Operation of Price Adjustment in Construction Projects

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ABSTRACT

The construction industry always faces problems on price fluctuation and adjustment of the price to compensate the cost fluctuation becomes necessary. There is dilemma on which formula of price adjustment to use in construction contracts. Price adjustment affects all the stakeholders i.e. client, consultant and contractor. This research has revealed about the trend of the cost of components of construction i.e. labor, material, fuel, equipment, etc. and compare the different formulas of price adjustment Ten contracts commencing within 2010 A.D to 2019 A.D have been chosen. The formula used in the contracts has been compared with other formulas under same circumstance that original formula was used. The cost of fuel and bitumen cannot be predicted as it is fluctuating with respect to time. PPMO formula for Price Adjustment use NRB index of labor, material and equipment or fuel. Labor index has increased by 44.86 % during June 2015 to June 2019. Material index is fluctuating and has increased by 20.66% and Equipment index by 31.54%. Comparing the price adjustment factor using different formulas it is seen that the value of price adjustment factor using different formulas are different and change with course of time. Thus, it cannot be generalized that which formula could give minimum value of price adjustment. It depends upon condition such as time, index and cost.

Keywords: Trend, Price adjustment, Index, Initial completion date, Formulas

1. INTRODUCTION:

Price fluctuations are the outcome of different forces i.e. both national and international bazzar forces, along with components of the development sector that mainly causes it vulnerable to average cost fluctuation and bank economic report (Riggs, 2006) [1]. Price fluctuation has become a very obvious trend in current economic scenario, all over the world. It particularly gets very important in the developing countries due to the dependency of the country on external factors (MCCartney, 2011) [2]. Market price fluctuations all levels directly affect contractors. Besides the contractor, the client and the beneficiaries of construction project also are affected by price fluctuation. Inflation has become an ongoing issue whose impacts saturate the whole development industry. Contractual workers are confronted with extreme vulnerability in offering and financing chips away at ventures. Efficiency is influenced on the grounds that contractual worker can't precisely estimate long haul returns on their ventures and are needed to redirect important funding to meet asset costs (Mishra and Regmi, 2017) [3]. It is therefore a major concern to know how the price of different components of construction is fluctuating during various time of a construction project and know the trend so that we can predict the risk in a more accurate way.

For addressing the adverse effect of price fluctuation price adjustment provision is introduced in most of the contracts with duration greater than 12 months. According to 'Price Adjustment Guidance on Procurement 2018', there is no single price adjustment formula that encompasses every situation. Different formulas are applied in contracts of different sizes and for different components. A contract may comprise one or more currencies of payment. For a contract with price adjustment provisions, at least one price adjustment formula should be given for each currency of payment. Agreements for major and complex works and plant may likewise contain a few areas, every one of which can be recognized commonly, area, access, timing, or whatever other exceptional attributes which may cause various strategies for development, staging of the

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works, or contemplations of cost. General things normal to all pieces of the works might be gathered as a different segment in the bill of amounts. For such contracts, a different price adjustment formula with different cost components and weights may be required for each group or section. So, it is of concern in construction industry to compare the different results that come by applying different price adjustment formulas and choose the one that minimizes the risk. Generally, FIDIC formula and PPMO's formula are used for price adjustment. Department of roads is one of the major agencies that conducts development activities on contractual basis. However, progress of individual project in their annual report shows that most of the time, projects are not completed within planned time, budget and also sometimes within specified quality. Price escalation is additionally considered as a major issue, which prevents venture progress, since it diminishes the contractual worker's benefit prompting immense misfortunes leaving venture in a difficult situation. There is dilemma among project personnel whether to deduct mobilization advance from IPC and calculate the price adjustment value or not to deduct mobilization advance for calculation of price adjustment.

2. OBJECTIVES:

The main objective of the paper is to analyze the trend of cost of components of construction for comparing value of price adjustment factor of selected contracts using different price adjustment formulas.

3. LITERATURE REVIEW:

3.1 Price Adjustments:

Generally, for the projects funded by Government of Nepal, price adjustment provision is used for contracts having the duration of 12 months or more. And for donor funded project (ADB), price adjustment provisions may also be used in consulting and on consulting service contracts, to adjust remuneration rates for the effects of inflation for contracts with duration of 18 months or more. Bidders will factor in the risk of price escalation when preparing their bid, depending on the contract specified in the bidding document. In a fixed-value contract, bidders will factor in the total money related dangers related with value heightening in their offers.

In a no fixed-value contract, a value change equation is utilized to appraise value acceleration, henceforth; bidders have the choice to diminish their premium related with dangers of value heightening in their offers to stay serious. A fixed-price contract may give certainty to budget and simplify contract management. However, it may lead to other problems since it requires bidders to estimate and bear the financial risks associated with price escalations. On the off chance that the evaluations are excessively high or functions don't appear, the borrower will follow through on a lofty cost that may influence the economy and proficiency of the agreement. In a worst case, it may mean that the bid price is then above budget and may lead to a reduction in the requirements or rebidding. If the estimates are too low, it may appear as an abnormally low bid and disrupt contract execution (ADB, 2018) [4].

Value change arrangements incorporate equations intended to address issues, and can shield both the borrower and temporary workers from value variances. Value change equations permit contractual workers to offer more practical costs at the hour of offering. Despite concerns that they may lead to budget uncertainties, price adjustment formulas will estimate the actual cost implications that will be encountered. They use indexes that can be used for cost projection (ADB, 2018) [4].

