91.88
Standard Deviation	15.74	3.44	3.97	5.28	3.69	11.36
Sample Variance	247.89	11.84	15.78	27.88	13.61	128.95
Range	61.33	13.10	14.94	19.16	15.00	46.65
Minimum	42.81	93.01	94.62	92.45	93.18	53.35
Maximum	104.14	106.10	109.57	111.61	108.18	100.00
Sum	2688.51	2962.14	3016.60	3145.20	2972.27	2652.47
Count (months)	30	30	30	30	30	30

Correlation analysis was carried out to find or observe any kind of association or correlation between these new suppliers with the original supplier as to bitumen pricing index.

Table 4.53:Correlation analysis for different sources for bitumen price index in Pawi-Junction DB project

Correlations						
	California	Kentucky	Virginia	NOC	Oklahoma	PPI; Petroleum
California	1					
Kentucky	-0.054	1				
Virginia	-0.225	0.629	1			
NOC	0.536	-0.006	0.323	1		

Oklahoma	-0.100	0.864	0.672	0.032	1	
PPI; Petroleum	**0.971**	0.019	-0.128	0.548	-0.047	1

The calculation shows in table 4.53strong positive correlation (0.971) between California Paving Asphalt Price Index (CPAPI) and Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S bitumen price indices. This means that California bitumen price index increases the index of PPI; Petroleum also increase. The above table clearly describes that except the PPI; petroleum price index all the other indices do not behave similarly throughout the time period (Sep 2012- Feb 2015) and have a very weak relationship with the CPAPI index.

Comparison of trends considering that both the CPAPI and Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S indices relate to have strong relationship (characterized by high correlation coefficient of 0.971). This research recommends that the appropriate replacement index that should be used is Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S which is of similar trend to CPAPI.

The bitumen price data for all sources is listed as from the period September 2012 (base date) to February 2015 (latest date of available information wherein the original Source of index ceased to exist) in the trend analysis are summarized in table 4.54 and figure 4.8; which analyses the month-to-month percent changes for the price index of all sources (using September 2012 as the base).

Table 4.54:Pawi-Junction DB project month to month percent changes for the price index of all sources (using September 2012 as the base)

Month	California Paving Asphalt Price Index			Kentucky Transportation Cabinet			Virginia Asphalt Price Adjustment Indices		
	Price (USD)	% change	Price Index (Sep- 2012 Base)	Price (USD)	% change	Price Index (Sep-2012 Base)	Price (USD)	% change	Price Index (Sep- 2012 Base)
12-Sep	589.1		100.00	563.13		100.00	573.33		`100.00
12-Oct	581.8	-1.24%	98.76	563.13	0.00%	100.00	567.22	-1.07%	98.93
12-Nov	554.7	-4.66%	94.16	563.13	0.00%	100.00	568.33	0.20%	99.13
12-Dec	573.2	3.34%	97.30	563.13	0.00%	100.00	560.56	-1.37%	97.77
13-Jan	598.4	4.40%	101.58	558.13	-0.89%	99.11	550.50	-1.79%	96.02
13-Feb	613.5	2.52%	104.14	546.25	-2.13%	97.00	542.50	-1.45%	94.62
13-Mar	577.1	-5.93%	97.96	546.25	0.00%	97.00	548.50	1.11%	95.67
13-Apr	607.9	5.34%	103.19	546.25	0.00%	97.00	549.50	0.18%	95.84
13-May	548.8	-9.72%	93.16	546.25	0.00%	97.00	562.50	2.37%	98.11
13-Jun	543.8	-0.91%	92.31	546.25	0.00%	97.00	605.50	7.64%	105.61
13-Jul	559.2	2.83%	94.92	542.50	-0.69%	96.34	609.00	0.58%	106.22
13-Aug	592.3	5.92%	100.54	553.75	2.07%	98.33	594.00	-2.46%	103.61
13-Sep	596.0	0.62%	101.17	548.75	-0.90%	97.45	581.50	-2.10%	101.43
13-Oct	552.4	-7.32%	93.77	543.75	-0.91%	96.56	579.50	-0.34%	101.08
13-Nov	523.9	-5.16%	88.93	536.88	-1.26%	95.34	579.00	-0.09%	100.99
13-Dec	538.3	2.75%	91.38	534.38	-0.47%	94.89	568.00	-1.90%	99.07
14-Jan	537.6	-0.13%	91.26	534.38	0.00%	94.89	566.25	-0.31%	98.77
14-Feb	547.3	1.80%	92.90	534.38	0.00%	94.89	567.22	0.17%	98.93
14-Mar	583.7	6.65%	99.08	539.38	0.94%	95.78	560.00	-1.27%	97.67
14-Apr	553.3	-5.21%	93.92	545.63	1.16%	96.89	546.82	-2.35%	95.38
14-May	550.1	-0.58%	93.38	557.50	2.18%	99.00	564.09	3.16%	98.39
14-Jun	564.4	2.60%	95.81	565.00	1.35%	100.33	571.36	1.29%	99.66
14-Jul	572.9	1.51%	97.25	577.50	2.21%	102.55	589.09	3.10%	102.75
14-Aug	532.5	-7.05%	90.39	596.25	3.25%	105.88	608.64	3.32%	106.16
14-Sep	500.8	-5.95%	85.01	597.50	0.21%	106.10	628.18	3.21%	109.57
14-Oct	477.5	-4.65%	81.06	595.00	-0.42%	105.66	622.50	-0.90%	108.58

14-Nov	411.7	-13.78%	69.89	586.88	-1.36%	104.22	603.50	-3.05%	105.26
14-Dec	349.9	-15.01%	59.40	571.88	-2.56%	101.55	593.50	-1.66%	103.52
15-Jan	252.2	-27.92%	42.81	553.75	-3.17%	98.33	573.50	-3.37%	100.03
15-Feb	253.7	0.59%	43.07	523.75	-5.42%	93.01	561.00	-2.18%	97.85

Month	National Oil EthiopiaPlc (NOC)					Oklahoma Department of Transportation			Producer Price Index (PPI); Petroleum		
	Price (USD)	Currency Exchange Rate (USD) to (ETB)	Price (USD)	% change	Price Index (Sep- 2012 Base)	Price (USD)	% change	Price Index (Sep-2012 Base)	Price (USD)	% change	Price Index (Sep- 2012 Base)
12-Sep	22,866.00	18.09	1,264.01		100.00	550.0		100.00	400.2		100.00
12-Oct	22,866.00	18.14	1,260.53	0.00%	100.00	545.0	-0.91%	99.09	400.2	0.00%	100.00
12-Nov	22,866.00	18.21	1,255.68	0.00%	100.00	545.0	0.00%	99.09	366.9	-8.32%	91.68
12-Dec	22,866.00	18.29	1,250.19	0.00%	100.00	545.0	0.00%	99.09	358.1	-2.40%	89.48
13-Jan	22,866.00	18.37	1,244.75	0.00%	100.00	545.0	0.00%	99.09	361.6	0.98%	90.35
13-Feb	22,866.00	18.44	1,240.02	0.00%	100.00	545.0	0.00%	99.09	390.4	7.96%	97.55
13-Mar	22,866.00	18.51	1,235.33	0.00%	100.00	545.0	0.00%	99.09	380.6	-2.51%	95.10
13-Apr	25,521.00	18.67	1,366.95	11.61%	111.61	545.0	0.00%	99.09	373.8	-1.79%	93.40
13-May	25,521.00	18.76	1,360.39	0.00%	111.61	540.0	-0.92%	98.18	372.9	-0.24%	93.18
13-Jun	25,521.00	18.76	1,360.39	0.00%	111.61	540.0	0.00%	98.18	372.7	-0.05%	93.13
13-Jul	25,521.00	18.84	1,354.62	0.00%	111.61	540.0	0.00%	98.18	370.1	-0.70%	92.48
13-Aug	25,521.00	18.90	1,350.32	0.00%	111.61	542.5	0.46%	98.64	380.0	2.67%	94.95
13-Sep	25,521.00	18.96	1,346.04	0.00%	111.61	532.5	-1.84%	96.82	377.7	-0.61%	94.38
13-Oct	25,521.00	19.02	1,341.80	0.00%	111.61	532.5	0.00%	96.82	364.9	-3.39%	91.18
13-Nov	23,900.00	19.10	1,251.31	-6.35%	104.52	532.5	0.00%	96.82	351.5	-3.67%	87.83
13-Dec	23,900.00	19.17	1,246.74	0.00%	104.52	532.5	0.00%	96.82	355.1	1.02%	88.73
14-Jan	24,335.00	19.26	1,263.50	1.82%	106.42	532.5	0.00%	96.82	355.8	0.20%	88.91
14-Feb	24,335.00	19.33	1,258.92	0.00%	106.42	532.5	0.00%	96.82	363.9	2.28%	90.93

14-Mar	24,335.00	19.42	1,253.09	0.00%	106.42	527.5	-0.94%	95.91	370.4	1.79%	92.55
14-Apr	24,335.00	19.51	1,247.31	0.00%	106.42	517.5	-1.90%	94.09	377.4	1.89%	94.30
14-May	24,335.00	19.61	1,240.95	0.00%	106.42	512.5	-0.97%	93.18	371.1	-1.67%	92.73
14-Jun	24,335.00	19.68	1,236.53	0.00%	106.42	542.5	5.85%	98.64	369.9	-0.32%	92.43
14-Jul	24,270.00	19.80	1,225.76	-0.27%	106.14	567.5	4.61%	103.18	368.5	-0.38%	92.08
14-Aug	24,270.00	19.88	1,220.82	0.00%	106.14	567.5	0.00%	103.18	366.0	-0.68%	91.45
14-Sep	24,270.00	19.99	1,214.11	0.00%	106.14	590.0	3.96%	107.27	360.3	-1.56%	90.03
14-Oct	24,270.00	20.09	1,208.06	0.00%	106.14	595.0	0.85%	108.18	330.7	-8.22%	82.63
14-Nov	24,270.00	20.16	1,203.87	0.00%	106.14	590.0	-0.84%	107.27	307.5	-7.02%	76.84
14-Dec	22,606.00	20.23	1,117.45	-6.86%	98.86	557.5	-5.51%	101.36	265.5	-13.66%	66.34
15-Jan	21,565.61	20.31	1,061.82	-4.60%	94.31	545.0	-2.24%	99.09	213.5	-19.59%	53.35
15-Feb	21,140.00	20.38	1,037.29	-1.97%	92.45	512.5	-5.96%	93.18	218.0	2.11%	54.47

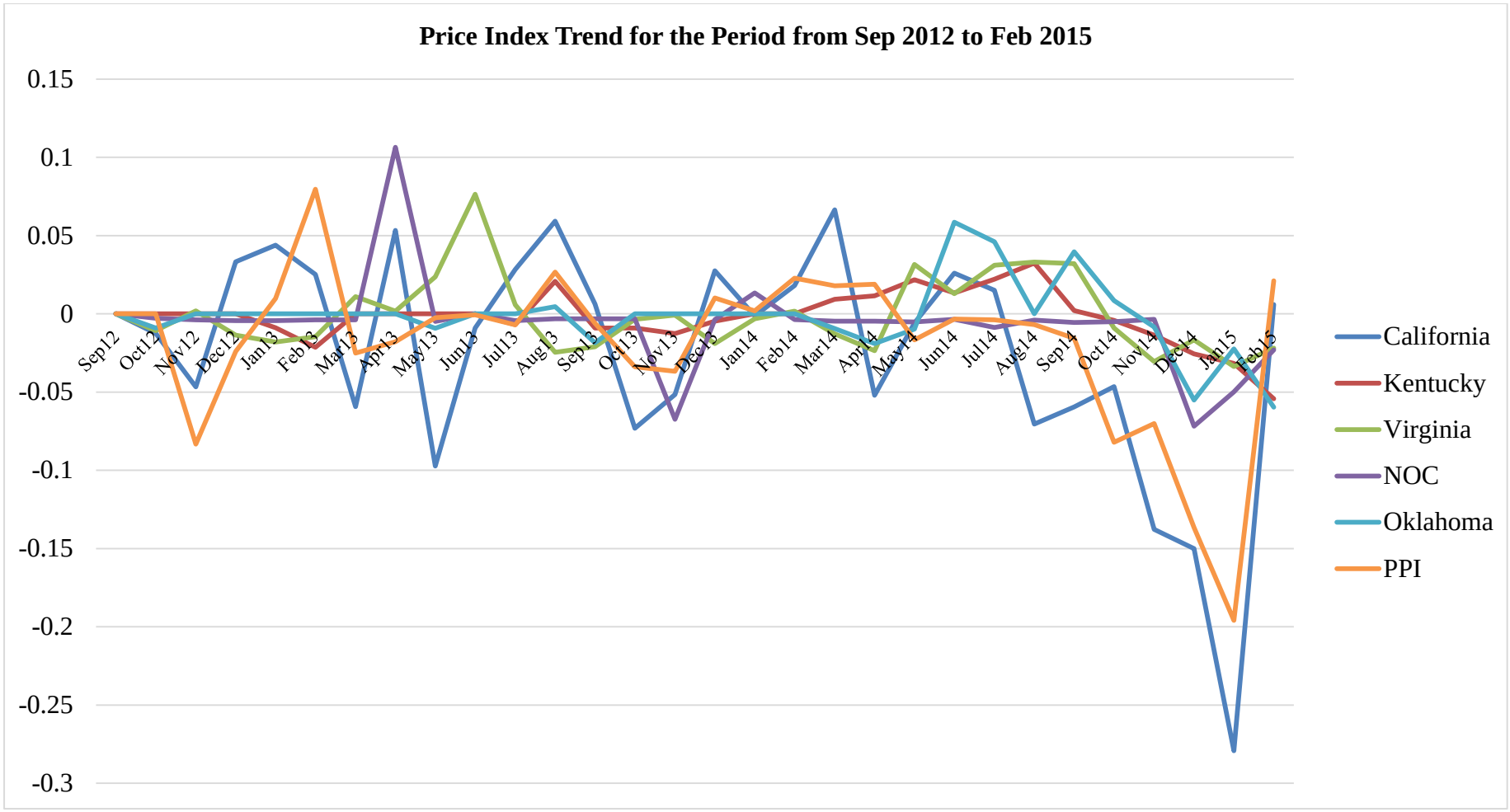


Figure 4.7: Pawi-Junction price indexes trend for the period from September 2012 to February 2015

The above figure demonstrates the trend in month-to-month price indices for the different sources. The NOC Ethiopia appears to have significantly increases in the price index as compared to the other sources, especially in the earlier years. The CAPAPI price index trend is observed to also have significantly increases, as well as decreases in the price index. The increment and decrement trend for the CAPAPI index appear to be comparatively erratic considering the similarity in trend for the other sources.

4.6.2.2 Pawi-Junction DB project T-test analysis

4.6.2.2.1 T–test to compare index of bitumen (setting June 2012 as base the price)

The comparison table of the indexes with the results of the t-test using the price are stated below:

Comparison of department of transportation California and Kentucky

A t-test is performed and found the result as shown below:

Table 4.55:T-test comparison of department of transportation of California and Kentucky

	California	Kentucky
Mean	527.933	556.023
Variance	8602.6	375.325
Observations	30	30
Hypothesized Mean Difference	0	
df	58	
t Stat	-1.6237	
P(T<=t) one-tail	0.05493	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.10985	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we do not reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This is not the case, -2.00172< -1.6237< 2.00172. Therefore, we do not reject the null hypothesis. The observed difference between the sample means (556.023- 527.933=28.09) is not convincing enough to say that the average bitumen Price Index of between Kentucky and California differ significantly.

Comparison of department of transportation California and Virginia

A t-test is performed and found the result as shown below:

Table 4.56:T-test comparison of department of transportation of California and Virginia

	California	Virginia
Mean	527.933	576.503
Variance	8602.6	518.77
Observations	30	30
Hypothesized Mean Difference	0	
df	58	
t Stat	-2.7855	
P(T<=t) one-tail	0.0036	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.00721	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail (-2.7855< -2.00172). Therefore, we reject the null hypothesis.

Comparison of department of transportation California and NOC

A t-test is performed and found the result as shown below:

Table 4.57:T-test comparison of department of transportation of California and NOC

	California	NOC
Mean	527.933	1250.62
Variance	8602.6	6302.61
Observations	30	30
Hypothesized Mean Difference	0	
df	58	
t Stat	-32.422	
P(T<=t) one-tail	3.7E-39	
t Critical one-tail	1.67155	
P(T<=t) two-tail	7.3E-39	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two t Stat < -t Critical two-tail (-32.422< -2.00172). Therefore, we reject the null hypothesis.

Comparison of department of transportation California and Oklahoma

A t-test is performed and found the result as shown below:

Table 4.58:T-test comparison of department of transportation of California and Oklahoma

	California	Oklahoma
Mean	527.933	544.917
Variance	8602.6	411.846
Observations	30	30
Hypothesized Mean Difference	0	
df	58	
t Stat	-0.9797	
P(T<=t) one-tail	0.16564	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.33128	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we do not reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This is not the case, -2.00172< -0.9797< 2.00172. Therefore, we do not reject the null hypothesis. The observed difference between the sample means (544.917-527.933=16.984) is not convincing enough to say that the average bitumen price index of between Kentucky and California differ significantly.

Comparison of department of transportation California and PPI

A t-test is performed and found the result as shown below:

Table 4.59:T-test comparison of department of transportation of California and PPI

	California	PPI
Mean	527.933	353.84
Variance	8602.6	2065.32
Observations	30	30
Hypothesized Mean Difference	0	
df	58	
t Stat	9.23215	
P(T<=t) one-tail	2.8E-13	
t Critical one-tail	1.67155	
P(T<=t) two-tail	5.5E-13	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	TRUE	we reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two or t Stat >t Critical two-tail 9.23215 >2.00172). Therefore, we reject the null hypothesis.