3.2 Deciding to Apply Price Adjustments:

This danger of value acceleration is probably going to arise for merchandise contracts with long conveyance periods, for works contracts with long culmination periods, for major common works contracts, for gets that contain supplies or wares whose costs vary fundamentally over a brief period, for time sensitive counseling administrations, for example, development oversight administrations and for because of any unordinary conditions in the market being referred to. The longer the delivery or completion period, the more likely those market prices for components will change. Since the cost of works, for example, depends directly on the cost components, this will also affect the overall cost of works contracts. ADB thus applies a general guidance that any contract with a delivery or completion period beyond 18 months should contain an appropriate price adjustment clause (ADB, 2018) [4].

The price of some components may still vary significantly within time periods shorter than 18 months. These usually include bitumen, fuel, cement and reinforced steel. Where; the price of such components fluctuates over short periods of time, it is also appropriate to include a price adjustment clause, whatever the length of

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the contract may be (ADB, 2018) [4]. According to 'Price Adjustment Guidelines 2018, ADB', price adjustment regulation may not be compulsory for general supply contracts (i.e. not including components that are usually affected by escalating or fluctuating prices) with short delivery periods.

The procurement of certain types of hardware where typical business practice expects bidders to submit firm costs paying little mind to the conveyance time, which may be the case for (a) engineering, procurement, and construction contracting arrangements; and (b) fixed-price contracts that are common in projects financed by private sector financiers, who are generally reluctant to accept the risk of cost overruns, as it increases credit risk rating and reduces financial viability of the project. Contracts for the supply, installation, and construction of facilities wherein the value of the permanent works represents the major part of the estimated cost of the contract. All major equipment is usually supplied from fixed production lines; thus, an experienced manufacturer should be able to mitigate the risk of price fluctuations.

3.3 Price Adjustment formulas:

Price adjustment equations involve fixed or nonadjustable and customizable cost parts. Each cost part has a coefficient or weight that is determined dependent on its relative incentive to the complete agreement sum according to the designer's gauge. A value record is utilized to appraise the periodical change of unit cost of each cost part remembered for the recipe.

The following tables 'table 1' and 'table 2' gives examples of price adjustment formulas from the standard bidding documents (SBD) of the Asian Development Bank (ADB) for goods, works, and plant.

Table 1 : FIDIC Formula for Large Work

SBD	Reference [5]	Clause	Formula
Large Works	FIDIC MDB 2010	GCC 13.8	$Pn = A + b\dfrac{Ln}{Lo} + c\dfrac{En}{Eo} + d\dfrac{Mn}{Mo} + \cdots$

Where "Pn" is the change multiplier to be applied to the assessed agreement esteem in the important money of the work did in period "n," this period being a month, except if in any case expressed in the agreement information. "a" (default esteem is set at 0.15) is a fixed coefficient, expressed in the applicable table of change information, speaking to the nonadjustable segment in legally binding installments. "b", "c", "d", … are coefficients speaking to the assessed extent of each cost component identified with the execution of the works, as expressed in the pertinent table of change information. Such classified cost components might be characteristic of assets, for example, work, gear, and materials. (a + b + c + d + … = 1) "Ln", "En", "Mn", … are the current expense records or reference costs for period "n," communicated in the significant cash of installment, every one of which is pertinent to the important organized cost component on the date 49 days preceding the most recent day of the period (to which the installment declaration relates). "Lo", "Eo", "Mo", … are the base expense files or reference costs, communicated in the important cash of installment, every one of which is appropriate to the applicable arranged cost component on the base date.

Table 2 : Standard Bidding Document for Small Work

SBD	Reference [5]	Clause	Formula
Small Works	MDB harmonized	GCC 54.1	$Pc = Ac + Bc\dfrac{Imc}{Ic}$

Where, Pc is the change factor for the bit of the agreement value payable in a particular cash "c." Ac and Bc are coefficients determined in the specific states of agreement, speaking to the nonadjustable (normally 0.10 to 0.20) and movable segments, separately, of the agreement value payable in that particular money "c." Ac + Bc = 1. Imc is a merged record winning toward the month's end being invoiced and Ioc is a similar united file winning 28 days before offer opening for inputs payable; both in the particular money "c." PPMO uses price adjustment formula as shown in table 'Table 3' below :

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Table 3 : Standard Bidding Document for Project of More than a Year

SBD	Reference [6]	Clause	Formula
Works with duration greater than 12 months.	PPMO	GCC 45.1	$Pn = A + b\dfrac{Ln}{Lo} + c\dfrac{En}{Eo} + d\dfrac{Mn}{Mo} + \cdots$

Where, Pn is the change factor for the bit of the agreement value for the work carried out in the period "n".
"A" "is a constant or the non-adjustable portion of price adjustment factor to be specified in Appendix- to bid, representing the non-adjustable portion of the contract price"
"b, c, d " " are coefficients or weightages of the order 0.xx (i.e.., fractions having two significant digits) for each specified element of adjustment in the contract. The sum of a, b, c, d, etc shall be one"
"Lo, Mo, Eo" "are the base date indices for specified (adjustable) elements"
"Ln, Mn, En - " are the current date records of the predetermined (customizable components for the period "n".
Regularly following wellspring of list is applied. Public Entity will pick material Index for everything.
(a) Labor: "Public Salary and Wage Rate Index"- "Development Labor" of Nepal Rastra Bank or rate fixed by District Rate Fixation Committee
(b) Material: "National Wholesale Price Index" - Construction Materials" of Nepal Rastra Bank
(c) Equipment use: "Public Wholesale Price Index" - "Transport Vehicles and Machinery Goods" of Nepal Rastra Bank or Fuel Price fixed by Nepal Oil Corporation.
The base costs of the development materials are taken of 30 days before the cutoff time for accommodation of the offer as cited by the bidder and checked by the business. With the end goal of count of value change, the ex-manufacturing plant cost of a similar source will be mulled over. HTMA (2010) [7] are found to be referred by experience engineer for modification in private contract. Hiyassant (2000) [8] has concluded bid evaluation is significant for price fluctuation decision. Jennings (1996) [9] also highlighted prequalification and M.T. Banki (2008) [10] focuses on bidding strategy of Iranian construction industry.

3.4 Price Escalation and Adjustment Problems:

Various studies have been conducted in the past about the price adjustment and related topics. Research study has been done on "Assessment of Price Escalation and Adjustment Problems on Federal Road Construction Projects, 2013" by Mohommed Gassow Mossa [11].
The objectives of the research were to assess the causes and effects of price escalation, to identify problems of price escalation adjustment, to assess the present price escalation administration system and to forward recommendations which can assist in improving the price escalation administration on federal road construction projects.
The results showed that: poor estimation, improper planning and/or improper implementation of proper planning and project schedule changes are identified as major internal causes of price escalation in Ethiopian federal road construction projects (Mossa, 2013) [11].
Besides, increase in material cost/material price fluctuation, increase in global demand for construction materials, fluctuation in money exchange rates and limited capacity of material producers are assessed as major external causes of price escalation in Ethiopian federal road construction projects. Finally, the main effects of price escalation found in this research are higher project costs, cash flow (project financing) problem of the projects, delay and dispute among parties (Mossa, 2013) [11].
From the survey; 36%, 20% and 14% of clients, consultants and contractors respectively, showed the current price escalation administration system (practice) in federal road construction projects as very good. And it is rated good by 50%, 35% and 36% of clients, consultants and contractors respectively. However, 14% of contractors and 20% consultants believe the current price escalation administration system (practice) in federal road construction projects as poor (Mossa, 2013) [11].
Consider fluctuation/escalation clauses, consider locally available materials in design, regular cost monitoring throughout the project and develop program wide contingencies and risk management protocol are identified as major methods to manage/administer price escalation in Ethiopian federal road construction projects (Mossa, 2013) [11].

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3.5 Market Price Fluctuation Trend:

According to the response of the contractors' representative who responded to the questionnaire survey, it can be seen that the degree of predictability of construction material price fluctuation is very low. The result shows that contractors cannot easily determine how the price of materials behaves in future. Degree of unpredictability in construction materials price is higher than that of construction labor and Construction equipment (Mishra & Regmi, 2017) [3]. Occurrence of price fluctuation on construction inputs especially on construction materials is unpredictable because the construction materials price is increasing and decreasing for short period of time due to social geographical complexity though on quarterly basis it consistently increases at a lower rate (Mishra & Regmi, 2017) [3]. It was found that most of the construction materials and its raw materials are imported which makes the chain longer resulting into high price fluctuation whereas labors are not having much more options to create their high demand so they want to grow with the industry resulting into lesser price fluctuation comparatively though the increment is higher (Mishra & Regmi, 2017) [3].

4. RESEARCH METHODOLOGY:

4.1 Study Area :

This study has focused on the contracts which have the clause of price escalation and have crossed two years period in construction under 'Government of Nepal, Department of Roads, Project directorate ADB, Kathmandu' and 'Road Division Butwal, Rupandehi', Mid-hill Project east sector, Bridge Project Western Sector No.3 Banke.

Name of organizations taken for study:

1. Department of Roads, Project directorate ADB, Kathmandu.
2. Road Division Butwal, Rupandehi.
3. Mid-hill Project east sector
4. Bridge Project Western Sector No.3 Banke

Contracts under DOR having price adjustment provisions and completing two years period were selected deliberately. The ten contracts whose base date is within in past ten years are Nepalgunj-Kohalpur Road Package-1, Nepalgunj-Kohalpur Road Package-2, Bhairahawa-Lumbini-Taulihawa Road Project, Construction of Prestressed RCC bridge over TinauRiver, Puspalal Midhill Highway Project East Sector, Design & Build of Rapti Nadi Bridge, Gauri Khola Bridge, Ungrida Khola Bridge Inguriya River Bridge and Chainpur-Khandbari Road Project.

4.2 Research Design:

The trend of price adjustment of various components of construction i.e. labor, material, equipment, fuel in selected contracts of DOR has been analyzed and price adjustment factor of selected contract using different formulas have been compared. Analytical research design has been used.

4.3 Data Collection:

The secondary data have been collected through the interim payment certificates and contract documents of the selected contracts of Department of Roads, Project directorate ADB, Kathmandu', 'Road Division Butwal, Rupandehi, 'Mid-hill Project east sector' and Bridge Project Western Sector No.3 Banke. It has also been collected the data from price index published by NRB. Secondary data have been obtained from various sources such as 'Price Adjustment Guidelines of ADB, 2018', previous thesis on the related topics, relevant text books regarding price adjustment. FIDIC and PPMO documents, journal's data from previously mentioned offices.

4.4 Data Analysis and Presentation of Data:

After collection of data, the data has been classified into different categories. The cost/index of material, equipment and labor has been separately noted and each of them has been plotted on graph where x-axis is duration and y-axis are cost/index. The trend of the material, equipment, labor, fuel cost/index varies during the construction period of each selected contract have been analyzed.