Hence:

- Virginia, NOC and PPI index with California - we reject the null hypothesis; which means the observed difference between the sample means is convincing enough to say that the average data differ significantly.
- Kentucky and Oklahoma index with California - we do not reject the null hypothesis; which means that the observed difference between the sample means Kentucky and Oklahoma index (556.023- 527.933=28.09) and (544.917-527.933=16.984) respectively are not convincing enough to say that the data differs significantly.

Therefore, t–test to compare index of bitumen price indices from Kentucky and Oklahoma, comparing the mean difference, Oklahoma is the more similar trend than Kentucky, and statistically Oklahoma is chosen as the best similar trend with the original Supplier.

4.6.2.2.2 T–test to compare index of bitumen (setting June 2012 as base index)

The comparison table of the indexes with the results of the t-test for using the price indexes are stated below:

Comparison of department of transportation California and Kentucky

A t-test is performed and found the result as shown below:

Table 4.60:T-test comparison of department of transportation of California and Kentucky as an index

T-test: Two-sample assuming equal variances

	California	Kentucky
Mean	0.89617	0.98738
Variance	0.02479	0.00118
Observations	30	30
Hypothesized Mean Difference	0	
df	58	
t Stat	-3.0999	
P(T<=t) one-tail	0.00149	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.00299	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two or t Stat < -t Critical two-tail (-3.0999 < -2.00172). Therefore, we reject the null hypothesis.

Comparison of department of transportation California and Virginia

A t-test is performed and found the result as shown below:

Table 4.61:T-test comparison of department of transportation of California and Virginia as an index

T-test: Two-sample assuming equal variances

	California	Virginia
Mean	0.89617	1.00553
Variance	0.02479	0.00158
Observations	30	30
Hypothesized Mean Difference	0	
df	58	
t Stat	-3.689	
P(T<=t) one-tail	0.00025	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.0005	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two or t Stat < -t Critical two-tail (-3.689< -2.00172). Therefore, we reject the null hypothesis.

Comparison of department of transportation California and NOC

A t-test is performed and found the result as shown below:

Table 4.62:T-test comparison of department of transportation of California and NOC as an index

T-test: Two-sample assuming equal variances

	California	NOC
Mean	0.89617	0.9894
Variance	0.02479	0.00394
Observations	30	30
Hypothesized Mean Difference	0	
df	58	
t Stat	-3.0126	
P(T<=t) one-tail	0.00192	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.00383	

t Critical two-tail	2.00172

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two or t Stat < -t Critical two-tail (-3.0126< -2.00172). Therefore, we reject the null hypothesis.

Comparison of department of transportation California and Oklahoma

A t-test is performed and found the result as shown below:

Table 4.63:T-test comparison of department of transportation of California and Oklahoma index

T-test: Two-sample assuming equal variances

	California	Oklahoma
Mean	0.89617	0.99076
Variance	0.02479	0.00136
Observations	30	30
Hypothesized Mean Difference	0	
df	58	
t Stat	-3.2038	
P(T<=t) one-tail	0.0011	
t Critical one-tail	1.67155	
P(T<=t) two-tail	0.0022	
t Critical two-tail	2.00172	

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we reject the null hypothesis
t Stat < - t Critical two-tail	TRUE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This result fulfils one of the two or t Stat < -t Critical two-tail (-3.2038< -2.00172). Therefore, we reject the null hypothesis.

Comparison of department of transportation California and PPI

A t-test is performed and found the result as shown below:

Table 4.64:T-test comparison of department of transportation of California and PPI index

T-test: Two-sample assuming equal variances

	California	PPI
Mean	0.89617	0.88416
Variance	0.02479	0.0129
Observations	30	30
Hypothesized Mean Difference	0	
df	58	
t Stat	0.3389	

P(T<=t) one-tail	0.36795
t Critical one-tail	1.67155
P(T<=t) two-tail	0.73591
t Critical two-tail	2.00172

The result is interpreted as:

t Stat > t Critical two-tail	FALSE	we do not reject the null hypothesis
t Stat < - t Critical two-tail	FALSE	

If t Stat < -t Critical two-tail or t Stat >t Critical two-tail, we reject the null hypothesis. This is not the case, -2.00172< 0.3389 < 2.00172. Therefore, we do not reject the null hypothesis. The observed difference between the sample variance (0.02479-0.0129=0.01189) is not convincing enough to say that the average bitumen Price Index of between California and PPI differ significantly.

Hence:

- Kentucky, Virginia, NOC and Oklahoma index with California - we reject the null hypothesis; which means the observed difference between the sample variance is convincing enough to say that the average data differ significantly.

- US BLS PPI index with California - we do not reject the null hypothesis; which means that the observed difference between the sample variance US BLS PPI index with California (0.02479-0.0129=0.01189) is not convincing enough to say that the data differs significantly.

Therefore, US BLS PPI is the most comparative than the other indexes, and statistically US BLS PPI is chosen as the best similar trend with the original supplier.

Data analysis using; The number of occasions where the difference between the two indices in a month was less than 5%.

When comparing the indices, it is found out that the US BLS PPI indices scored best in each of the criteria requested to be applied. On better occasions that index and CPAPI both showed either increases or decreases further, there were twenty-one occasions where the difference between the US BLS PPI indices and CPAPI was less than 5%.

Table 4.65:Pawi-Junction DB project number of occasions where the difference between the two indices in a month was less than 5%.

No.	Source of Index	Difference with California indices in a month was less than 5%
1	Kentucky	16
2	Virginia	15
3	NOC	17
4	Oklahoma	15
5	USBLSPPI	**21**

Hence;

Under this methodology, the closest correlation to the CPAPI indices is that of the US BLS PPI.Therefore, in consideration of the above three comparison methods, the index from US BLS PPI satisfies the Statistical analysis on two of the methods, and proposes the use of the index from US BLS PPI as a new source of index, of bitumen.

4.6.2.3 Pawi-Junction DB project regression analysis

A regression model has been produced to estimate the price of the original supplier by using the prices of the input parameters or new suppliers that have strong / perfect correlation with the original supplier. The California paving asphalt is taken to be dependent variable and the others new sources is taken as independent or explanatory variable. Periodic evaluation of correlation of the price indices between the original and the proposed 5 new sources (value of the coefficient of determination R^2,standard error and P-value)

Table 4.66:Pawi-Junction DB project coefficient of R square, standard error and P-value

No.	Name of State	R Square	Standard Error	P-value
1	Kentucky	0.00294	15.99951	0.19182
2	Virginia	0.05071	15.61153	0.02116
3	NOC	0.65092	9.46698	0.00044
4	Oklahoma	0.00997	15.94300	0.10863
5	US BLS PPI	**0.94359**	**3.80562**	**0.00001**

As can be seen from table 4.67 above the value of the coefficient of determination between California and PPI is the largest R^2, low standard error and lass P-value ($P<0.05$), showing that the relation of the index data of California with PPI is the strongest of all the other sources.

As such, in consideration of the observed relatively strong correlation between the index data of California and PPI, we have selected the data PPI to be used for producing a linear regression Model.

Table 4.67:Pawi-Junction DB project regression result summary output

Regression Statistics	
Multiple R	0.97139
R Square	0.94359
Adjusted R Square	0.94157
Standard Error	3.80562
Observations	30

Table 4.68:Pawi-Junction DB project ANOVA

	df	SS	MS	F	Significance F
Regression	1	235402.4983	235402.4983	468.362	5.073E-19
Residual	28	14073.0284	502.6081573		
Total	29	249475.5267			

Table 4.69:Pawi-Junction DB project model summary

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-173.5539	32.67114	-5.312	0.00001	-240.478	-106.63	-240.478	-106.63
Producer Price Index (PPI)	1.9824983	0.091606	21.64	0.00000	1.79485	2.170144	1.794853	2.17014

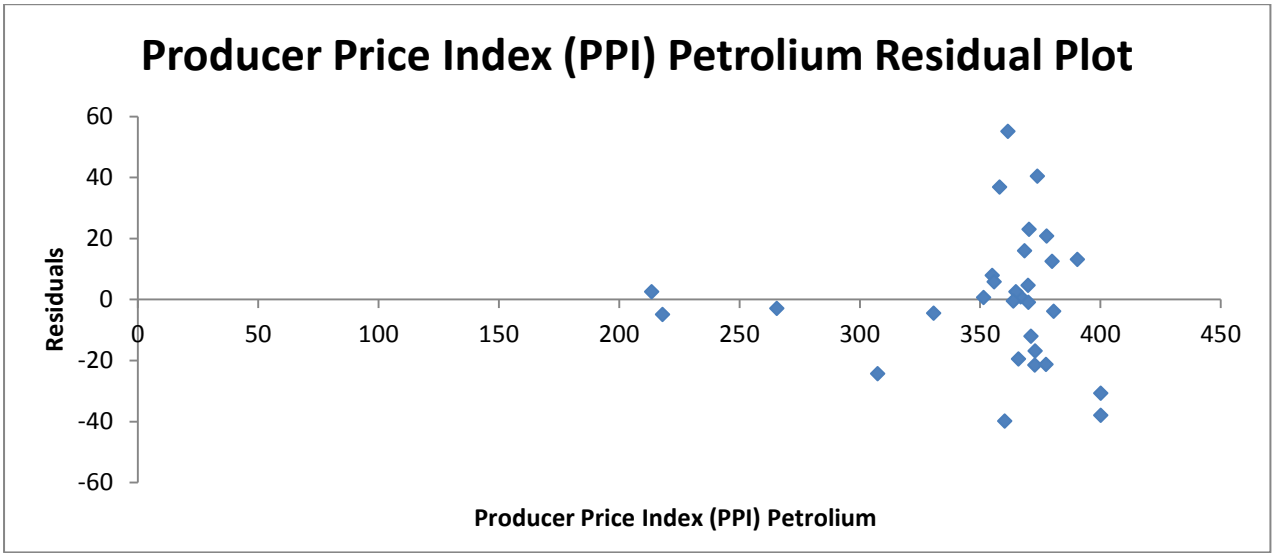


Figure 4.8:Producer Price Index (PPI); Petroleum Residual Plot

The model for forecasting the Californian paving assault price index using input or explanatory variable US BLS PPI is shown in table and figure

Table 4.70:Pawi-Junction DB project residual output

Observation/ months	Predicted California Paving Asphalt Price Index	Residuals	Standard Residuals
1	619.84195	-30.74195	-1.39552
2	619.84195	-38.04195	-1.72690
3	553.82476	0.87524	0.03973
4	536.37878	36.82122	1.67149
5	543.31752	55.08248	2.50045
6	600.41347	13.08653	0.59406
7	580.98499	-3.88499	-0.17636
8	567.50400	40.39600	1.83376
9	565.71975	-16.91975	-0.76807
10	565.32325	-21.52325	-0.97704
11	560.16876	-0.96876	-0.04398
12	579.79549	12.50451	0.56764
13	575.23574	20.76426	0.94259
14	549.85976	2.54024	0.11531
15	523.29429	0.60571	0.02750
16	530.43128	7.86872	0.35720

17	531.81903	5.78097	0.26243
18	547.87727	-0.57727	-0.02620
19	560.76350	22.93650	1.04120
20	574.64099	-21.34099	-0.96877
21	562.15125	-12.05125	-0.54706
22	559.77226	4.62774	0.21008
23	556.99676	15.90324	0.72192
24	552.04051	-19.54051	-0.88704
25	540.74027	-39.94027	-1.81308
26	482.05832	-4.55832	-0.20692
27	436.06436	-24.36436	-1.10601
28	352.79944	-2.89944	-0.13162
29	249.70953	2.49047	0.11305
30	258.63077	-4.93077	-0.22383

Table 4.71:Pawi-Junction DB project probability output

Observation/ months	Percentile	California Paving Asphalt Price Index
1	1.66667	252.20000
2	5.00000	253.70000
3	8.33333	349.90000
4	11.66667	411.70000
5	15.00000	477.50000
6	18.33333	500.80000
7	21.66667	523.90000
8	25.00000	532.50000
9	28.33333	537.60000
10	31.66667	538.30000
11	35.00000	543.80000
12	38.33333	547.30000
13	41.66667	548.80000
14	45.00000	550.10000
15	48.33333	552.40000
16	51.66667	553.30000
17	55.00000	554.70000
18	58.33333	559.20000
19	61.66667	564.40000
20	65.00000	572.90000
21	68.33333	573.20000
22	71.66667	577.10000
23	75.00000	581.80000
24	78.33333	583.70000
25	81.66667	589.10000
26	85.00000	592.30000
27	88.33333	596.00000
28	91.66667	598.40000
29	95.00000	607.90000
30	98.33333	613.50000

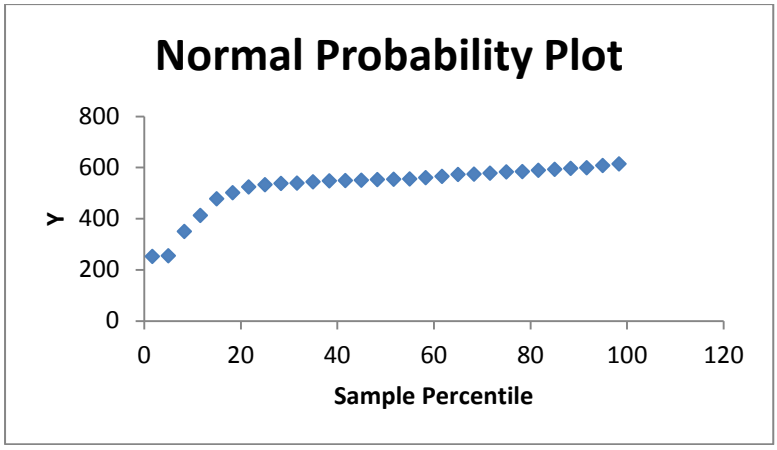


Figure 4.9:Pawi-Junction Design Build Project Normal Probability Plot

Therefore, the predicating model is:

$$\mathbf{Y} = 1.9824983\mathbf{X} - 173.5539$$

Where:Y = California Paving Asphalt Price Index(CPAPI)

X = Producer Price Index (PPI); Petroleum; US BLS

As it can be seenfrom the result,it reveals strong/perfect positive correlation between CPAPI and Producer Price Index (PPI); Petroleum (multiple R = 0.97139, p<.00001). Based on the regression model summary the predictor (Producer Price Index (PPI); Petroleum) is significant (p=.00001). The model predictor discovered adjusted R square = 0.94157, F (1,28) = 468.362, p<.00001 that illustrates sound model for forecasting or predicating relationship between CPAPI and Producer Price Index (PPI); Petroleum based on the dataset as from the base period September 2012 until February 2015.Furthermore, the model predicator Producer Price Index (PPI); Petroleum is available from US BLS in detailed manner and can be applied until completion date of the contract.

New Source Selection:

- **Trend analysis:** the result from descriptive and correlation analysis for appropriate replacement price index indicated that, Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S is the new source. It has similar trend with the original source of index (CPAPI).
- **T-test analysis:**comparing the mean difference, Oklahoma has more similar trend than other sources, and statistically Oklahoma is chosen as the best similar trend with the original supplier.

  Comparing the Variance difference, US BLS PPI is the most comparative than the other indexes, and statistically US BLS PPI is chosen as the best similar trend with the original source.

  The number of occasions where the difference between two indices in a month was less than 5%. When comparing the indices, it is found out that the Producer Price Index (PPI);

Petroleum from Bureau of Labour Statistics (BLS) U.S indices scored best in each of the criteria requested to be applied.

Therefore, in consideration of the above three T-test comparison methods, the index from US BLS PPI satisfies the statistical analysis on two of the methods, and proposes the use of the index from Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S as a new source of index.

- **Regression analysis:** As can be seen from the analysis, the value of the coefficient of determination between California and Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S, Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S has the largest R Square, low standard error and less P-value ($P<0.05$), showing that the relation of the index data of California with Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S is the strongest of all the other sources.

Based on the above three (trend, T-test and regression) analytical methods, in consideration of the observed relatively strong relationship between the Index Data of the original source, Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S is selected a new source of index.

The findings from the above detail analysis process indicates that, there is a difference from the findings of the contractors and consultants. The comparison between findings is presented below for each project respectively.

Chole-Magna:The ER's looked into the trend of change of the index value of the new sources and make comparisons with the original source, it had considered data of the last four years from the month the original source has ceased to publish the information from January 2011 to February 2015. But according to the project contract document the base date is not January 2011 the project base date is June 28/2012 because of base date difference the indices calculation outputs are different so that analysis of trend beyond the original base date would be unnecessary and maybe lead to wrong results.

The ER's specified that only he adopted the coefficient of determination, R^2 parameter in order to evaluate the relationship between the California index and the selected six indices. It hadn't to see others comparison methods like standard errors and P-values in regression analysis and t-test statistical analysis method.

The ER's assessment report shows that, he considered different trend analysis period (last 1 year from Mar 2014 to Feb 2015, last 1.5 years from Sep 2013 to Feb 2015, last 2 year from Mar 2013 to Feb 2015, Last 2.5 years from Sep 2012 to Feb 2015, last 3 years from Mar 2012 to Feb 2015), last 3.5 years from Sep 2011 to Feb 2015 and last 4 years & 2 months from Jan 2011 to Feb 2015) for evaluating the strength of coefficient of determination, R^2. It arrived at an R2 value of 0.89, 0.79,0.68, 0.60, 0.43,0.39 and 0.32 for analysis periods of 1,1.5,2, 2.5, 3,3.5 years and 4 years and 2 months, respectively. The ER finally recommended (last 2.5 years from Sep 2012 to Feb 2015) R^2

value of 0.68 for predicting current index of California from current indices of NOC. It is not clear why the ER has been recommended (last 2.5 years from Sep 2012 to Feb 2015) an R^2 value of 0.68.