The data has been used to compare the price adjustment factor of selected contract using different formulas. Each value of price adjustment calculated from the formula mentioned in the price adjustment clause of

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contract and the value of price adjustment calculated from formula other than that mentioned in price adjustment clause has been compared.

5. RESULTS AND DISCUSSION:

5.1 Trend of Cost of Components of Construction on Contracts using FIDIC formula:
FIDIC formula have been used in the contracts namely Nepalgunj-Kohalpur Road Package-1, Nepalgunj-Kohalpur Road Package-2, Bhairahawa-Lumbini-Taulihawa Road Project and Construction of Prestressed RCC bridge over Tinau River. The cost of components of construction in each IPC is taken starting from the base date and graph is plotted.

5.2 Labor Cost Trend:
The cost of labor has been taken from the district rates of the respective district on which the project is implemented. The graphs below show the actual trend of the cost of labor in the four contracts using FIDIC formula for price adjustment.
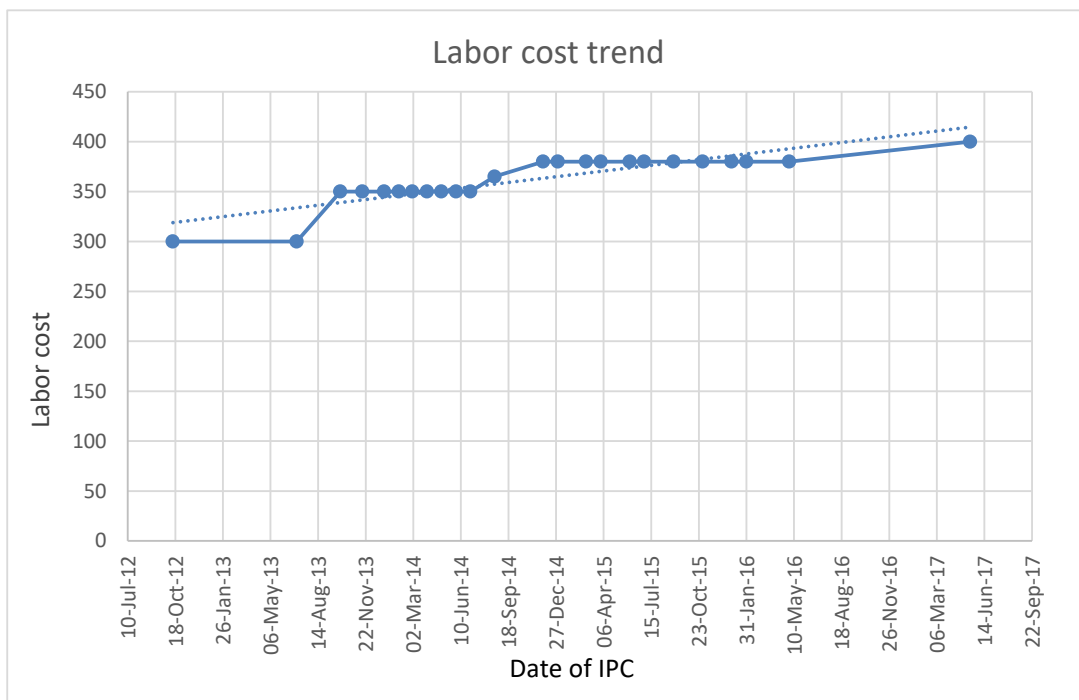
Fig. 1: Labor Cost trend of Nepalgunj Kohalpur Road Package-1

Similarly, by analyzing the all 4 contracts, it can be seen that the labor cost has increased with respective to time in every contract. Labor cost has increased by 33.33 % in Nepalgunj-Kohalpur Road Package-1, 21.67% in Nepalgunj-Kohalpur Road Package-2, 29.21%in construction of Prestressed Bridge over Tinau River and 18.17% in Bhairahawa-Lumbini-Taulihawa Road project up to the last IPC date.

5.3 Fuel Cost Trend:
The cost of fuel has been taken from the district rates of the respective district on which the project is implemented. The graphs below show the actual trend of the cost of fuel in the four contracts using FIDIC formula for Price adjustment.
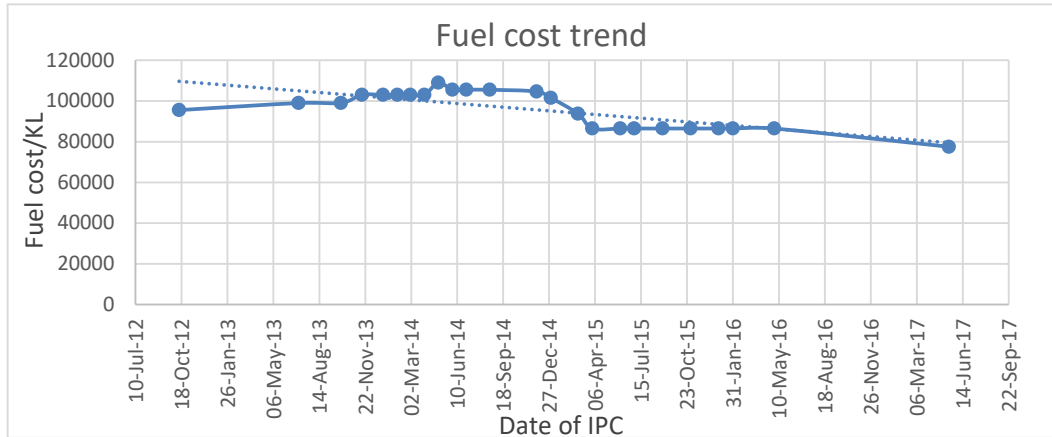
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Fig. 2: Fuel Cost trend of Nepalgunj Kohalpur Road Package-1

Similarly, by observing the all 4 contracts, it can be seen that the fuel cost has fluctuated more with respect to time. In Nepalgunj-Kohalpur Road Package-1, it can be seen that base value of fuel was 95500/KL in October 2012 and cost has increased up to 109000/KL in April 2014 and again went on decreasing to 77500/KL in May 2017.The cost of fuel has reduced by 23.22% up to last IPC. In Nepalgunj Road Kohalpur Package-2, the cost of fuel has increased by 4.71% up to last IPC. In construction of Prestressed RCC bridge over Tinau River, the cost of fuel has reduced by 5.81% up to last IPC date. In Bhairahawa-Lumbini-Taulihawa Road Project the cost of fuel has increased by 34.93% up to last IPC date. So, it cannot be predicted accurately whether the fuel cost increase or decrease in a contract over time.

5.4 Bitumen Cost Trend :

The cost of Bitumen has been taken from the district rates of the respective district on which the project was implemented. The graphs below show the actual trend of the cost of bitumen in the three contracts using FIDIC formula for Price adjustment. As bitumen is not used in bridge construction so Tinau River Bridge has not been considered.
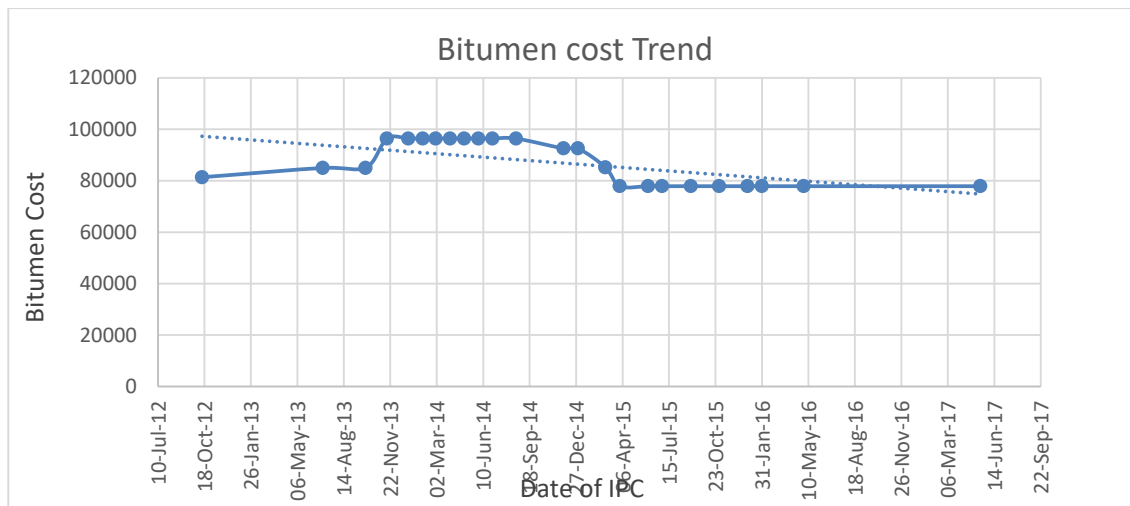
Fig. 3: Bitumen Cost trend of Nepalgunj Kohalpur Road Package-1

Similarly, it can be seen that the bitumen cost has fluctuated with respect to time. In Nepalgunj Road Kohalpur Package-1, base value of bitumen is Rs 81350, peak value is 96400 and value at last date of IPC is 77900. The cost of bitumen has reduced by 4.24 % up to last IPC. Similarly, in Nepalgunj Road Kohalpur Package-2, the cost of bitumen has reduced by 7.8 % up to last IPC date. In Bhairahawa-Lumbini-Taulihawa Road Project the

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cost of bitumen has increased by 18.13% up to last IPC date. It can be seen that the bitumen cost cannot be predicted in more accurate way.

5.5 Trend of cost of components of construction on Contracts using PPMO formula:
PPMO formula has been used in 5 construction contracts under study. Three inputs labor, material and equipment index are taken from NRB [12] economic bulletin and publications. The base dates of these contracts are
Puspalal Midhill Highway Project East Sector: 7 June 2015
Design & Build of Rapti Nadi Bridge: 10 April 2016
Gauri Khola Bridge:12 March 2017
Ungrida Khola Bridge: 7 May 2017
Inguriya River Bridge:12 March 2017
All the contracts study period is before July 2019. So, the trend of labor, material and equipment index from June 2015 to present has been analyzed to know how the construction input index is changing.

5.6 Labor index Trend:
Labor index is published by NRB [12]. For our study of five contracts using PPMO formula of price adjustment labor index starting from June 2015 to June 2019 has been plotted.

Fig. 4: Labor Index Trend

From the figure 4; it can be seen that labor index has increased every month from June-2015 to June-2019. Labor index has increased by 44.86 % during four years.

5.7 Material Index Trend:
Material index is published by NRB [12]. For our study of five contracts using PPMO formula of price adjustment Material index starting from June 2015 to June 2019has been plotted.

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Fig. 5: Material Index Trend

From the figure 5, it can be seen that material index has increased from month from June-2015 with value 291.6 to March 2016 with value 299.9 and decreasing up to October 2016 with value 285.9 and then increased to June-2019 with value 359.47. Material index has increased by 20.66 % during four years.