Dire Dawa-Dewelle: Both the contractor and ER's analyse the data using only trend analysis and T-test methods. They didn't to see and cross check by others comparison method like regression analysis. The contractor and ER's approval of the new proposed source was Georgia asphalt index. But, based on the analysis result by comparing the number of monthly occasions where the California index and the indices in question both showed either increases and decrease in the analysis period (Sep 2012 to Feb 2015), the difference between the California indices in a month was less than 5% and states that NOC indices scored best by showing 18 out of 30 whereas Georgia indices scored 17 out of 30.

The correlation coefficient between California paving asphalt index and NOC was calculated as 0.808, whereas that between California paving asphalt index and Georgia was 0.138, which indicated a weak relationship. Which means that NOC Ethiopia represents the trend of the original source of index, i.e. California paving asphalt price index and the recommended determination of a cost with a trend from the NOC Ethiopia which fairly represents the original increment trend.Therefore, the Contractor and ER's analysis result was incorrect and doesn't support selection of Georgia Asphalt index as the only representative source satisfying the criteria adopted.

4.5 Developing guideline for price adjustment administration system when supplier cease to exist and replaced by new source.

The third objective of this research is to develop a guideline to help ERA in order to systematically compare and select new source for its projects when the supplier cease to publish and to assist the decision-making process. As it discussed in the literature review there is no standard guideline to administer such phenomenon. Primarily, this framework guides how to select the new source for a particular type of road construction project and guide the decision-making process. It also ensures systematic and consistent approach for price adjustment administration through the application of relevant selection models. The guideline will Provides better understanding on various types of alternative sources in practice. In this way, it will be possible to ensure that the price adjustment administration in an efficient and effective way. The proposed guideline consists of three main stages whichare alternative source suggestion to be used as an input, source index calculation stage and source selection output stage. The following figure 4.10shows the developed guideline for the selection of new source when supplier cease to exist.

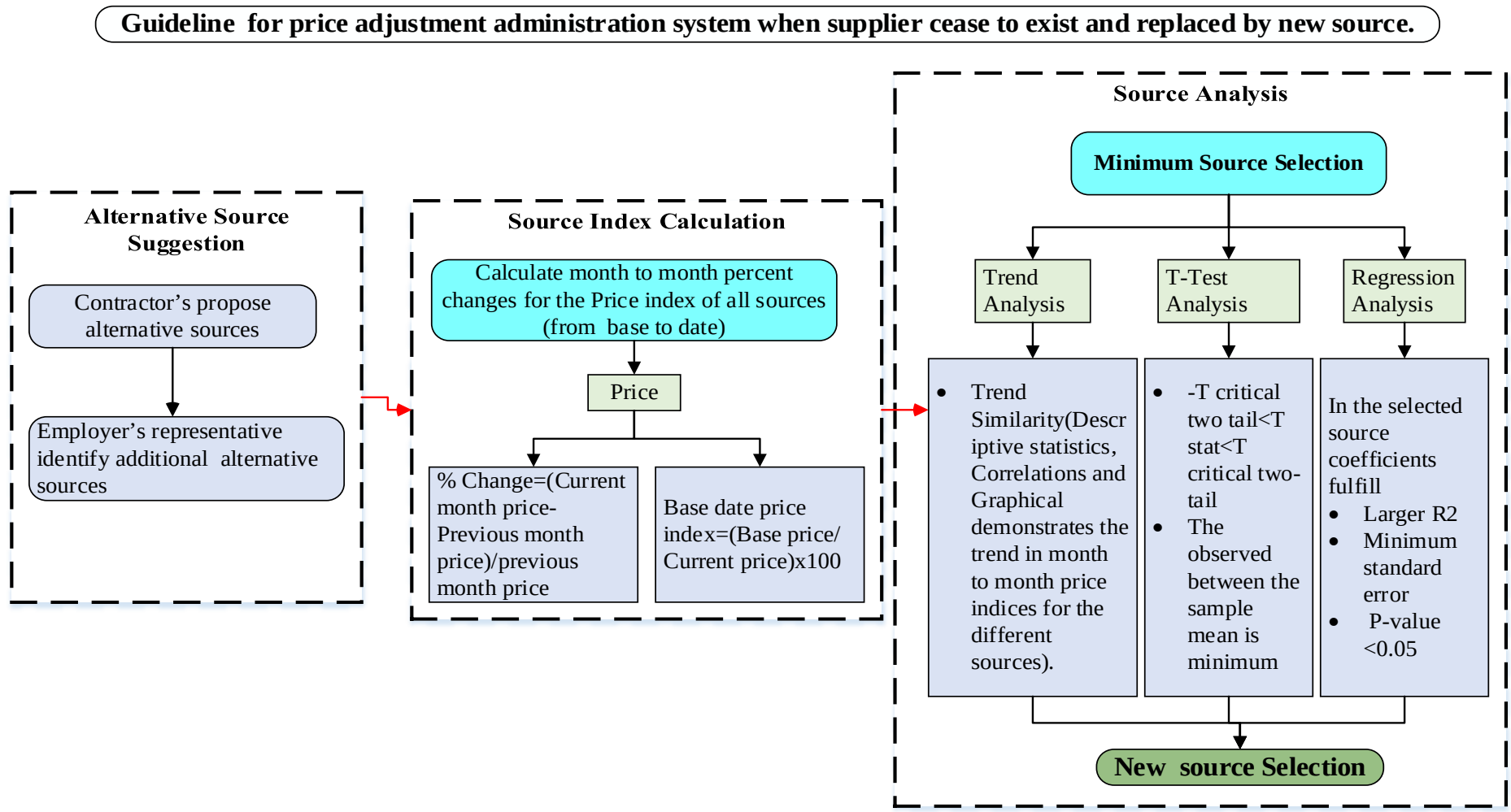


Figure 4.10:Guideline for price adjustment administration system when supplier cease to exist and replaced by new source.

Chapter 5

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Construction price indices are developed to measure the degree of price variations in construction material, equipment and labor costs. The concept of construction industry, cost overrun, price escalation, inflation, price adjustment, price indices, price index forecasting methods and contract clauses regarding price adjustment change of supplier of price index and yielded through many studies but suppliers cease to published price indices particularly for federal road projects is the major area for the research. This research effort provides a comprehensive solution for original supplier cease to publish price index and replaced by new supplier source.

Based on the data obtained from document analysis, the research concluded that: In Chole-Magna project, The ER's specified that only it adopted the coefficient of determination, R^2 parameter in order to evaluate the relationship between the California index and the selected six indices. In Dire Dawa-Dewelle project, both the contractor and ER analyse the data using only trend analysis and T-test methods. In Pawi-Junction project, The ER specified that, adopted trend and regression analysis in order to evaluate the relationship between the California index and the selected five sources.

The data analyzed was introduced and subsequently provides the steps for the calculations achieved to find new supplier source of index. The new supplier source of price index was compared with the original ones, and the indices which provided the best linear relationship. Nevertheless, the selected source of index was analyzed by the trend, T-test and regression analysis techniques and the relationship between the values of each output. The aims of these steps were to prepare a guideline which would make it possible to predict the future values of the selected indices. Such a step in this study was covered to be able to predict the new reliable source of price index when suppliers cease to publish index.

The proposed guideline constitutes all components for price adjustment administration system when supplier cease to exist and replaced by new source. The new supplier source of price index was compared with the original ones, and the indices which provided the best linear relationship. Nevertheless, the selected source of index was analyzed by trend, T-test and regression analysis techniques and the relationship between the values of each output. The proposed guideline would use to make it possible to predict the future values of the selected indices. Such a step in this study was covered to be able to predict the new reliable source of price index when suppliers cease to publish index.

Generally, the result from the three analysis mechanisms for the selected projects shows that, using only one analysis mechanism does not reveal the appropriate source selection. Instead, it is

better to use the three (T-test, Regression analysis and Trend analysis) because the result will vary. This research provide a comprehensive solution for the new source of index selection.

5.2 Recommendation

The main objective of this thesis was to assessing reliable sources selection to minimize ceasing of publishing indices and developing guideline for price adjustment administration system when supplier cease to exist and replaced by new source. Based on the findings of the analysis, recommendations will focus in addressing the major problems identified through the research processes and below listed specific recommendations are forwarded to ERA.

- It is recommended that; ERA should early determine the contract document how to calculate price adjustment when suppliers cease to publish price index problems in the bid stage.
- It is recommended that; ERA should select and recommend their own reliable sources in the biding stage.
- It is recommended to use the proposed framework as a guideline (figure 4.10) which detailed in previous chapter to assist in the selection of an appropriate new source selection in ERA's Road projects. ERA can use this guideline tofairly represent the original trend and reduce claim in the implementation stages.
- Major stakeholders (ERA, consultants and contractors) should work together to improve the price adjustment administration problems when suppliers cease to publish price index and replaced by new sources calculation should be clear and consistent.

References

Abiy Z., A. W. (2009). *Introduction to Research Methods.* Addis Ababa: Graduate Studies and Research Office Addis Ababa University.

Abukar Warsame. (2011). *Performance of Construction Projects.* Stockholm .

Adam Hayes. (2019, April 14). Trend Analysis.

Aigbavboa, C. O. (2014). Identification of Critical Success Factors for the survival of small, medium and micro enterprise contracting firms in the greater Johannesburg Metropolitan Area. *In 8th Construction Industry Development Board Postgraduate Conference.* (pp. 349-356). Johannesburg : University of Witwatersrand .

Akintoye S.A. (1991). *Construction Tender price index: modelling and forecasting trends.* UK: University of Salford.

Amadou Dem, G. M. (2001). *Inflation and Hyperinflation in the 20th century causes and Patterns.*

Amaha Gebretsadik. (2012, September). A study of the Effects of Inflation, and Price Adjustments, on Road Projects in Ethiopia, including an analysis of impacts on Ethiopian and Foreign Contractors, and a comparative analysis of practices in United Kingdom .

Asian Development Bank. (2008). *Inflation in developing asia.* Manila, Philippines.

Asian Development Bank. (2018). Price Adjustment Guidance Note on Proqurement.

Asteway Yigezu. (2008). The Iffects of Unpredictable price Fluctuation on the Capacity of Construction Contractors.

Asumadu, K. (2013). A Survey of the Ghanaian Construction Industry's Perceptions on the use of the Local Price Adjustment Formula Indices. *M.S. Thesis, Kwame Nkrumah University, Construction Management College of Architecture and Planning.*

Belmonte, D. (2013). *Calculating The Annual estimation Adjustment for Municipal Infrastracture.* South Africa: Aurecon (pty) Ltd.

Bryman, A. (2008). *The end of the paradigm wars. The Sage handbook of social research methods* .

Chantal C. Cantarelli, B. F. (2010). Cost overruns in Large-Scale Transportation Infrastructure Projects:Explanations and Their Theoretical Embeddedness. *European Journal of Transport and Infrastructure Research*, 5-18.

Chitkara K.K. (2011). *Construction Project Management - Planning, Scheduling and Controlling 2nd Edition.* Tata McGraw Hills.

Choi, M., Kim, J., and Kim, M. (2006). A study on the price escalation system in a construction contract. *KSCE Journal of Civil Engineering*, Vol.10, Issue 4, 227-232.

Cohen, L. M. (2013). *Research methods in education.* Routledge.

Creswell&Clark. (2007). *Designing and conducting mixed methods research.*

CSA. (2014, October). *Consumer price index. Central Statistics Agency Website.Retrived* . Retrieved from from CSA website. http://www.csa.gov.et/index.php/2013-02-20-10-00-28/price-indices/consumer-price-index.

David E. Newcomb, R. L. (June 2013). *Price Adjustment Clauses.* TEXAS: TEXAS A&M TRANSPORTATION INSTITUTE.

DuberleyJ, J. P. (2000). *Understanding management research: An introduction to epistemology.*

ERA. (2014). Addis Ababa: Ethiopian Road Authority.

ERA. (2016). *Road Sector Development Program19 Years Performance Assessment.* Addis Ababa: ERA.

EUROSTAS. (1996). *Souces and Methods Construction Price Indices.* Paris.

EUROSTAT. (1996). *Methodological Aspects of Construction Price Indices.* Luxembourg.

Fetene Nega. (2008). *Causes and Effects of Cost Overrun on Public Building Construction Projects in Ethiopia.*

FHWA. (2014). *The Mathematics of the National Highway Construction Cost Index.* Federal Highway Administration.

Garry D. Creedy Martin Skitmore, J. K. (2010). Evaluation of Risk Factors Leading to Cost Overrun in Delivery of Highway Construction Projects,. In *CONSTRUCTION ENGINEERING AND MANAGEMENT.*

Gebretsadik, A. (2012). *Effects of Inflation, and Price Adjustments, on Road Projects in Ethiopia, including an analysis of impacts on Ethiopian and Foreign Contractors, and a comparative analysis of practices* .

Ghaleb J. Sweis,Rateb Sweis,Malek Abu Rumman,Ruba Abu Hussein and Samer E. Dahiyat. (2013). Cost Overruns in Public Construction Projects. *Journal of American Science* .

Government of India Wholesale Price Index. (2011). *Manual on Wholesale Price Index.* New Delhi .

Graham Hole. (2009). *Research Skills.*

H.M.S. Belmonte . (2013). *Calculating the Annual Escalation Adjustment for Municipal Infrastructure.* South Africa: Aurecon(Pty) Ltd.

Hassanein A.A.G. and Khalil B.N.L. (2006). *A general indicator cost index for the Egyptian construction industry: Engineering costruction and architectural management* (Vol.13 No.5 ed.). Emerald Group Publishing Ltd.

IMF. (2004). *Producer Price Index Manual.* Washington, D.C.: International Monetary Fund.

International Labour Ofce. (2004). *Consumer price index manual Thiory and Practce.*

Jack, B. &. (2008). *Qualitative case study methodology: Study design and implementation for novice researchers.* .

Joseph Falzon and David Lanzon. (2011). *Price and Quality Indices of Food Imports in Malta.*

Joseph Ignatius Teye Buertey, Theophilus Adjei-Kumi, Felix Atsrim, Kwasi Boateng. (2015). Managing the Drivers of Cost Escalation in the Road Development Sector. *International Journal of Science, Technology and Society*, 295-303.

K.Yin, R. (2003). *Case study research design and methods 3rd edition.* Sage Publication Inc.

Kahraman, S. (2005). *Determination of a Price Index for Escalation of Building Construction Costs in Turkey.*

Karama Kanoun and Jean-Claude Laprie. (2012). *Trend Analysis.*

Kissi, E. (2017). *A Model for the Development of Tender Price Indices in the Ghanaian Building Industry.*

Kothari, C. (2004). *Research methodology methods and techniques.* Jaipur (India): New age international publishers.

Lee, J.-K. (2008). Cost Overrun and Cause in Korean Social Overhead Capital Projects: Roads, Rails, Airports, and Ports. *Journal of Urban Planning and Development* , 59-62.

Liu, R. F. (2008). *Research Methods for Construction.* Printed in Singapore by Utopia Press Pte Ltd.

Louis Kincannon. (n.d.). *Sources and Methods Construction Price Indices.*

Marsh, D. a. (2002). *Theory and Methods in Political Science.*

Mr. P. G. Tamhankar, D. A. (2018). A Study of Factors affecting Escalation Cost in Construction Projects.

Mustafa Alptekin. (2007). Bilding Cost Index Forcasting wiith Time Series Analysis.

National Bank of Ethiopia. (2018/19). *National Bank of Ethiopia Annual Report.* Addis Ababa: National Bank of Ethiopia.

National Bureau of Statistics. (2013). *Producer Price Index.*

Ndihokubwayo R. and Haupt T. (2009). *Theories and Concepts for an Increased Cost Adjustment Formula for Optimum Cost Escalation Recovery*. Retrieved from http://works.bepress.com/ruben_ndihokubwayo/12/ (last access: 22.11.2016).

Neuman, S. P. (2003). *Maximum likelihood Bayesian averaging of uncertain model predictions. Stochastic Environmental Research and Risk Assessment.*

Office of the Secretary of Defense . (2017, January). Inflation and Escalation Best Practices for Cost Analysis handbook .

Pakistan Engineering Council. (2009). *Standard Procedure and Formula for Price Adjustment.* Islamabad: Pakistan Engineering Council.

Park, C. S. (2007). *Contemporary Engineering Economics.* New Jersey.

Park, C. S. (2007). *Fundamentals of Engineering Economics.* New Jersey.

Patton. (2002). *Qualitative research and evaluation methods (3rd ed.).* Thousand Oaks: Sage.

Paulos, G.-M. (2002). *Construction Industry: A Base for Development.*

Peter von der Lippe. (2008, January). Index Formula of Laspeyres and the Inversion Test.

PPA. (2011). *Standard Bidding Document.* Addis Ababa: The Federal Democratic Republic of Ethiopia.

Pravin Raniga. (2008). Cost Escalation in Road and Rail Construction Projects.

(2004). *Producer Price Index Manual.*

Robert B. Barsky, L. K. (2000). *A Monetary Explanation of the Great Stagflation of the 1970s.*

Ronald E. Walpole. (2007). *Probability and Statistics for Engineers and Scientists, 8th Edition.* Texas: Pearson Education International.