5.8 Equipment index Trend:

Equipment index is published by NRB [12]. For our study of five contracts using PPMO formula of price adjustment equipment index starting from June 2015 to June 2019 is plotted.
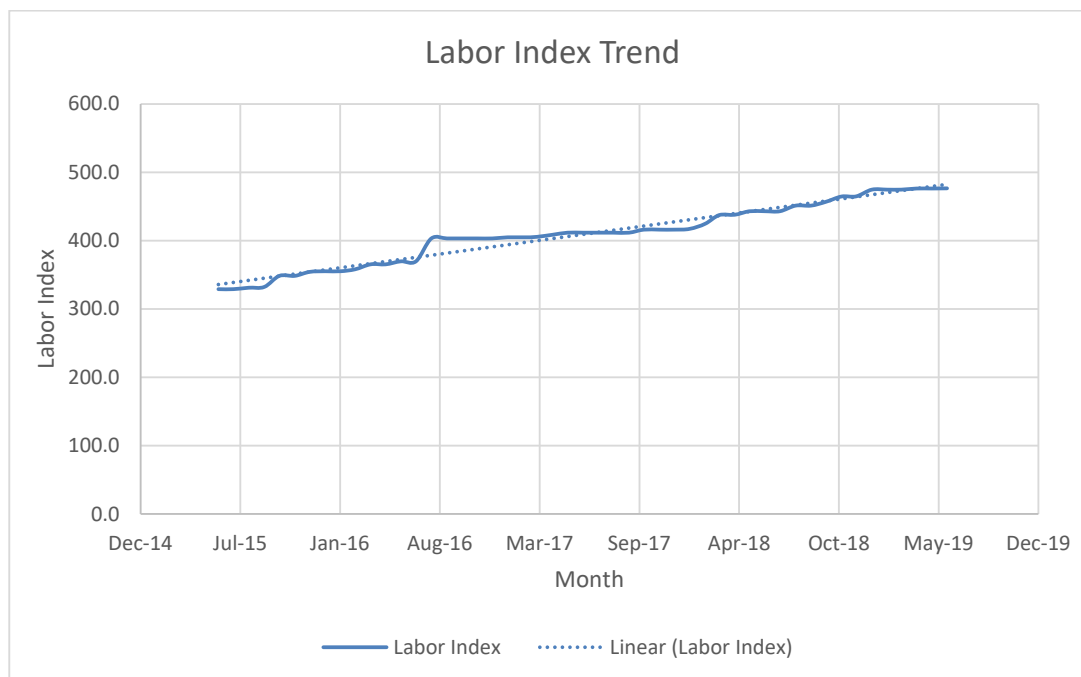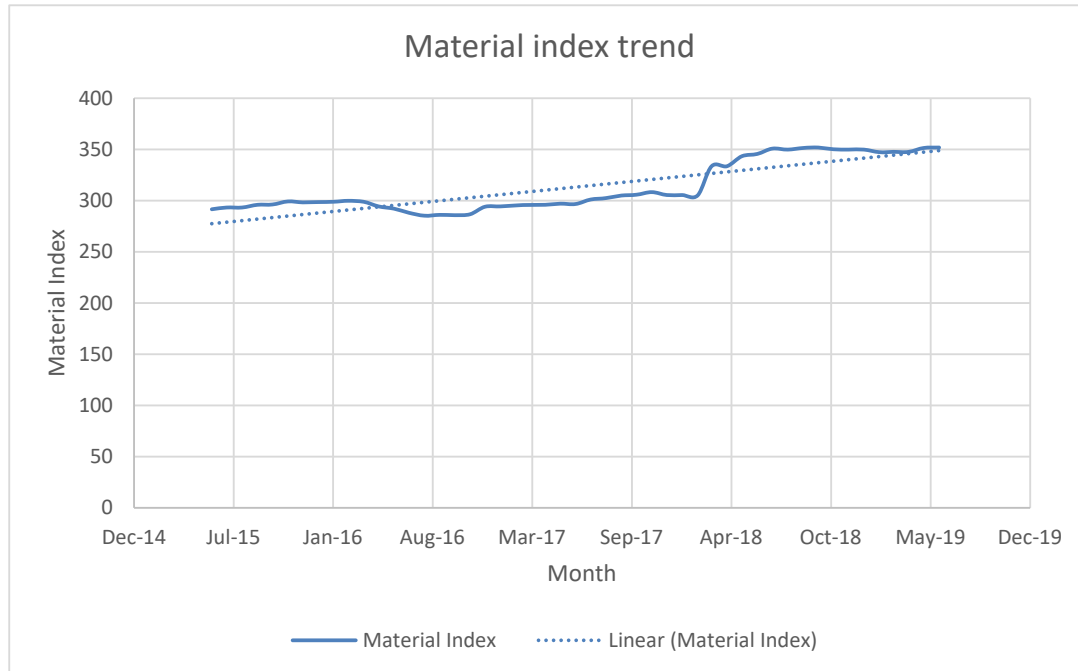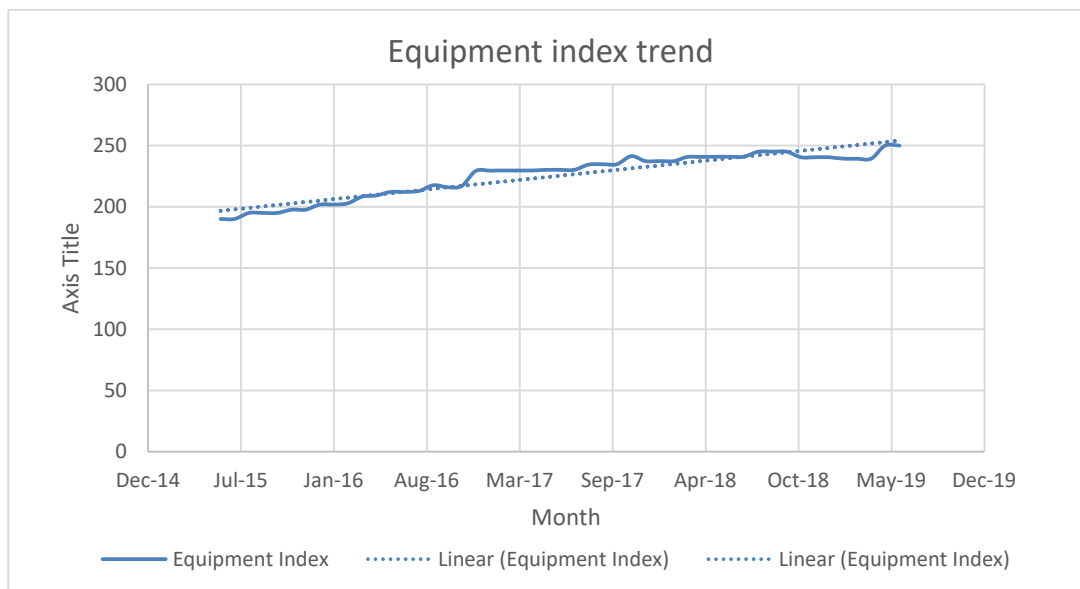

Fig. 6: Equipment index Trend

From the figure 6, it can be seen that equipment index has increased from month from June-2015 with value 190.1 to October 2018 with value 245.04 and decreasing up to April 2019 with value 239.3 and then increased

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up to June-2019 with value 250.07. Equipment index has increased by 31.54 % during last four years.

5.9 Comparison of Price Adjustment Factor:
Price Adjustment Factor is calculated using different formulas. In Nepalese Construction industry three formulas of Price Adjustment are under Practice, i.e. FIDIC formula, PPMO formula and Small works formula. The IPC of each contract is taken and Original Price Adjustment Factor calculated in contract is compared with other formulas. In our study contracts having price adjustment calculation using FIDIC formula is compared with PPMO formula and Small works formula. Contracts using PPMO formula is compared with Small works formula and vice versa.

5.10 Nepalgunj Kohalpur Road Package-1:
Bid Opening date: 11-November-2012

Base Date: 13-October-2012

Original formula used is FIDIC formula: $Pf = a+b*(ln/l0)+c(Fn/Fo)+d(Bn/Bo)+e(On/Oo)$

Where a=0.15, b=0.10, c=0.10, d=0.35, e=0.30

Ln, Fn, Bn, On are the current cost of labor, fuel, bitumen and others index (consumer price index)49 days before each IPC. Lo, Fo, Bo, Oo are base value of labour, Fuel, Bitumen and Others index (consumer price index).

Small works formula is $Ps=Ac+Bc*(Lmc/Lmo)$. Where Ac=0.15 and Bc=0.85 Lmc is consolidated consumer price index at current IPC and Lmo is consolidated consumer price index at base date. From NRB economic bulletin was taken the value of Lmo for the base date and Lmc for 49 days before IPC date. Lmo is 180.8 for the base date.

PPMO formula is taken as $Pp=a+b*(Ln/Lo)+c*(Mn/Mo)+d*(En/Eo)$ where Ln, Mn, En are the NRB index of Labor, Material and Equipment respectively taken 49 days before IPC date and Lo, Mo, Eo are the base index of Labor, Material and Equipment respectively. Apart from this, the coefficient of b,c and d are not known. Generally, the limits are set by the employer for the value of b, c and d as

A	B	C	D
0.15	0.15 to 0.25	0.30 to 0.40	0.20 to 0.30

Where the sum of a, b, c and d should be equal to 1.

The value of b, c, d has been chosen with three combinations and calculate the price adjustment factor using PPMO formula

(i) Pp1 has been calculated using coefficients b=0.25, c=0.40, d=0.20 where coefficient of labor is Maximum, Material is maximum and Equipment is minimum. In simpler form combination can be denoted as Lmax, Mmax, Emin

(ii) Pp2 has been calculated using coefficients b=0.15, c=0.40, d=0.30 (Lmin, Mmax, Emax)

(iii) Pp3 has been calculated using coefficients b=0.25, c=0.30, d=0.30 (Lmax, Mmin, Emax)

Table 4: Comparison of Price Adjustment Factor in Nepalgunj Kohalpur Road Package-1

Price adjustment		FIDIC Formula	Small works formula	PPMO formula		
	Date of IPC					
		Pf	Ps	Pp1	Pp2	Pp3
Base value	13-Oct-12	1	1	1	1	1
IPC 3	30-Jun-13	1.022	1.008	1.000	0.999	1.001