Sae-Hyun, J. M.-S. (2011). *Military Facility Cost Estimation System Using Case-Based Reasoning in Korea.*

Sang C. Lhee, R. R. (2012). Prediction of Financial Contingency for Asphalt Resurfacing Projects using Artificial Neural Networks. *Journal of Construction Engineering and Management*, 22-23.

Sarantakos, S. (2012). *Social research. .* Palgrave Macmillan.

Seneviratne, P. N. (2013). *Costs and Benefits of the Price Adjustment Clause in FIDIC MDB.* Mandaluyong City, Philippines: Asian Development Bank.

Serhan Kahraman. (2005). *Determination of a Price index for Escalation of Building Construction Costs in Turky.*

Serkhan Kahraman. (2005). Determination of a Price Index for Escalation of Building Construction Costs in Turkey.

Shane, J. S. (2009). Construction Project Cost Escalation Factors. *Management in Engineering*, 221-229.

Silje Gunlaug Yun. (2008). *American Economy Towards Stagflation.*

SMEC. (2019, February). Ethiopian Roads Authority Contract Administration Manual.

Snowy Mountains Engineering Corporation (SMEC, A. (2007). *Manuals and Guidelines.* Ethiopian Roads.

Statistics South Africa. (2013). *Producer Price Index Methods, Sources and Theory.*

Statistics South African. (2017, March 15). The South African Consumer Price Index Sources and Methods Manual.

T.Subramani and P S Sruthi. (2014). Causes of Cost Overrun In Construction.

Thillai A. Rajan, G. G. (2013). PPPs and Project Overruns. *Evidence from Road Projects in India," Journal of Construction Engineering and Management*, 221-229.

Totonchi, J. (2011). Macroeconomic Theories of Inflation. *International Conference on Economics and Finance Research.* Singapore.

Turkey, W. (2011). *Risk Factors Leading to Cost Overrun in Ethiopian Federal Road Construction Projects and Its Consequences.* Addis Ababa.

Turochy, R. E. (2001). *Highway Project Cost Estimating Methods usedin the Planning Stage of Project Development.* Virginia: Virginia Transportation Research Council.

Walter A. Shewhart and Samuel S. Wilks. (2008). *Introduction to Time Series Analysis and Forecasting.* New Jersey: John Wiley & Sons. Inc.

Wubishet Jekale,Ashebir Shiferaw and Murad Mohammed. (2017). Causes of Cost Overrun in Federal Road Projects of Ethiopia in Case of Southern District. *American Journal of Civil Engineering*.

Wubishet, (2004). Performances for Public Construction Projects in (Least) Developing Countries: Road & Educational Building Projects in Ethiopia. *Doctoral Thesis in 'Business Management by Projects'*, 182.

Yadav, S., Shedabale, K., Suman, S., and Tanga, D. (2011). Cost Escalation in Construction: An Alternative Approach. *The IUP Journal of Infrastructure , Vol. IX, No. 3*.

Yin, R. K. (2003). Case study research design and methods. In R. K. Yin, *Case study research design and methods.* New Delhi: SAGE publications,international educational and professional publisher.

Appendix 1: Article

A study on Improving Price Adjustment Administration in Federal Road Projects

Simreteab Gebremedhin
Email:-semregkm@gmail.com
Tel:-+251910337114

Advisor: Wubishet Jekale (Dr. Eng.)
Email:-jekale.cmc@gmail.com
Tel: +251911526596

Abstract

Construction price indices are developed to measure the degree of price variations in construction material, equipment and labor costs. As such, the degree of price variations referring to each specific type of construction shall be measured by specific price indices in order to achieve more accurate results. In Ethiopian Road Authority, Price Index is commonly used for price adjustment administration in the escalation of road construction costs.

This study aims to improve price adjustment administration in federal road projects. The objectives of the study report in this research; to assessing current price indices determination practice when original source cease to publish indices, assessing reliable sources to minimize ceasing of publishing indices and developing guideline for price adjustment when supplier cease to exist and replaced by new source.

The outcomes of the research established new source selection using different analytical methods like trend, T-test and regression analysis methods to minimize the supplier cease to publish price index. Finally, based on the analysis of the results; develop guideline, conclusions and recommendations that enables to improve price adjustment administration in federal road projects.

Key Words: Price Index and Price Adjustment.

1 INTRODUCTION

Price adjustment clause is a contractual mechanism that allows a contractor to be at least partially protected against construction material, equipment or fuel price increases that may occur between the contract award

and the execution of the work. This is done by having an owner accepting the risk for escalating prices by offering a Price Adjustment Clause (PAC) that pays the contractor for any increase above agreed upon trigger value. Many PACs contain provisions for the contractor to provide a rebate to the owner in the event of decreasing prices (David E. et al, 2013).

In general, the integration of PACs in construction contracts enables the contractor or the owner to be protected against price fluctuation that may occur between the contract signing and execution of the contract.

2. LITERATURE REVIEW

2.1 Price adjustment in Ethiopian construction industry

In projects of reasonably long duration (greater than one year) undertaken in areas which suffer from continuous inflation, project Owners consider it reasonable to compensate contractors for losses which they might suffer as a result of increases in the prices of labour, materials, fuel, plant etc. There are a number of methods of calculating such CPA. Whichever method is used it usually arranges for both increases and decreases in prices and can accordingly result in either an increase or a decrease in the contract price. Unfortunately, the norm is that CPA tends to be an escalation of the contract price (SMEC, 2019).

There are different methods available for calculating the contract price adjustment. Whichever method is used it usually provides for both increases and decreases in prices and can thus result in either an increase or a decrease in the contract price. Normally, Ethiopian Road Authority uses two contract price adjustment (CPA) methods. The two most common methods of calculating CPA are: proven cost method and formula method.

2.2 Price Adjustment Vs Legislationchanges

According to (SMEC, 2019) price adjustment inputs which rely on data from a particular supplier rather than indices, if that original price source ceases to exist, the Employer Representative (ER) will consider the trend of increment of the material cost of the new supplier and compare it with the trend of the original supplier and determine a cost with a trend which could fairly represent the original increment trend.

Based on ERA contract document Sub-Clause13.1. [b], the source of indices shall be

appropriate for their purpose and shall relate to the Contractor's proposed source of supply of inputs on the basis of which his contract price have been computed. As the proposed basis for price adjustment, the Contractor shall have submitted with his bid the tabulation of weightings and source of indices, which shall be subject to approval by the ER's.

The Contractor shall not sign the agreement before he submits base indices from the approved sources. If the contractor desires to order materials from a supplier other than from whom he obtained his original quotations or indices because the original supplier ceases to exist, the ER's will look into the trend of increment of the material cost of the new supplier and compare it with the trend of the original supplier and determine a cost with a trend which could fairly represent the original increment trend.

However, if the original supplier exists and the Contractor proposes a new supplier for any reason, the Employer's Representative will look into the current quotations or indices of the original supplier and the newly proposed supplier, and will use the quotations or indices favorable to the Employer.

3.METHODOLOGY

3.1 Introduction

A research methodology is the sequence that guides the researcher in the process of collecting, analyzing, and interpreting observations (Abiy Z., 2009). (Yin, 2003), considers it as an action plan for getting from here to there. Where here, is regarded as the initial set of questions to be answered, and there, is some set of conclusions about the questions. This chapter includes the methodology used in this research. It provides research type, methods selected and the information about the research design from the research instrument.

3.2 Research Instrument

Document analysis from selected projects, this instrument is used for answering question number one and two which are, what are the current price indices determination practice when original source cease to publish indices, what are the reliable sources to minimize ceasing of publishing indices and How can we select a new reliable source when the supplier cease to exist? this part of the methodology will present, the rational for selection of case study projects, data gathering and analysis mechanisms to find the reliable new source,

to develop a guideline and to draw a valid conclusion.

3.3 Research Type

The research methodology will lead to accomplish the specified objectives of this study. As stated in the above statements, the Major objectives of this research are assessing current price indices determination practice when original source cease to publish indices, assessing reliable sources to minimize ceasing of publishing indices and developing guideline for price adjustment administration system when supplier cease to exist and replaced by new source.

3.3.1 Data Source and Data collection mechanism

The primary data sources for this research will be primarily from ERA, consultants and Contractor's for the challenges and problems they have faced during construction period of different projects in related to price adjustment. Secondary sources will be different manuals, guidelines, journals, thesis papers, books and reports which used for identifying factors which affect price indices determination and reliable source selection. The following tables 3.1 lists the projects are reported suppliers ceased to publish Price Indices and change by the new sources. The projects are:

Table 3.1:The projects suppliers ceased to publish Price Indices report and proposed change by the new sources.

No.	Name of Project	Proposal
1	Chole-Magna	❖ Employer's Representative assessment report on Bitumen Price Index.
2	Dire Dawa-Dewelle	❖ Contractor's proposal for changed source of Bitumen, Reinforcement steel, labor and Equipment indices. ❖ Employer's Representative recommendation on Bitumen Price Index.
3	Pawi-Junction-Fendkia-Ayma	❖ Employer's Representative recommendation on Bitumen Price Index.

Primary data were collected through document analysis from adjustable payment certificates, contract documents, data's, contractors claim heads on when the original suppliers cease to publish price indices and change by new sources, employer representatives' analysis based on contractor documents for ERA's Design and Build (DB)

projects. It involved in-depth study of the most critical issues of ERA price indices determination practice when original source cease to publish indices and reliable sources selection criteria in federal road projects.Secondary data were collected from different manuals guidelines and literatures.

The data are collected from three RSDP IV and above 70% completed federal rod projects. These data covered the proposed applicable and appropriate new sources of bitumen, equipment, steel and labour price indices, source of indices, base value date and price and percentage completion of these projects.

3.3.2 Population and Sampling

The population of the study falls to federal road construction Design and Build (DB) projects whose constructions were started after July 2010 (RSDP IV projects). The basis of selecting these particular projects are based on the information and document availability as well as price adjustment techniques.

3.3.2.1 Sample size determination

Sampling is the process of selecting representative units of a population for the study in research investigation. Sample is a small proportion of a population selected for analysis.

The total number of Design Build (DB) projects from RSDP IV, more than 70% complete are 29 projects. only three projects have faced supplier cease to exist problems. Therefore, all three projects used for analysis.

3.4 Data analysis mechanism

Collected data were analyzed by using correlational analysis mechanisms. Data's from client (ERA), consultants and contractors price adjustment indices and weight determination reports should be correlated through triangulation of each results. Trend analysis, T- test and regression analysis was used.

4. DATA ANALYSIS

4.1 Introduction

Construction price indices have always been used to evaluate the variations in equipment, labor and material costs (Wang C.H. and Mei Y.H., 1998).Several price indices are calculated and published by governmental organizations to be used for several purposes.

This study aims to improve price adjustment method in federal road projects in

terms of equipment, material and labor price indices when the original suppliers cease to publish Price Indices and changed by new sources in ERA DB projects.

4.2 **General Description of the Projects**

The selected projects are asphalt roads Commencement date from November 2012 up to October 2014 with average cost per kilometer of 26.11Million Birr and contract completion period around four and one fourth (4.25) years, 3 years and four and half (4.5) years period. Currently, all the projects are 100% completed and provisionally accepted by the employer. Table 4.1 and 4.2 presents the general description of the selected Design Build projects.

Table 4.1:Selected Ethiopian Road Authority Design and Build Projects

Ethiopian Road Authority Design and Build Projects										
No.	**Project Name**	**Contractor**	**Consultant**	**Description of index**	**Range of weighting**	**Bidder's Proposed**		**Source of Index**	**Base Value & Date**	**Percent Completion**
						Local Currency	**Foreign Currency**			
1	Chole-Magna	CGC Overseas Construction Group Ltd	Road Design and Development Consultants PLC	Nonadjustable	30%	30%	30%		June/28/2012	100%
				Fuel	8 - 12%	12%	12%	NOC	18.03	
				Bitumen	15 - 30%	28%	28%	California PAPI	518.00	
				Reinforcement Bar	2 - 5%	2%	2%	CEMAC, China	290.00	
				Cement	3- 8%	8%	8%	Mugher	121.40	
				Equipment	20- 30%	20%	20%	CEMAC, China	108.10	
				Total	**100%**	**100%**	**100%**			
2	Dire Dawa - Dewelle	CGC Overseas Construction Group Co. Ltd.	Shandong Great Supervision and Consultation Co. Ltd.	Nonadjustable		25%	25%		**Sep, 2012**	**100%**
				Fuel		30%		TOTAL Ethiopia S.C.	16.89	
				Bitumen			15%	California PAPI	589.10	
				Reinforcement Bar			10%	CEMAC, China	107.90	
				Cement		20%		Mugher	290.00	
				Equipment		25%	40%	CEMAC	108.30	
				Foreign Labor			10%	CEMAC, China	306.40	

				Total		**100%**	**100%**			
3	Pawi Junction Fendkia-Ayma	CGC Overseas Construction Group Co. Ltd.	Ethio Infra Engineering in association with STADIA Engineering Works Consultant PLC	Nonadjustable	30%	30%	30%		Sep, 2012	**100%**
				Fuel	10 – 20%	15%		Total Ethiopia	17.16	
				Bitumen	15 – 30%	25%	30%	California PAPI	589.10	
				Reinforcement Bar	2 – 5%	2%	5%	CEMAC	107.90	
				Cement	3 -8%	8%	0%	Mugher	290.00	
				Equipment	25 -35%	20%	30%	CEMAC	108.30	
				Foreign Labor	0-5%		5%			
				Total	**100%**	**100%**	**100%**			

Table 4.2: General description of the selected Design Build projects

Project Description	**Project Name**		
	Chole-Magna	**Dire Dawa-Dewelle**	**Pawi Junction-Fendkia-Ayma**
Project Financer	GOE	China	GOE
Length in (km)	20	220	83
Commencement Date	Nov. 30/2012	Oct.1/2014	Dec.27/2012
Project starting date	11/30/2012	10/1/2014	12/27/2012
Original Contract cost with VAT	ETB 869,512,570.00	ETB 4,584,266,282.30	ETB 1,163,233,848.63
Revised Project Cost with VAT	ETB 869,512,570.00	ETB 4,584,266,282.30	ETB 1,342,304,198.02
Contract Duration	1,547 Calendar date	36 months	1,635 Calendar date
Original Completion Date	Feb.24/2017	Sep. 30/2017	May 30/2017
Revised Completion Date	Feb.24/2017	Nov. 15/2018	June 18/2017

4.3 Current price index determination in Chole-Magna Design Build Project

The contractor (CGC Overseas Construction Group Co. Ltd) addresses the reality that the original source of bitumen price index for calculation of price adjustments (California Paving Asphalt Price Index) has ceased to publish from the date after 1st March 2015.

Employer's Representative of this project (Road Design and Development Consultant PLC) refers to contractor's letter ref.no. CGCOC/CM/15119 dated 20th January 2016, the contractor forwarded and proposed three alternatives. These are: National Oil Ethiopia, Virginia Roads and Kentucky KAPI Asphalt as the new source of Bitumen price index. Accordingly, the Employer Representative has assessed the contractor's proposed alternatives of sources of indices. The Contractor's and ER proposed sources of indices are listed in the following table.

Table 4.2:Sources for bitumen price index in Chole-Magna Design Build Project

No.	Name of Source	Proposed by
1	NOC	Contractor
2	Virginia Roads	Contractor
3	Kentucky	Contractor
4	New Jersey	Employer's Representative
5	S.T. Wooten	Employer's Representative
6	Georgia	Employer's Representative

4.4 Current price index determination in Dire Dawa-Dewelle Design Build Project

The Contractor of Dire Dawa-Dewelle Design Build Road Project (CGC Overseas Construction Group Ltd) has submitted four proposals to the Employer's Representative (Shandong Great Supervision and Consultation Co. Ltd), declaring that its original sources of indices for bitumen, reinforcement steel, labour and equipment have ceased to publish and requested the ER's approval of his new proposed Georgia Asphalt index.

Table 4.3:Dire Dawa-Dewelle Design Build Project Sources of the data sets used in the assessment

Name of Source	Source Information
California Asphalt Price Index (Base source)	California Department of Transportation
Georgia Asphalt Cement Price Index	Georgia Department of Transportation
North Carolina Asphalt Price Index	State of North Carolina Department of Transportation
West Virginia Asphalt Prices	West Virginia Department of Transportation
New Jersey Asphalt Price Index	State of New Jersey Department of Transportation
Oklahoma Asphalt Binder Price Index	State of Oklahoma Department of Transportation
National Oil Ethiopia (NOC)	As submitted by National Oil Ethiopia PLC
Canada - MTO AC Price Index	OHMPA Website http://www.ohmpa.org/mtopriceindex/

4.5 Current price index determination in Pawi Junction-Fendkia-Ayma Design and Build Project

The Contractor of Pawi Junction-Fendkia-Ayma Design and Build Project (CGC Overseas Construction Group Ltd) his letter ref.no. CGCOC/PJFA/15334 dated December 10, 2015 informedthe Employer's Representative (ER) that the original supplier for Bitumen (i.e. California Paving Asphalt Price Index)ceased to published indices for bitumen as from March 2015and requested ER to changethe supplier to National Oil Ethiopia plc (NOC).

Table 4.4:Potential sources for bitumen price index in Pawi-Junction Design Build Project

No.	Name of Source	Proposed by
1	NOC	Contractor
2	Kentucky	Contractor
3	Virginia	Contractor
4	Oklahoma	Employer's Representative
5	US Bureau of Labour Statistics Producer Price Index (PPI)	Employer's Representative

4.6Discussion

Chole-Magna: TheER's looked into the trend of change of the index value of the new sources and make comparisons with the original source, he had considered data of the last four years from the month the original source has ceased to publish the information from January 2011 to February 2015. But according to the project contract document the base date is not January 2011 the project base date is June 28/2012 because of base date difference the indices calculation outputs are different so that analysis of trend beyond the original base date would be unnecessary and maybe lead to wrong results.

The Employer's Representative specified that only he adopted the Coefficient of Determination, R^2 parameter in order to evaluate the relationship between the California index and the selected six indices. He hadn't to see others comparison methods like Standard errors and P-values in regression analysis and t-test statistical analysis method.

The Employer's Representative assessment report shows that, he considered different trend analysis period (Last 1 year from Mar 2014 to Feb 2015, Last 1.5 years from Sep 2013 to Feb 2015, Last 2 year from Mar 2013 to Feb 2015, Last 2.5 years from Sep 2012 to Feb 2015, Last 3 years from Mar 2012 to Feb 2015), Last 3.5 years from Sep 2011 to Feb 2015 and Last 4 years & 2 months from Jan 2011 to Feb 2015) for

evaluating the strength of Coefficient of Determination, R2. He arrived at an R2 value of 0.89, 0.79,0.68, 0.60, 0.43,0.39 and 0.32 for analysis periods of 1,1.5,2, 2.5, 3,3.5 years and 4 years and 2 months, respectively. The ER finally recommended (Last 2.5 years from Sep 2012 to Feb 2015) R^2 value of 0.68 for predicting current index of California from current indices of NOC. It is not clear why the ER has been recommended (Last 2.5 years from Sep 2012 to Feb 2015) an R^2 value of 0.68.

Chole-Magna New source selection:

Trend analysis: the result from descriptive and correlation analysis for appropriate replacement price index indicated that, NOC Ethiopia is the new source. It has similar trend with the original source of index (CPAPI).

T-test analysis: Comparing the mean difference, Kentucky has more similar trend than other sources, and statistically Kentucky is chosen as the best similar trend with the original supplier. Comparing the variance difference, NOC has more similar trend than other sources, and statistically NOC is selected as the best similar trend with the original supplier. The number of occasions where the difference between two indices in a month was less than 5%. When comparing the indices, it is found out that NOC indices scored best in each of the criteria requested to be applied.

Therefore, based on the analysis result of the above three T-test comparison methods, the index from NOC Ethiopia satisfies the statistical analysis from the two methods. This research proposes the use of index from NOC Ethiopia as a new source of index.

Regression analysis: As can be seen from the analysis, the value of the Coefficient of determination between California and NOC, NOC has the largest R square, low standard error and less P-value ($P<0.05$), showing that the relation of the Index Data of California with NOC is the strongest of all the other sources. Therefore, statistically NOC is picked as the best similar with the original source.

Based on the above three (trend, T-test and regression) analytical methods, in consideration of the observed relatively strong relationship between the index data of the original source, NOC Ethiopia is selected a new source of index.

Dire Dawa-Dewelle: Both the Contractor and ER's analyse the data using only trend

analysis and T-test methods. They didn't to see and cross check by others comparison method like regression analysis. The Contractor and ER's approval of the new proposed source was Georgia Asphalt index. But, based on the analysis result by comparing the number of monthly occasions where the California index and the indices in question both showed either increases and decrease in the analysis period (Sep 2012 to Feb 2015), the difference between the California indices in a month was less than 5% and states that NOC indices scored best by showing 18 out of 30 whereas Georgia indices scored 17 out of 30.

The correlation coefficient between California Paving Asphalt index and NOC was calculated as 0.808, whereas that between California Paving Asphalt index and Georgia was 0.138, which indicated a weak relationship. Which means that NOC Ethiopia represents the trend of the original source of index, i.e. California paving asphalt price index and the recommended determination of a cost with a trend from the NOC Ethiopia which fairly represents the original increment trend. Therefore, the Contractor and ER's analysis result was incorrect and doesn't support selection of Georgia Asphalt index as the only representative source satisfying the criteria adopted.

Dire Dawa-Dewelle New Source Selection:

Trend analysis: the result from descriptive and correlation analysis for appropriate replacement price index indicated that, NOC Ethiopia is the new source. It has similar trend with the original source of index (CPAPI).

T-test analysis: Comparing the mean difference, Oklahoma has more similar trend than other sources, and statistically Oklahoma is chosen as the best similar trend with the original Supplier. Comparing the Variance difference, all the results fulfil one of the two. The number of occasions where the difference between two indices in a month was less than 5%. When comparing the indices, it is found out that the NOC indices scored best in each of the criteria requested to be applied.

Therefore, in consideration of the above three t-test comparison methods, the index from Oklahoma and NOC Ethiopia satisfies the Statistical analysis.

Regression analysis: As can be seen from the analysis, the value of the Coefficient of determination between California and NOC, NOC has the largest R square, low standard

error and less P-value (P<0.05), showing that the relation of the index data of California with NOC is the strongest of all the other sources. Therefore, statistically NOC Ethiopia is picked as the best similar with the original source.

Based on the above three (trend, t-test and regression) analytical methods, in consideration of the observed relatively strong relationship between the index data of the original source, NOC Ethiopia is selected a new source of index.

Pawi Junction-Fendkia-Ayma:

The Contractor proposed to use National Oil Ethiopia (NOC) as alternative bitumen price index source.ER plotted the trends of bitumen indices between the various sources, and determined that the PPI index from BLS shows a strong correlation / association with California Paving Asphalt Price Index. He used that model to predict new determined index value of California index after March 2015. The correlation coefficient between California Paving Asphalt index and US BLS PPI was calculated as 0.972, whereas that between the CPAI and the other five sources were 0.14, -0.15, -0.05 and -0.08, respectively which all indicated a weak relationship. ERA noted that the PPI index of US BLS represents the trend of the original source of index, i.e. California paving asphalt price index and he recommended determination of "a cost with a trend" from the PPI index of US BLS which fairly represents the original increment trend.

Pawi Junction New Source Selection:

Trend analysis: the result from descriptive and correlation analysis for appropriate replacement price index indicated that, Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S is the new source. It has similar trend with the original source of index (CPAPI).

T-test analysis: comparing the mean difference, Oklahoma has more similar trend than other sources, and statistically Oklahoma is chosen as the best similar trend with the original supplier.

Comparing the Variance difference, US BLS PPI is the most comparative than the other indexes, and statistically US BLS PPI is chosen as the best similar trend with the original source.

The number of occasions where the difference between two indices in a month was less than 5%. When comparing the indices, it is found out that the Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics

(BLS) U.S indices scored best in each of the criteria requested to be applied.

Therefore, in consideration of the above three T-test comparison methods, the index from US BLS PPI satisfies the statistical analysis on two of the methods, and proposes the use of the index from Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S as a new source of index.

Regression analysis: As can be seen from the analysis, the value of the coefficient of determination between California and Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S, Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S has the largest R Square, low standard error and less P-value ($P<0.05$), showing that the relation of the index data of California with Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S is the strongest of all the other sources.

Based on the above three (trend, T-test and regression) analytical methods, in consideration of the observed relatively strong relationship between the Index Data of the original source, Producer Price Index (PPI); Petroleum from Bureau of Labour Statistics (BLS) U.S is selected a new source of index.

4.7 Developing guideline for price adjustment administration system when supplier cease to exist and replaced by new source.

The third objective of this research is to develop a guideline to help ERA in order to systematically compare and select new source for its projects when the supplier cease to publish and to assist the decision-making process. As discussed in the literature review there is no standard guideline to administer such phenomenon. Primarily, this framework guides how to select the new source for a particular type of road construction project and guide the decision-making process. It also ensures systematic and consistent approach for price adjustment administration through the application of relevant selection models. The guideline will Provides better understanding on various types of alternative sources in practice. In this way, it will be possible to ensure that the price adjustment administration in an efficient and effective way. The proposed guideline consists of three main stages whichare alternative source suggestion to be used as an input, source index calculation stage and source selection output stage. The following Figure 4.1shows the developed guideline for the selection of new source when supplier cease to exist.

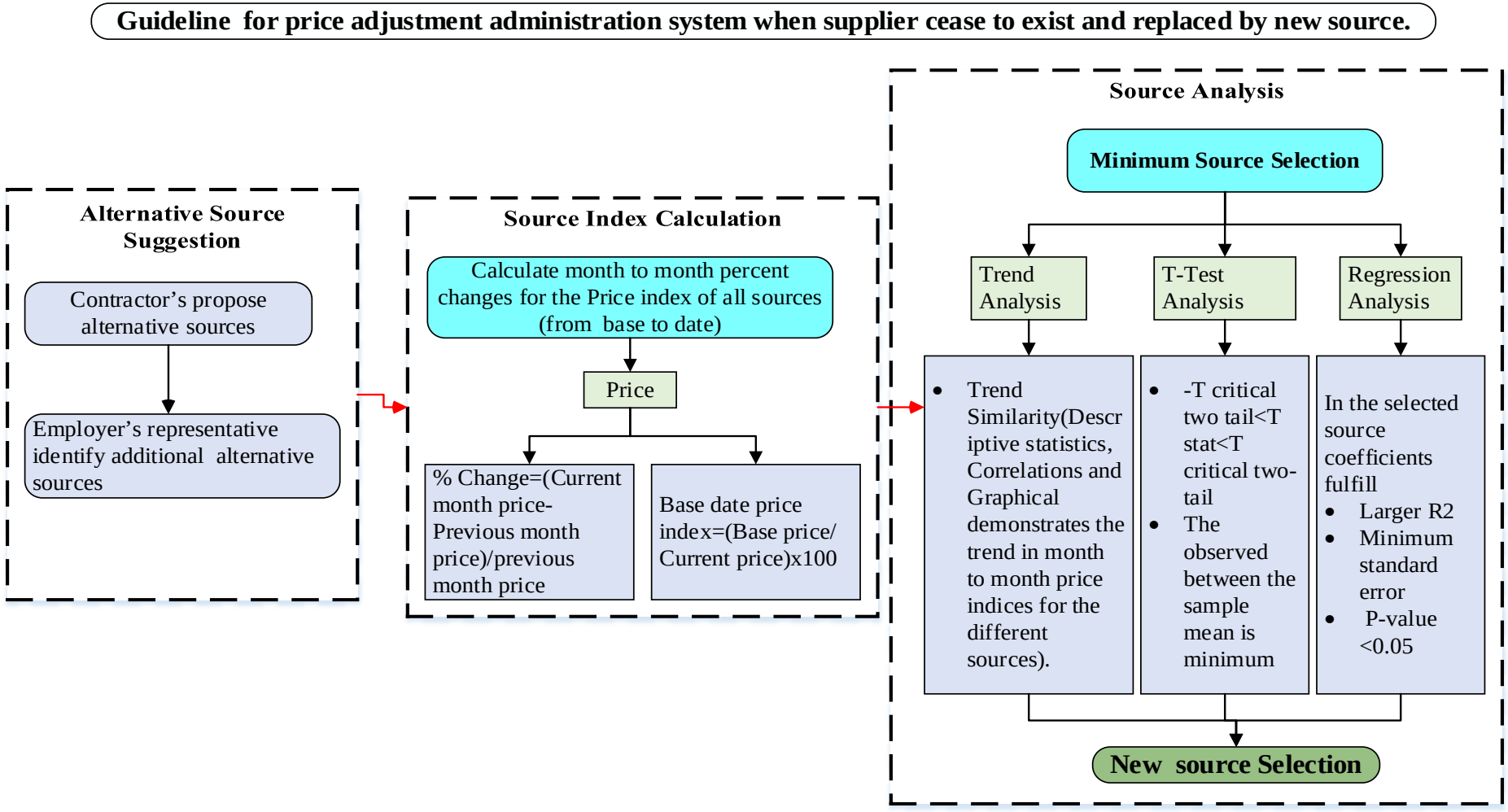


Figure 4.1:Guideline for price adjustment administration system when supplier cease to exist and replaced by new source.

5.CONCLUSION ANDRECOMMENDATION

5.1 Conclusion

This research covered the studies on improving price adjustment administration in federal road projects. Moreover, price adjustmentadministration when suppliers cease to published price indices were analyzed by trend, T-tests and regression analysis techniques.

The research methodology covered the steps and the processes how to collect, analyze, and interpret the collected data. Data analysis and discussion with steps and detailed explanations of the studies executed to meet the objectives of this research. The data analyzed was introduced and subsequently provides the steps for the calculations achieved to find new supplier source of index. The new supplier source of price index was compared with the original ones, and the indices which provided the best linear relationship. Nevertheless, the selected source of index was analyzed by the trend, T-test and regression analysis techniques. The aims of these steps were to prepare a guideline which would make it possible to predict the future values of the selected indices.

5.2 Recommendation

The main objective of this research was to assessing reliable sources selection to minimize ceasing of publishing indices and developing guideline for price adjustment administration system when supplier cease to exist and replaced by new source. Based on the findings of the analysis, recommendations will focus in addressing the major problems identified through the research processes and below listed specific recommendations are forwarded to ERA.

- It is recommended that; ERA should early determine the contract document how to calculate price adjustment when suppliers cease to publish price index problems in the bid stage.
- It is recommended that; ERA should select and recommend their own reliable sources in the biding stage.
- It is recommended to use the proposed framework as a guideline (Figure 4.1) which detailed in previous chapter to assist in the selection of an appropriate new source selection in ERA's road projects. ERA can use this guideline tofairly represent the original trend and reduce claim in the implementation stages.
- Major stakeholders (ERA, consultants and contractors) should work together to

improve the price adjustment administration problems when suppliers cease to publish price index and replaced by new sources calculation should be clear and consistent.

- ERA should have to give regular and intensive capacity building trainings, workshops, and seminars should be arranged for professionals on the construction sectors so as to develop their awareness on contract documents and impact of price adjustment when suppliers cease to publish price indices and replaced by new source.

APPENDIX 2

PRICE INDEX

PRICE INDEX FROM DEPARTMENT OF TRANSPORTATION OF THE STATE OF CALIFORNIA

Home | Travel | Business | Engineering | News | Maps | Jobs | About Caltrans | Contact Us

Office Engineer | Advertised Highway Projects | Construction Contract Standards | Bids Opened & Awarded Contracts |

Bidding
- Advertised Projects
- New! Electronic Bidding
- Information for contractors
- Bidder's Exchange
- Bidder Inquiries
- Caltrans Connect
- Map of advertised projects
- Planholder Search
- Specialty License Project Search
- Bid Item Contract Search

Awards
- Post-bid files
- Awarded Contracts Search
- Bid Summaries
- Bids Opened & Awarded Contracts

Standards
- Construction Contract Standards
- New! Construction Standards E-mailing List

General Information
- About Us
- Bidder Survey
- Contact Office Engineer
- Contractor Info Table
- Cost Information
- Federal Wages
- File Format Information
- Frequently Asked Questions
- Latest Updates
- Ready to List (RTL) Guide (with updates)
- Send Us Feedback
- Special Notices
- Website Feature Tour

Caltrans

Caltrans > Engineering > Office Engineer > **Asphalt Price Index**

California Paving Asphalt Price Index

Looking for the **California Statewide Crude Oil Price Index**? Go here.

Jan-11	477.1		Jan-12	595.0
Feb-11	488.9		Feb-12	589.7
Mar-11	586.3		Mar-12	669.8
Apr-11	634.7		Apr-12	655.5
May-11	667.5		May-12	640.9
Jun-11	592.2		Jun-12	518.0
Jul-11	565.9		Jul-12	520.8
Aug-11	570.5		Aug-12	544.3
Sep-11	589.7		Sep-12	589.1
Oct-11	559.8		Oct-12	581.8
Nov-11	637.0		Nov-12	554.7
Dec-11	625.0		Dec-12	573.2

This Index is to be used for adjustments to compensation for paving asphalt in accordance with the provisions of the special provisions section "Compensation Adjustments for Price Index Fluctuations" in those projects containing the section. The index values are to be used in both metric and non metric projects. Unit adjustment is included in the formulas as shown in the special provisions.

The California Statewide Paving Asphalt Price Index is determined each month by the Department using the median of posted crude oil prices in effect on the first business day of the month as posted by Chevron, Exxon Mobil and Union 76 for the Buena Vista, Huntington Beach, and Midway Sunset fields.

Previous years California Asphalt Price Index, can be viewed at the following:
Asphalt Index Archive

Office Engineers has been a service to the California Department of Transportation for over 100 years, and has built this on-ramp to the Information Highway demonstrating that Caltrans does provide for the movement of goods, people, and Information!

For further information send E-mail to: gchau@dot.ca.gov

Back to Top | Contact Office Engineer

Conditions of Use | Privacy Policy
Copyright © 2007 State of California

California Department of Transportation

Home | Contact Us | Site Index | Print | Search | This Site | California

Contract Awards & Services | Construction Contract Standards | Contractor's Corner | Guidance

Home » Asphalt Index

California Paving Asphalt Price Index

Looking for the **California Statewide Crude Oil Price Index**? Go here.

JAN-13	598.4	JAN-14	537.6
FEB-13	613.5	FEB-14	547.3
MAR-13	577.1	MAR-14	583.7
APR-13	607.9	APR-14	553.3
MAY-13	548.8	MAY-14	550.1
JUN-13	543.8	JUN-14	564.4
JUL-13	559.2	JUL-14	572.9
AUG-13	592.3	AUG-14	532.5
SEP-13	596.0	SEP-14	500.8
OCT-13	552.4	OCT-14	477.5
NOV-13	523.9	NOV-14	411.7
DEC-13	538.3	DEC-14	349.9

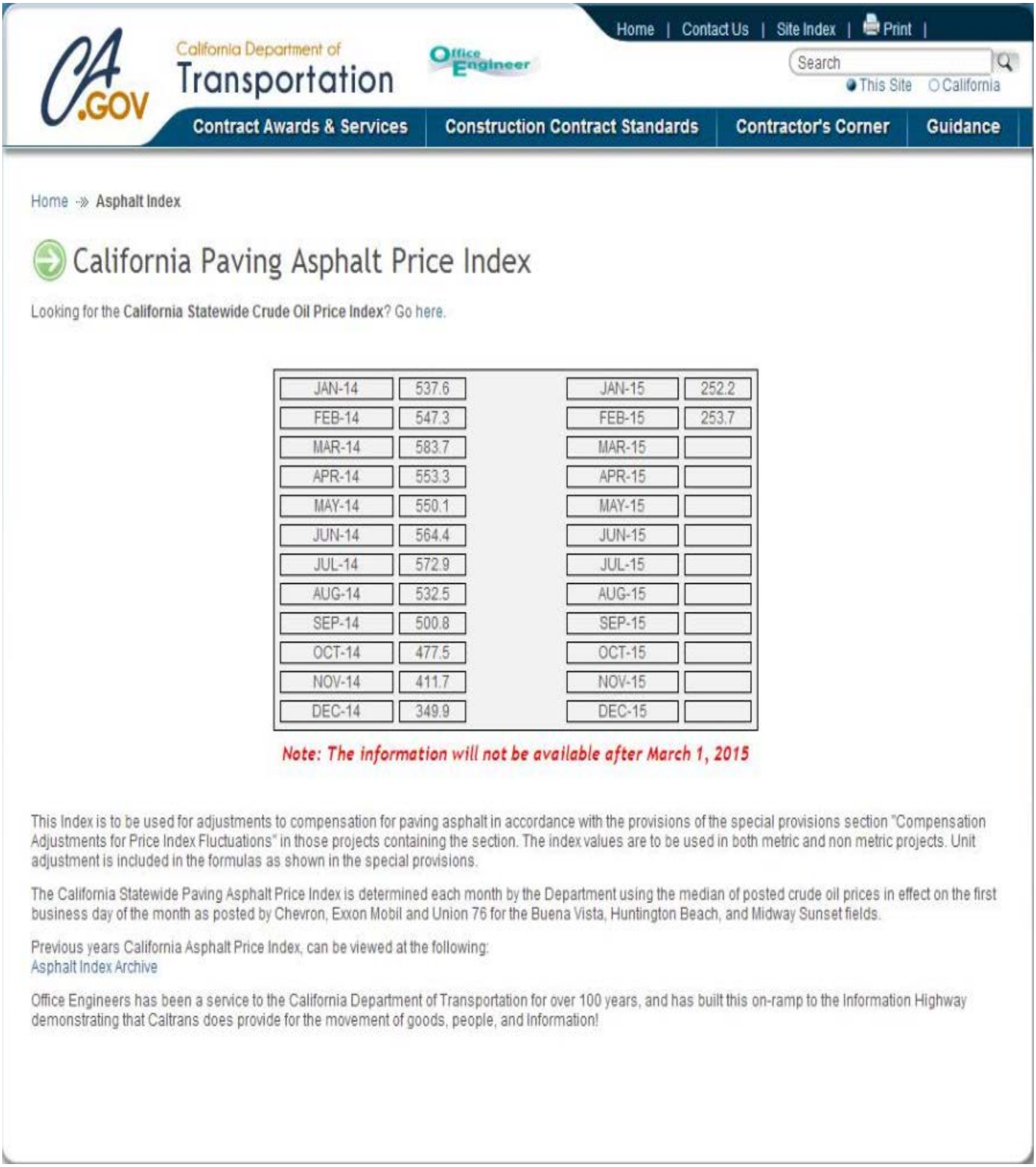
Note: The information will not be available after March 1, 2015

This Index is to be used for adjustments to compensation for paving asphalt in accordance with the provisions of the special provisions section "Compensation Adjustments for Price Index Fluctuations" in those projects containing the section. The index values are to be used in both metric and non metric projects. Unit adjustment is included in the formulas as shown in the special provisions.

The California Statewide Paving Asphalt Price Index is determined each month by the Department using the median of posted crude oil prices in effect on the first business day of the month as posted by Chevron, Exxon Mobil and Union 76 for the Buena Vista, Huntington Beach, and Midway Sunset fields.

Previous years California Asphalt Price Index, can be viewed at the following:
Asphalt Index Archive

Office Engineers has been a service to the California Department of Transportation for over 100 years, and has built this on-ramp to the Information Highway demonstrating that Caltrans does provide for the movement of goods, people, and Information!



Home | Contact Us | Site Index | Print |

Search

This Site California

California Department of Transportation

Office Engineer

Contract Awards & Services | Construction Contract Standards | Contractor's Corner | Guidance

Home » Asphalt Index

California Paving Asphalt Price Index

Looking for the **California Statewide Crude Oil Price Index**? Go here.

JAN-14	537.6	JAN-15	252.2
FEB-14	547.3	FEB-15	253.7
MAR-14	583.7	MAR-15	
APR-14	553.3	APR-15	
MAY-14	550.1	MAY-15	
JUN-14	564.4	JUN-15	
JUL-14	572.9	JUL-15	
AUG-14	532.5	AUG-15	
SEP-14	500.8	SEP-15	
OCT-14	477.5	OCT-15	
NOV-14	411.7	NOV-15	
DEC-14	349.9	DEC-15	

Note: The information will not be available after March 1, 2015

This Index is to be used for adjustments to compensation for paving asphalt in accordance with the provisions of the special provisions section "Compensation Adjustments for Price Index Fluctuations" in those projects containing the section. The index values are to be used in both metric and non metric projects. Unit adjustment is included in the formulas as shown in the special provisions.

The California Statewide Paving Asphalt Price Index is determined each month by the Department using the median of posted crude oil prices in effect on the first business day of the month as posted by Chevron, Exxon Mobil and Union 76 for the Buena Vista, Huntington Beach, and Midway Sunset fields.

Previous years California Asphalt Price Index, can be viewed at the following:
Asphalt Index Archive

Office Engineers has been a service to the California Department of Transportation for over 100 years, and has built this on-ramp to the Information Highway demonstrating that Caltrans does provide for the movement of goods, people, and information!

PRICE INDEX FROM DEPARTMENT OF TRANSPORTATION OF THE STATE OF NEW JERSEY

STATE OF NEW JERSEY
DEPARTMENT OF TRANSPORTATION
Chris Christie, Governor | Kim Guadagno, Lieutenant Governor

Trns•port Software

Asphalt Cement and Fuel Price Index

The Asphalt Price Index is the average of suppliers selling price in both North and South New Jersey. The Fuel Price Index is the average statewide selling price of Unleaded Regular Gasoline and Diesel Fuel.

Contractors and Estimators are to use the index price from the month before receipt of bids, regardless of posted date.

Effective Date	Asphalt Cement North of Route 195		Asphalt Cement South of Route 195		Entire State Fuel		Date Calculated
	English	Metric	English	Metric	English	Metric	
Jan 2017	$332.00	$366.00	$332.00	$366.00	$2.37	$0.63	12/28/16
Dec 2016	$301.00	$332.00	$301.00	$332.00	$2.21	$0.58	11/29/16
Nov 2016	$299.00	$329.00	$299.00	$329.00	$2.24	$0.59	11/2/16
Oct 2016	$303.00	$333.00	$303.00	$333.00	$2.07	$0.55	9/30/16
Sep 2016	$318.00	$350.00	$318.00	$350.00	$2.09	$0.55	8/30/16
Aug 2016	$335.00	$369.00	$335.00	$369.00	$2.03	$0.54	7/29/16
Jul 2016	$334.00	$368.00	$334.00	$368.00	$2.15	$0.57	6/29/16
Jun 2016	$323.00	$355.00	$323.00	$355.00	$2.14	$0.57	5/26/16
May 2016	$303.00	$333.00	$303.00	$333.00	$2.02	$0.53	4/28/16
Apr 2016	$299.00	$329.00	$299.00	$329.00	$1.89	$0.50	3/30/16
Mar 2016	$303.00	$334.00	$303.00	$334.00	$1.67	$0.44	2/29/16
Feb 2016	$303.00	$334.00	$303.00	$334.00	$1.78	$0.47	1/29/16
Jan 2016	$360.00	$397.00	$360.00	$397.00	$1.95	$0.52	12/31/15
Dec 2015	$401.00	$442.00	$401.00	$442.00	$2.08	$0.55	11/30/15
Nov 2015	$422.00	$465.00	$422.00	$465.00	$2.08	$0.55	10/29/15
Oct 2015	$435.00	$480.00	$435.00	$480.00	$2.14	$0.57	9/25/15
Sep 2015	$465.00	$513.00	$465.00	$513.00	$2.32	$0.61	8/27/15
Aug 2015	$484.00	$534.00	$484.00	$534.00	$2.55	$0.67	7/29/15
Jul 2015	$486.00	$536.00	$486.00	$536.00	$2.67	$0.70	6/26/15
Jun 2015	$477.00	$526.00	$477.00	$526.00	$2.65	$0.70	5/29/15
May 2015	$482.00	$531.00	$482.00	$531.00	$2.60	$0.68	5/1/15
Apr 2015	$509.25	$561.35	$509.25	$561.35	$2.47	$0.65	4/1/15
Mar 2015	$532.25	$586.69	$532.25	$586.69	$2.49	$0.66	2/27/15
Feb 2015	$553.25	$609.57	553.25	$609.57	$2.27	$0.60	1/28/15
Jan 2015	$568.00	$626.00	$568.00	$626.00	$2.65	$0.70	12/29/14
Dec 2014	$586.00	$645.00	$586.00	$645.00	$2.98	$0.78	11/28/14
Nov 2014	$591.00	$651.00	$591.00	$651.00	$3.09	$0.82	10/29/14
Oct 2014	$612.00	$675.00	$612.00	$675.00	$3.34	$0.88	9/29/14

Sep 2014	$620.00	$683.00	$620.00	$683.00	$3.43	$0.91	8/28/14
Aug 2014	$599.15	$660.44	$599.15	$660.44	$3.56	$0.94	8/1/14
Jul 2014	$588.33	$648.52	$588.33	$648.52	$3.67	$0.97	6/30/14
Jun 2014	$565.00	$623.48	$565.00	$623.48	$3.65	$0.96	5/30/14
May 2014	$545.00	$600.75	$540.00	$595.24	$3.70	$0.98	5/1/14
Apr 2014	$530.00	$578.00	$525.00	$573.20	$3.65	$0.96	3/31/14
Mar 2014	$535.00	$589.73	$530.00	$584.22	$3.73	$0.98	2/28/14
Feb 2014	$540.00	$595.24	$540.00	$595.24	$3.59	$0.95	2/2/14
Jan 2014	$537.50	$592.45	$535.00	$589.73	$3.55	$0.94	1/7/14
Dec 2013	$542.50	$609.23	$535.00	$600.81	$3.50	$0.92	12/1/13
Nov 2013	$555.00	$611.78	$555.00	$611.78	$3.57	$0.94	11/1/13
Oct 2013	$557.50	$614.50	$557.50	$614.50	$3.53	$0.93	9/30/13
Sep 2013	$550.00	$611.78	$550.00	$611.78	$3.91	$1.03	8/30/13
Aug 2013	$565.00	$622.81	$565.00	$622.81	$3.83	$1.01	7/31/13
July 2013	$590.00	$650.36	$590.00	$650.36	$3.85	$1.02	6/28/13
Jun 2013	$595.00	$655.88	$595.00	$655.88	$3.73	$0.98	5/31/13
May 2013	$545.00	$600.76	$545.00	$600.76	$3.69	$0.98	5/1/13
Apr 2013	$537.50	$586.97	$535.00	$586.97	$3.68	$0.97	3/28/13
Mar 2013	$532.50	$586.97	$532.50	$586.97	$3.80	$1.00	2/28/13
Feb 2013	$530.00	$584.22	$527.50	$581.46	$3.65	$0.96	2/1/13
Jan 2013	$542.50	$598.00	$542.50	$598.00	$3.58	$0.94	1/2/13
Dec 2012	$560.00	$617.29	$560.00	$617.29	$3.72	$0.98	12/3/12
Nov 2012	$572.50	$631.07	$572.50	$631.07	$3.94	$1.04	11/1/12
Oct 2012	$567.50	$625.56	$567.50	$625.56	$4.08	$1.08	10/1/12
Sep 2012	$570.00	$628.32	$570.00	$628.32	$3.94	$1.04	8/31/12
Aug 2012	$585.00	$644.85	$585.00	$644.85	$3.74	$0.99	8/1/12
Jul 2012	$602.50	$664.14	$602.50	$664.14	$3.66	$0.97	6/29/12
Jun 2012	$632.50	$697.21	$632.50	$697.21	$3.92	$1.04	6/1/12
May 2012	$635.00	$699.97	$635.00	$699.97	$4.09	$1.08	5/1/12
Apr 2012	$632.50	$697.21	$632.50	$697.21	$4.18	$1.10	4/2/12
Mar 2012	$625.00	$688.94	$625.00	$688.94	$4.04	$1.07	3/1/12
Feb 2012	$607.50	$669.65	$607.50	$669.65	$3.75	$0.99	2/1/12
Jan 2012	$597.50	$658.63	$597.50	$658.63	$3.69	$0.97	1/1/12
Dec 2011	$595.00	$655.87	$595.00	$655.87	$3.51	$0.93	11/30/11
Nov 2011	$590.00	$650.36	$590.00	$650.36	$3.53	$0.93	11/1/11
Oct 2011	$590.00	$650.36	$590.00	$650.36	$3.53	$0.93	10/1/11
Sep 2011	$592.50	$653.11	$592.50	$653.11	$3.66	$0.96	9/1/11
Aug 2011	$610.00	$672.40	$610.00	$672.40	$3.78	$1.00	8/1/11
Jul 2011	$630.00	$694.45	$630.00	$694.45	$3.70	$0.98	7/1/11
Jun 2011	$635.00	$699.96	$635.00	$699.96	$3.85	$1.02	5/31/11
May 2011	$630.00	$694.46	$630.00	$694.46	$3.97	$1.05	4/29/11
Apr 2011	$545.00	$600.75	$545.00	$600.75	$3.68	$0.97	4/1/11
Mar 2011	$502.50	$553.91	$502.50	$553.91	$3.43	$0.91	2/25/11
Feb 2011	$490.00	$540.13	$490.00	$540.13	$3.42	$0.90	1/28/11
Jan 2011	$485.00	$534.62	$485.00	$534.62	$3.34	$0.88	12/29/10
Dec 2010	$477.50	$526.35	$477.50	$526.35	$3.15	$0.83	11/30/10
Nov 2010	$477.50	$526.35	$477.50	$526.35	$3.09	$0.82	10/28/10
Oct 2010	$477.50	$526.35	$477.50	$526.35	$2.97	$0.78	9/29/10
Sep 2010	$475.00	$523.60	$475.00	$523.60	$2.81	$0.74	8/31/10
Aug 2010	$477.50	$526.35	$477.50	$526.35	$2.99	$0.79	7/29/10
Jul 2010	$482.50	$531.87	$482.50	$531.87	$2.89	$0.76	6/29/10

PRICE INDEX FROM DEPARTMENT OFTRANSPORTATION OF THE STATE OF NORTHCAROLINA

Asphalt and Fuel Prices

Pricing for terminal asphalt binder, fuel and AC (Asphalt-Cement).

Average Terminal Prices: Fuel & AC Monthly Terminal Asphalt Binder FOB Prices [#MSOZoneCell_WebPartWPQ4]
PG64-22 Asphalt Binder Pricing [#MSOZoneCell_WebPartWPQ7]

Date [javascript:]	English Fuel Price [javascript:]	Metric Fuel Price [javascript:]	English AC Price [javascript:]	Metric AC Price [javascript:]
1/1/2013	3.1655	0.8362	551.56	607.58
12/1/2012	3.3899	0.8955	557.33	614.34
11/1/2012	3.2145	0.8492	559.33	616.54
10/1/2012	3.3405	0.8825	563.33	620.95
9/1/2012	3.4238	0.9045	568.67	626.84
8/1/2012	3.0348	0.8017	590.33	650.72
7/1/2012	2.9064	0.7678	614.33	677.17
6/1/2012	2.8675	0.7575	639.00	704.37
5/1/2012	3.3682	0.8898	637.14	702.31
5/1/2012			483.08	532.49
4/1/2012	3.3877	0.8949	634.29	699.17
3/1/2012	3.3509	0.8852	627.14	691.29

[JAVASCRIPT:]

Pavement Resources

Pavement Construction Documents
Worksheets, guides and specification sheets for pavement construction projects.

Employee Directory
Staff contacts for *Construction Unit.*

Contact Form
For questions & feedback about this area of Connect NCDOT, contact *Construction Unit.*

Asphalt and Fuel Prices

Pricing for terminal asphalt binder, fuel and AC (Asphalt-Cement).

Average Terminal Prices: Fuel & AC Monthly Terminal Asphalt Binder FOB Prices [#MSOZoneCell_WebPartWPQ4]
PG64-22 Asphalt Binder Pricing [#MSOZoneCell_WebPartWPQ7]

Date [javascript:]	English Fuel Price [javascript:]	Metric Fuel Price [javascript:]	English AC Price [javascript:]	Metric AC Price [javascript:]
1/1/2014 [javascript:]	3.1407 [javascript:]	0.8297	561.07	618.46
12/1/2013	3.1244	0.8254	562.19	619.70
11/1/2013	3.0850	0.8150	569.38	627.62
10/1/2013	3.0655	0.8098	572.81	631.40
9/1/2013	3.2446	0.8571	573.13	631.76
8/1/2013	3.1538	0.8331	588.44	648.63
7/1/2013	2.9570	0.7812	593.44	654.15
6/1/2013	2.8880	0.7629	590.31	650.59
5/1/2013	2.9306	0.7742	559.06	616.25
4/1/2013	3.1691	0.8372	552.50	609.02
3/1/2013	3.1631	0.8356	553.75	610.39
2/1/2013	3.2793	0.8663	546.56	602.47

[JAVASCRIPT:] [JAVASCRIPT:]

Pavement Resources

Pavement Construction Documents
Worksheets, guides and specification sheets for pavement construction projects.

Employee Directory
Staff contacts for *Construction Unit*.

Contact Form
For questions & feedback about this area of Connect NCDOT, contact *Construction Unit*.

Asphalt and Fuel Prices

Pricing for terminal asphalt binder, fuel and AC (Asphalt-Cement).

Average Terminal Prices: Fuel & AC Monthly Terminal Asphalt Binder FOB Prices [#MSOZoneCell_WebPartWPQ4]
PG64-22 Asphalt Binder Pricing [#MSOZoneCell_WebPartWPQ7]

Date [javascript:]	English Fuel Price [javascript:]	Metric Fuel Price [javascript:]	English AC Price [javascript:]	Metric AC Price [javascript:]
1/1/2015 [javascript:]	2.0633 [javascript:]	0.5426	578.85	638.06
12/1/2014	2.5028	0.6612	598.46	659.68
11/1/2014	2.6380	0.6969	608.46	670.70
10/1/2014	2.7552	0.7278	624.23	688.08
9/1/2014	2.9552	0.7807	630.00	694.44
8/1/2014	2.9777	0.7866	611.92	674.52
7/1/2014	3.0612	0.8087	594.00	654.76
6/1/2014	2.9971	0.7918	580.67	640.07
5/1/2014	3.0511	0.8060	572.67	631.25
4/1/2014	3.1143	0.8227	556.33	613.24
3/1/2014	3.2882	0.8687	558.21	615.31
2/1/2014	3.1476	0.8315	559.29	616.50

[JAVASCRIPT:] [JAVASCRIPT:]

Pavement Resources

Pavement Construction Documents
Worksheets, guides and specification sheets for pavement construction projects.

Employee Directory
Staff contacts for *Construction Unit*.

Contact Form
For questions & feedback about this area of Connect NCDOT, contact *Construction Unit*.

Asphalt and Fuel Prices

Pricing for terminal asphalt binder, fuel and AC (Asphalt-Cement).

Average Terminal Prices: Fuel & AC Monthly Terminal Asphalt Binder FOB Prices [#MSOZoneCell_WebPartWPQ4]
PG64-22 Asphalt Binder Pricing [#MSOZoneCell_WebPartWPQ7]

Date [javascript:]	English Fuel Price [javascript:]	Metric Fuel Price [javascript:]	English AC Price [javascript:]	Metric AC Price [javascript:]
1/1/2016 [javascript:]	1.1954 [javascript:]	0.3161	401.43	442.49
12/1/2015	1.4384	0.3800	410.00	451.94
11/1/2015	1.5065	0.3980	423.21	466.50
10/1/2015	1.5374	0.4061	437.31	482.04
9/1/2015	1.4789	0.3907	464.62	512.15
8/1/2015	1.7405	0.4598	479.62	528.68
7/1/2015	1.9859	0.5246	473.08	521.47
6/1/2015	2.0345	0.5375	470.00	518.08
5/1/2015	2.0563	0.5432	483.08	532.49
4/1/2015	1.8192	0.4806	511.15	563.44
3/1/2015	2.1882	0.5781	540.77	596.09
2/1/2015	1.7910	0.4731	557.69	614.74

[JAVASCRIPT:] [JAVASCRIPT:]

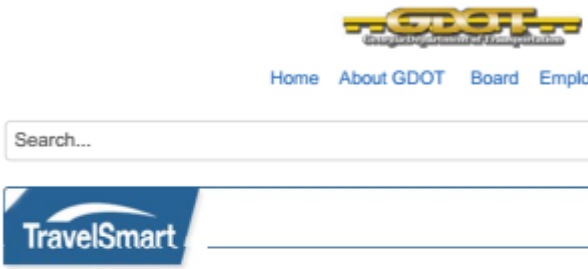
Pavement Resources

Pavement Construction Documents
Worksheets, guides and specification sheets for pavement construction projects.

Employee Directory
Staff contacts for *Construction Unit*.

Contact Form
For questions & feedback about this area of Connect NCDOT, contact *Construction Unit*.

PRICE INDEX FROM DEPARTMENT OFTRANSPORTATION OF THE STATE OF GEORGIA



Home About GDOT Board Employment Contact Us Site Map

Search...

Home -> Partner Smart -> Materials -> Asphalt Cement / Fuel Price Index

Asphalt & Fuel Index

Asphalt Cement Price Index

Beginning with awarded contracts in the September 17, 2009 letting, payments under Section 109 "Monthly Asphalt Cement Price" on eligible projects will be made using the Georgia Base Asphalt Price.

Filter

Year Exclude from search

Month Exclude from search -Select One-

Go! Reset Close

Year	Month	English	Metric	Let Date
2015	March	$505 /Ton	$557 /MG	After Sept 2009
2015	February	$534 /Ton	$589 /MG	Prior to Sept 2009
2015	February	$534 /Ton	$589 /MG	After Sept 2009
2015	January	$556 /Ton	$613 /MG	Prior to Sept 2009
2015	January	$556 /Ton	$613 /MG	After Sept 2009
2014	December	$576 /Ton	$635 /MG	After Sept 2009
2014	December	$575 /Ton	$634 /MG	Prior to Sept 2009
2014	November	$595 /Ton	$656 /MG	Prior to Sept 2009
2014	November	$600 /Ton	$661 /MG	After Sept 2009
2014	October	$615 /Ton	$678 /MG	After Sept 2009
2014	October	$602 /Ton	$664 /MG	Prior to Sept 2009
2014	September	$601 /Ton	$662 /MG	Prior to Sept 2009

1 2 3 4 5 6 7 8 | Displaying Page 2, items 27 to 52

2014	September	$618 /Ton	$681 /MG	After Sept 2009
2014	August	$608 /Ton	$670 /MG	After Sept 2009
2014	August	$591 /Ton	$651 /MG	Prior to Sept 2009
2014	July	$596 /Ton	$657 /MG	After Sept 2009
2014	July	$574 /Ton	$633 /MG	Prior to Sept. 2009
2014	June	$566 /Ton	$624 /MG	Prior to Sept. 2009
2014	June	$581 /Ton	$640 /MG	After Sept. 2009
2014	May	$561 /Ton	$618 /MG	Prior to Sept 2009
2014	May	$572 /Ton	$630 /MG	After Sept 2009
2014	April	$563 /Ton	$621 /MG	After Sept 2009
2014	April	$557 /Ton	$614 /MG	Prior to Sept 2009
2014	March	$563 /Ton	$621 /MG	After Sept 2009
2014	March	$557 /Ton	$614 /MG	Prior to Sept 2009
2014	February	$558 /Ton	$615 /MG	After Sept 2009

1 2 3 4 5 6 7 8 | Displaying Page 2, items 27 to 52

Fuel Price Index (Georgia Average Price)

The Fuel Adjustment Index (Georgia Average Prices) is posted in accordance with Special Provision 109 - Measurement and Payment. Average prices can be found at http://www.fuelgaugereport.com

Filter

Year Exclude from search

Month Exclude from search -Select One-

Go! Reset Close

Year	Month	Regular	Diesel
2017	January	$2.252 /Gal	$2.475 /Gal
2016	December	$2.092 /Gal	$2.395 /Gal
2016	November	$2.159 /Gal	$2.405 /Gal
2016	October	$2.318 /Gal	$2.390 /Gal
2016	September	$2.135 /Gal	$2.359 /Gal
2016	August	$1.989 /Gal	$2.299 /Gal
2016	July	$2.126 /Gal	$2.341 /Gal
2016	June	$2.267 /Gal	$2.311 /Gal

1 2 3 4 5 6 7 8 9 10 | Displaying Page 1, items 1 to 13

Home About GDOT Board Employment Contact Us Site Map

Search...

TravelSmart

Home -> Partner Smart -> Materials -> Asphalt Cement / Fuel Price Index

Asphalt & Fuel Index

Asphalt Cement Price Index

Beginning with awarded contracts in the September 17, 2009 letting, payments under Section 109 "Monthly Asphalt Cement Price" on eligible projects will be made using the Georgia Base Asphalt Price.

Filter

Year: Exclude from search

Month: Exclude from search -Select One-

Go! Reset Close

Year	Month	English	Metric	Let Date
2014	February	$549 /Ton	$605 /MG	Prior to Sept 2009
2014	January	$557 /Ton	$614 /MG	After Sept 2009
2014	January	$549 /Ton	$605 /MG	Prior to Sept 2009
2013	December	$559 /Ton	$616 /MG	After Sept 2009
2013	December	$550 /Ton	$606 /MG	Prior to Sept 2009
2013	November	$565 /Ton	$623 /MG	After Sept 2009
2013	November	$556 /Ton	$613 /MG	Prior to Sept 2009
2013	October	$568 /Ton	$626 /MG	After Sept 2009
2013	October	$558 /Ton	$616 /MG	Prior to Sept 2009
2013	September	$571 /Ton	$629 /MG	After Sept 2009
2013	September	$561 /Ton	$618 /MG	Prior to Sept 2009
2013	August	$576 /Ton	$635 /MG	After Sept 2009

1 2 3 4 5 6 7 8 | Displaying Page 3, items 53 to 78

2013	August	$569 /Ton	$627 /MG	Prior to Sept 2009
2013	July	$572 /Ton	$630 /MG	After Sept 2009
2013	July	$570 /Ton	$628 /MG	Prior to Sept 2009
2013	June	$567 /Ton	$625 /MG	After Sept 2009
2013	June	$568 /Ton	$626 /MG	Prior to Sept 2009
2013	May	$565 /Ton	$623 /MG	After Sept 2009
2013	May	$567 /Ton	$625 /MG	Prior to Sept 2009
2013	April	$565 /Ton	$623 /MG	After Sept 2009
2013	April	$567 /Ton	$625 /MG	Prior to Sept 2009
2013	March	$567 /Ton	$625 /MG	After Sept 2009
2013	March	$568 /Ton	$626 /MG	Prior to Sept 2009
2013	February	$565 /Ton	$623 /MG	After Sept 2009
2013	February	$567 /Ton	$625 /MG	Prior to Sept 2009
2013	January	$567 /Ton	$625 /MG	After Sept 2009

1 2 3 4 5 6 7 8 | Displaying Page 3, items 53 to 78

Fuel Price Index (Georgia Average Price)

The Fuel Adjustment Index (Georgia Average Prices) is posted in accordance with Special Provision 109 - Measurement and Payment. Average prices can be found at http://www.fuelgaugereport.com

Filter

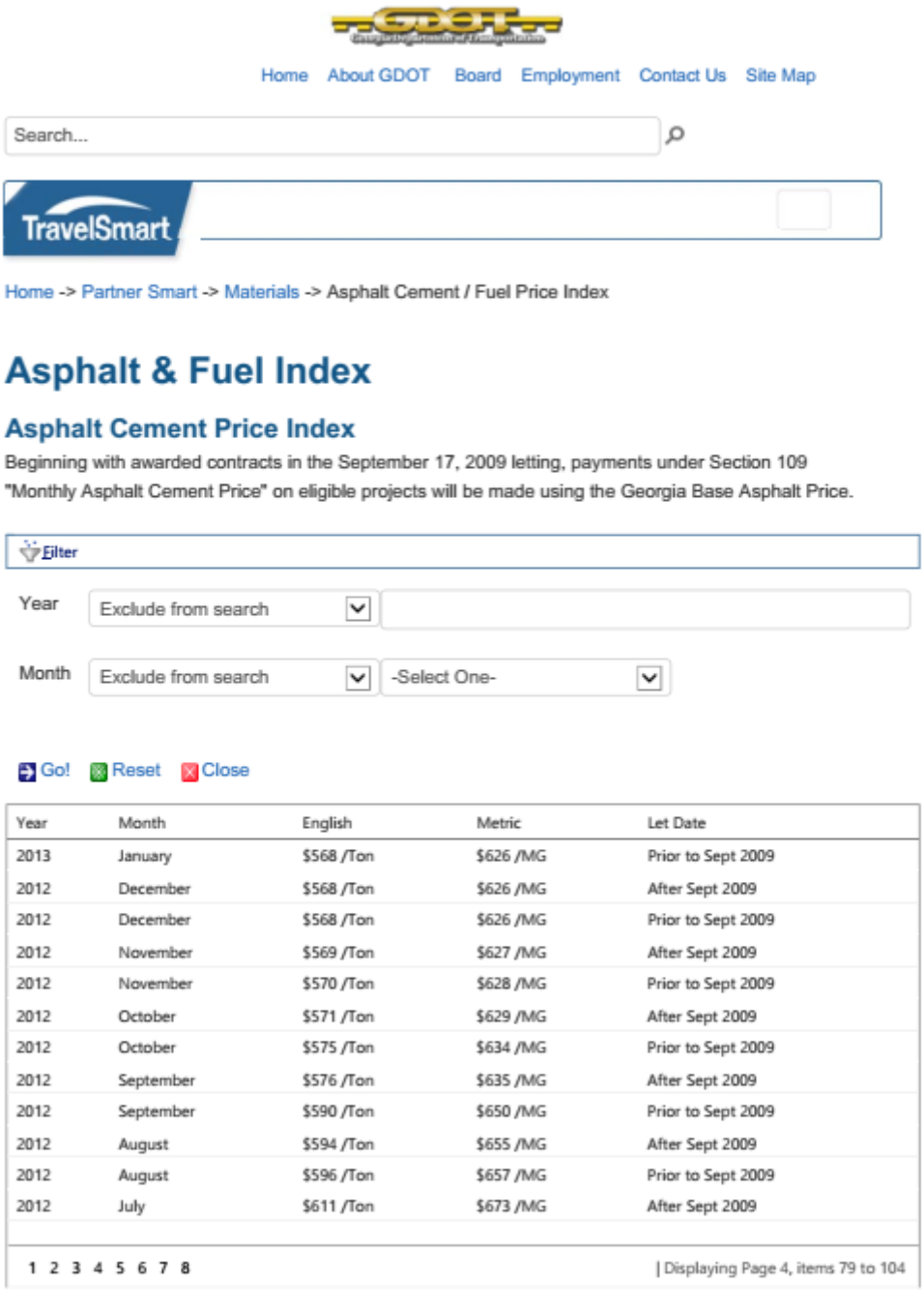
Year: Exclude from search

Month: Exclude from search -Select One-

Go! Reset Close

Year	Month	Regular	Diesel
2017	January	$2.252 /Gal	$2.475 /Gal
2016	December	$2.092 /Gal	$2.395 /Gal
2016	November	$2.159 /Gal	$2.405 /Gal
2016	October	$2.318 /Gal	$2.390 /Gal
2016	September	$2.135 /Gal	$2.359 /Gal
2016	August	$1.989 /Gal	$2.299 /Gal
2016	July	$2.126 /Gal	$2.341 /Gal
2016	June	$2.267 /Gal	$2.311 /Gal

1 2 3 4 5 6 7 8 9 10 | Displaying Page 1, items 1 to 13



Home About GDOT Board Employment Contact Us Site Map

Search...

TravelSmart

Home -> Partner Smart -> Materials -> Asphalt Cement / Fuel Price Index

Asphalt & Fuel Index

Asphalt Cement Price Index

Beginning with awarded contracts in the September 17, 2009 letting, payments under Section 109 "Monthly Asphalt Cement Price" on eligible projects will be made using the Georgia Base Asphalt Price.

Filter

Year: Exclude from search

Month: Exclude from search -Select One-

Go! Reset Close

Year	Month	English	Metric	Let Date
2013	January	$568 /Ton	$626 /MG	Prior to Sept 2009
2012	December	$568 /Ton	$626 /MG	After Sept 2009
2012	December	$568 /Ton	$626 /MG	Prior to Sept 2009
2012	November	$569 /Ton	$627 /MG	After Sept 2009
2012	November	$570 /Ton	$628 /MG	Prior to Sept 2009
2012	October	$571 /Ton	$629 /MG	After Sept 2009
2012	October	$575 /Ton	$634 /MG	Prior to Sept 2009
2012	September	$576 /Ton	$635 /MG	After Sept 2009
2012	September	$590 /Ton	$650 /MG	Prior to Sept 2009
2012	August	$594 /Ton	$655 /MG	After Sept 2009
2012	August	$596 /Ton	$657 /MG	Prior to Sept 2009
2012	July	$611 /Ton	$673 /MG	After Sept 2009

1 2 3 4 5 6 7 8 | Displaying Page 4, items 79 to 104

2012	July	$616 /Ton	$679 /MG	Prior to Sept 2009
2012	June	633 /Ton	$598 /MG	After Sept 2009
2012	June	$627 /Ton	$691 /MG	Prior to Sept 2009
2012	May	$626 /Ton	$690 /MG	After Sept 2009
2012	May	$615 /Ton	$680 /MG	Prior to Sept 2009
2012	April	$623 /Ton	$687 /MG	After Sept 2009
2012	April	$613 /Ton	$676 /MG	Prior to Sept 2009
2012	March	$614 /Ton	$677 /MG	After Sept 2009
2012	March	$602 /Ton	$664 /MG	Prior to Sept 2009
2012	February	$604 /Ton	$666 /MG	After Sept 2009
2012	February	$591 /Ton	$651 /MG	Prior to Sept 2009
2012	January	$578 /Ton	$637 /MG	After Sept 2009
2012	January	$568 /Ton	$626 /MG	Prior to Sept 2009
2011	December	$567 /Ton	$625 /MG	After Sept 2009

1 2 3 4 5 6 7 8 | Displaying Page 4, items 79 to 104

Fuel Price Index (Georgia Average Price)

The Fuel Adjustment Index (Georgia Average Prices) is posted in accordance with Special Provision 109 - Measurement and Payment. Average prices can be found at http://www.fuelgaugereport.com

Filter

Year Exclude from search

Month Exclude from search -Select One-

Go! Reset Close

Year	Month	Regular	Diesel
2017	January	$2.252 /Gal	$2.475 /Gal
2016	December	$2.092 /Gal	$2.395 /Gal
2016	November	$2.159 /Gal	$2.405 /Gal
2016	October	$2.318 /Gal	$2.390 /Gal
2016	September	$2.135 /Gal	$2.359 /Gal
2016	August	$1.989 /Gal	$2.299 /Gal
2016	July	$2.126 /Gal	$2.341 /Gal
2016	June	$2.267 /Gal	$2.311 /Gal

1 2 3 4 5 6 7 8 9 10 | Displaying Page 1, items 1 to 13

Oklahoma Department of Transportation
Monthly Asphalt Binder Price Index

As per Special Provision 109-7(a-b)99.
The price shown is the average selling price of PG 64-22 asphalt binder as listed under "Midwest/Mid-Continent Market - Tulsa, Oklahoma/Southern Kansas area", as published in the last issue of the Asphalt Weekly Monitor furnished by Poten & Partners, Inc. for the month prior to the month listed.

YEAR	MONTH	Dollars ($) per STANDARD TON
2017	January	$280.00
2016	December	$280.00
2016	November	$280.00
2016	October	$280.00
2016	September	$300.00
2016	August	$300.00
2016	July	$300.00
2016	June	$300.00
2016	May	$305.00
2016	April	$310.00
2016	March	$340.00
2016	February	$350.00
2016	January	$360.00
2015	December	$362.50
2015	November	$382.50
2015	October	$417.50
2015	September	$440.00
2015	August	$447.50
2015	July	$447.50
2015	June	$452.50
2015	May	$457.50
2015	April	$462.50
2015	March	$477.50
2015	February	$512.50
2015	January	$545.00
2014	December	$557.50
2014	November	$590.00
2014	October	$595.00
2014	September	$590.00
2014	August	$567.50
2014	July	$567.50
2014	June	$542.50
2014	May	$512.50
2014	April	$517.50

12/27/2016

YEAR	MONTH	Dollars ($) per STANDARD TON
2014	March	$527.50
2014	February	$532.50
2014	January	$532.50
2013	December	$532.50
2013	November	$532.50
2013	October	$532.50
2013	September	$532.50
2013	August	$542.50
2013	July	$540.00
2013	June	$540.00
2013	May	$540.00
2013	April	$545.00
2013	March	$545.00
2013	February	$545.00
2013	January	$545.00
2012	December	$545.00
2012	November	$545.00
2012	October	$545.00
2012	September	$550.00
2012	August	$562.50
2012	July	$587.50
2012	June	$587.50
2012	May	$582.50
2012	April	$562.50
2012	March	$537.50
2012	February	$537.50
2012	January	$535.00
2011	December	$535.00
2011	November	$535.00
2011	October	$552.50
2011	September	$557.50
2011	August	$557.50
2011	July	$557.50
2011	June	$557.50
2011	May	$492.50
2011	April	$462.50
2011	March	$440.00
2011	February	$440.00
2011	January	$427.50
2010	December	$427.50
2010	November	$432.50

12/27/2016

PRICE INDEX FROM DEPARTMENT OFTRANSPORTATION OF THE STATE OF WESTVIRGINIA

Fuel, Asphalt, and Cement Prices

Download Excel spreadsheet from Maintenance Purchase Order Contract Asphalt Prices site

- Fuel Prices
- Asphalt Prices
- Cement Prices

Contract Bidding Indexes

Letting Date	#2 Fuel (Cbp)		Asphalt (lb)		Cement (lb)	
	English	Metric	English	Metric	English	Metric
1/2/2017	1.7898	0.4729	301.00	331.80	99.10	109.23
12/1/2016	1.6113	0.4257	300.00	330.70	99.10	109.23
11/1/2016	1.5928	0.4208	300.00	330.70	99.10	109.23
10/3/2016	1.5985	0.4223	302.00	332.90	99.10	109.23
9/1/2016	1.5735	0.4157	311.00	342.82	107.76	118.78
8/1/2016	1.2941	0.3419	316.00	348.33	107.76	118.78
7/1/2016	1.5695	0.4147	309.00	340.62	107.76	118.78
6/1/2016	1.5981	0.4222	311.00	342.82	107.76	118.78
5/1/2016	1.4456	0.3819	320.00	353.74	107.76	118.78
4/1/2016	1.2868	0.3400	330.00	363.77	107.76	118.78
3/1/2016	1.1127	0.2940	333.00	367.07	107.76	118.78
2/1/2016	1.0574	0.2794	370.00	407.86	107.76	118.78
1/1/2016	1.1471	0.3031	393.00	433.21	107.76	118.78
12/1/2015	1.3979	0.3693	405.00	446.44	107.76	118.78
11/1/2015	1.6462	0.4349	426.00	469.59	107.76	118.78
10/1/2015	1.5719	0.4153	442.00	487.23	107.76	118.78
9/1/2015	1.4883	0.3932	456.00	502.66	107.76	118.78
8/4/2015	1.6318	0.4311	462.00	509.27	107.76	118.78
7/7/2015	1.9278	0.5093	460.00	507.07	107.76	118.78
6/9/2015	2.0892	0.5520	458.00	504.86	107.76	118.78
5/19/2015	1.8726	0.4947	466.00	513.68	107.76	118.78
4/14/2015	1.8467	0.4879	488.00	537.93	107.76	118.78
3/17/2015	2.0198	0.5336	509.00	561.08	107.76	118.78
2/10/2015	1.7266	0.4562	539.00	594.15	107.76	118.78
1/13/2015	1.8850	0.4980	559.00	616.20	107.76	118.78
12/9/2014	2.6931	0.7115	578.00	637.14	107.76	118.78
11/18/2014	2.6753	0.7068	591.00	651.47	107.76	118.78
10/7/2014	2.8312	0.7480	603.00	664.70	107.76	118.78
9/9/2014	2.9059	0.7677	606.00	668.01	107.76	118.78
8/5/2014	2.9506	0.7795	593.00	653.68	107.76	118.78
7/8/2014	3.1234	0.8252	578.00	637.14	107.76	118.78
6/10/2014	3.0955	0.8178	562.00	619.50	107.76	118.78
5/6/2014	3.2158	0.8496	551.00	607.38	107.76	118.78
4/15/2014	3.2227	0.8515	542.00	597.46	107.76	118.78
3/18/2014	3.5672	0.9425	544.00	599.66	107.76	118.78
2/11/2014	3.1919	0.8433	546.00	601.87	99.70	109.90
1/14/2014	3.1640	0.8359	548.00	604.07	99.70	109.90
12/10/2013	3.0694	0.8109	549.00	605.17	99.70	109.90
11/5/2013	3.0875	0.8157	554.00	610.69	99.70	109.90
10/8/2013	3.0751	0.8124	563.00	620.61	99.70	109.90
9/10/2013	3.1595	0.8347	564.00	621.71	99.70	109.90
8/20/2013	3.0672	0.8104	569.00	627.22	99.70	109.90

Letting Date	#2 Fuel (Cbp)		Asphalt (lb)		Cement (lb)	
	English	Metric	English	Metric	English	Metric
8/6/2013	3.0672	0.8104	569.00	627.22	99.70	109.90
7/23/2013	3.0068	0.7944	568.00	626.12	99.70	109.90
7/9/2013	3.0068	0.7944	568.00	626.12	99.70	109.90
6/25/2013	3.0314	0.8009	569.00	627.22	99.70	109.90
6/11/2013	3.0314	0.8009	569.00	627.22	99.70	109.90
5/14/2013	2.9957	0.7915	550.00	606.28	99.70	109.90
4/30/2013	3.0913	0.8167	545.00	546.25	99.70	109.90
4/16/2013	3.0913	0.8167	545.00	546.25	99.70	109.90
3/12/2013	3.3707	0.8906	541.00	596.36	99.70	109.90
2/5/2013	3.1611	0.8352	539.00	594.15	99.70	109.90
1/31/2013	3.1678	0.8369	554.00	610.69	99.70	109.90
1/15/2013	3.1678	0.8369	554.00	610.69	99.70	109.90
12/20/2012	3.4994	0.9245	564.00	621.71	99.70	109.90
12/6/2012	3.4994	0.9245	564.00	621.71	99.70	109.90
12/4/2012	3.4994	0.9245	564.00	621.71	99.70	109.90
11/14/2012	3.2256	0.8522	567.00	625.02	99.70	109.90
11/8/2012	3.2256	0.8522	567.00	625.02	99.70	109.90
10/23/2012	3.2034	0.8463	567.00	625.02	99.70	109.90
9/25/2012	3.3015	0.8723	568.00	640.45	102.20	112.66
9/11/2012	3.3015	0.8723	581.00	640.45	102.20	112.66
8/21/2012	3.0096	0.7951	602.00	663.60	102.20	112.66
8/7/2012	3.0096	0.7951	602.00	663.60	102.20	112.66
7/24/2012	2.7048	0.7146	613.00	675.72	102.20	112.66
7/19/2012	2.7048	0.7146	613.00	675.72	102.20	112.66
7/10/2012	2.7048	0.7146	613.00	675.72	102.20	112.66
6/19/2012	2.9925	0.7906	611.00	673.52	99.69	109.88
6/12/2012	2.9925	0.7906	611.00	673.52	99.69	109.88
6/5/2012	2.9925	0.7906	611.00	673.52	99.69	109.88
5/22/2012	3.3362	0.8814	605.00	666.90	99.69	109.88
5/10/2012	3.3362	0.8814	605.00	666.90	99.69	109.88
5/2/2012	3.3362	0.8814	605.00	666.90	99.69	109.88
4/17/2012	3.4212	0.9039	597.00	658.09	99.69	109.88
4/13/2012	3.4212	0.9039	597.00	658.09	99.69	109.88
4/3/2012	3.4212	0.9039	597.00	658.09	99.69	109.88
3/20/2012	3.3681	0.8898	597.00	658.09	98.14	108.18
3/14/2012	3.3681	0.8898	597.00	658.09	98.14	108.18
3/6/2012	3.3681	0.8898	597.00	658.09	98.14	108.18
2/22/2012	3.1127	0.8224	579.00	638.24	98.14	108.18
1/18/2012	2.9810	0.7876	563.00	620.61	98.14	108.18
1/4/2012	2.9810	0.7876	563.00	620.61	98.14	108.18
12/13/2011	3.1552	0.8336	540.00	595.25	98.14	108.18
11/15/2011	3.1576	0.8343	540.00	595.25	98.14	108.18
11/1/2011	2.9752	0.7861	552.00	608.48	98.14	108.18
10/18/2011	2.9752	0.7861	552.00	608.48	98.14	108.18
10/13/2011	2.9752	0.7861	552.00	608.48	98.14	108.18
10/4/2011	2.9752	0.7861	552.00	608.48	98.14	108.18
9/20/2011	3.1323	0.8276	557.00	613.99	98.14	108.18
9/15/2011	3.1323	0.8276	557.00	613.99	98.14	108.18
9/7/2011	3.1323	0.8276	557.00	613.99	98.14	108.18
8/23/2011	3.2062	0.8471	574.00	632.73	97.64	107.63
8/9/2011	3.2062	0.8471	574.00	632.73	97.64	107.63
7/26/2011	3.1006	0.8192	578.00	637.14	97.64	107.63
7/12/2011	3.1006	0.8192	578.00	637.14	97.64	107.63
6/28/2011	3.1790	0.8399	574.00	632.73	97.64	107.63
6/14/2011	3.1790	0.8399	574.00	632.73	97.64	107.63
6/1/2011	3.3974	0.8976	529.00	583.13	97.64	107.63
5/17/2011	3.3974	0.8976	529.00	583.13	97.64	107.63
5/3/2011	3.0529	0.8066	529.00	583.13	95.14	104.87
4/26/2011	3.2529	0.8066	529.00	583.13	95.14	104.87
4/20/2011	3.2529	0.8066	529.00	583.13	95.14	104.87
4/19/2011	3.2529	0.8066	529.00	583.13	95.14	104.87

PRICE INDEX FROM NOC ETHIOPIA

NATIONAL OIL ETHIOPIA PLC (NOC)

Supplier's VAT Reg. No. 21901
Supplier's TIN No. 0000059459
Date of Registration 07-Aug-2004

Cape Verde Road
P.O.Box 951 code 1250
Tel. 251-11-663-94-91/94
Fax. 251-11-663-94-95

PRICE INDEX

Date: - November 27, 2015

To: - CGC Overseas Construction Eth. Ltd.
Addis Ababa

Following to your request dated on November 24, 2015 for the price index of bitumen grades of AC 60-70 and AC 80-100 from March, 2011 up to Mach, 2015 at delivery site of **Addis Ababa** our price is presented as per the following **(VAT inclusive).**

Date	Birr/Mt AC 80-100	Birr/Mt AC 60-70
January, 2011 - April, 2011	19,500.00	19,500.00
May, 2011 - July, 2011	21,250.00	21,250.00
August , 2011 - December, 2011	21,500.00	21,500.00
January, 2012 - August, 2012	21,500.00	21,500.00
September, 2012 - December, 2012	22,866.00	22,866.00
January, 2103 - March,2013	22,866.00	22,866.00
April, 2013 - October, 2013	25,521.00	25,521.00
November, 2013 - December, 2013	23,900.00	23,900.00
January, 2014 - June, 2014	24,335.00	24,335.00
July, 2014 - November, 2014	24,270.00	24,270.00
December, 2014 - January 9, 2015	22,606.00	22,606.00
January 10, 2015 - March, 2015	21,140.00	21,140.00

We hope the above satisfies your requirement.

We are always looking forward to thriving partnership with your esteemed company.

Faithfully yours,

Getahun Mengistu
Bitumen & Special Products Manager

National Oil Ethiopia PLC (NOC)

FAX NO. : +251-11- 6639495
TEL. : +251-11- 6639498/91
Cape Verde Street
P. O. Box 951 Code 1250
Addis Ababa, Ethiopia

Price Index

Date: 25/2/2016

Customer's Name: **CGC Overseas Construction Eth. Ltd**
Customer's Request letter for Price Index: ***Ref. No. CGCOC/LOG/20160225/04 and date: Jan. 25, 2016***
Delivery Place :-**Addis Ababa**

No	Date of Price Index	Product Type
		Bitumen penetration grade 60-70 & Bitumen penetration grade 80-100 (Birr per Mt)
1	January 26, 2015 - January 31, 2015	21,535.00
2	February, 2015 - June, 2015	21,140.00
3	July, 2015 - October 14, 2015	21,700.00
4	October 15, 2015 - January 14, 2016	20,810.00
5	January 15, 2016 - February 14, 2016	20,522.00
6	February 15,2016- February 25, 2016	19,648.00

Note : The above price are 15%VAT inclusive

Should you need any further information, please do not hesitate to contact us.

NOC is the Customers' preferred choice.

Yours faithfully,

Getahun Mengistu
Bitumen & Special Products Manager

PRICE INDEX FROM CANADA - MTO AC

MTO AC Price Index

View Historical MTO AC Price Index Graph (http://www.ohmpa.org/mtopriceindex/price_index_graph.html)

Contract Language (http://www.ohmpa.org/mtopriceindex/contract_language.html)

AUG 17, 2015: PLEASE CLICK HERE TO VIEW THE QUALITY OF ASPHALT PAVEMENT TASK FORCE'S SPECIAL BULLETIN #4 (http://www.ohmpa.org/qaptf---bulletin-4.html)

MTO AC Price Index

	2016	2015	2014	2013	2012	2011	2010	2009
Jan	$648.75	$832.75	$679.50	$723.75	$615.95	$624.25	$540.75	$739.8
Feb	$648.75	$832.75	$679.50	$723.75	$615.95	$624.25	$540.75	$739.8
Mar	$624.40	$810.00	$747.00	$723.75	$615.95	$624.25	$540.75	$739.8
Apr	$598.00	$795.50	$759.75	$731.55	$762.50	$685.50	$751.75	$707.2
May	$574.05	$767.60	$769.60	$731.25	$782.50	$693.13	$747.05	$698.(
Jun	$559.05	$739.05	$788.50	$731.25	$779.75	$688.75	$678.30	$668.2
Jul	$555.00	$732.35	$811.75	$707.50	$753.75	$679.25	$656.80	$592.6
Aug	$537.80	$729.90	$834.20	$699.50	$748.75	$665.95	$624.30	$581.2
Sep	$508.75	$711.25	$850.50	$709.55	$733.15	$641.50	$615.50	$551.5
Oct	$495.65	$682.80	$857.40	$693.15	$723.75	$618.15	$626.25	$523.9
Nov	$481.55	$648.75	$832.75	$679.50	$723.75	$615.95	$624.25	$540.7
Dec	$481.55	$648.75	$832.75	$679.50	$723.75	$615.95	$624.25	$540.7