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IPC 4	30-Sep-13	**1.05**	1.04	1.004	1.002	1.004
IPC 5	15-Nov-13	**1.113**	1.068	1.0235	1.022	1.021
IPC 6	31-Dec-13	**1.119**	1.083	1.024	1.023	1.022
IPC 7	31-Jan-14	**1.119**	1.083	1.03	1.027	1.028
IPC 8	28-Feb-14	**1.117**	1.079	1.032	1.024	1.027
IPC 9	31-Mar-14	**1.115**	1.072	1.193	1.181	1.15
IPC 10	30-Apr-14	**1.121**	1.076	1.051	1.039	1.043
IPC 11	31-May-14	**1.12**	1.085	1.055	1.042	1.046
IPC 12	30-Jun-14	**1.124**	1.092	1.058	1.046	1.049
IPC 13	20-Aug-14	**1.135**	1.108	1.0615	1.049	1.053
IPC 14	30-Nov-14	**1.132**	1.134	1.087	1.07	1.08
IPC 15	31-Dec-14	**1.134**	1.15	1.094	1.078	1.088
IPC 16	28-Feb-15	**1.093**	1.146	1.0885	1.069	1.0805
IPC 17	31-Mar-15	**1.051**	1.136	1.093	1.072	1.085
IPC 18	31-May-15	**1.054**	1.145	1.100	1.0785	1.091
IPC 19	30-Jun-15	**1.055**	1.149	1.104	1.081	1.094
IPC 20	31-Aug-15	**1.066**	1.18	1.1065	1.0835	1.096
IPC 21	31-Oct-15	**1.073**	1.199	1.1175	1.096	1.109
IPC 22	31-Dec-15	**1.078**	1.213	1.1395	1.1125	1.1305
IPC 23	31-Jan-16	**1.078**	1.254	1.147	1.119	1.139
IPC 24	30-Apr-16	**1.094**	1.258	1.155	1.128	1.149
IPC 25	15-May-17	**1.089**	1.254	1.161	1.134	1.155

By application of FIDIC formula the price adjustment has increased by 8.9% up to last IPC, Small works formula has shown increment up to 25.4%. PPMO formula using coefficients Lmax, Mmax, Emin (Pp1) has shown increment up to 16.1%, PPMO formula using coefficients Lmin, Mmax, Emax (Pp2) has shown increment up to 13.4%, PPMO formula using coefficients Lmax, Mmin, Emax (Pp3) has shown increment up to 15.5%.
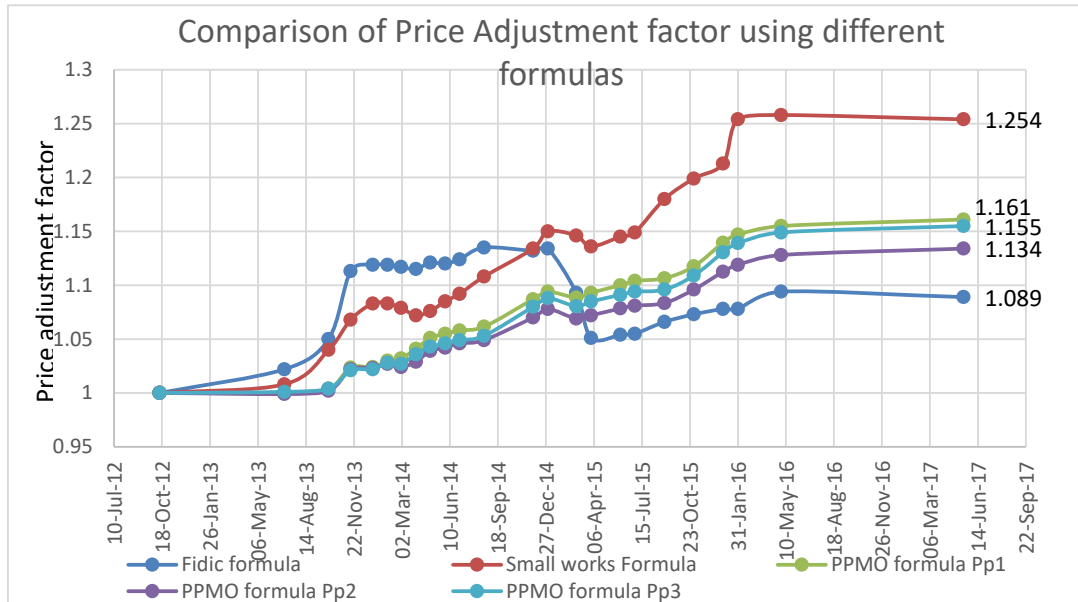
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Fig 7: Comparison of Price adjustment factor using different formulas in Nepalgunj Kohalpur Road Package-1

From the figure 7, it can be seen that Price adjustment factor has fluctuated more during time in FIDIC formula. The reason behind this is the fluctuation in cost of fuel and bitumen.

5.11 NepalgunjKohalpur Road Package-2:
Bid Opening date: 11-November-2012 and Base Date: 13-October-2012
By application of FIDIC formula the price adjustment has increased by 1.17% up to last IPC, Small works formula has shown increment up to11.8%up to last IPC. PPMO formula using coefficients Lmax, Mmax, Emin (Pp1) has shown increment up to10.1%, PPMO formula using coefficients Lmin, Mmax, Emax (Pp2) has shown increment up to8.0%, PPMO formula using coefficients Lmax, Mmin, Emax (Pp3) has shown increment up to9.2%.The reason behind this is the fluctuation in cost of major construction components fuel and bitumen.

5.12 Bhairahawa-Lumbini-Taulihawa Road Project:
Base Dated on 22-September-2016, by application of FIDIC formula the price adjustment has increased by 11.36% up to last IPC, Small works formula has shown increment of 8.8% up to last IPC. PPMO formula using coefficients Lmax, Mmax, Emin (Pp1) has shown increment of 16.99%, PPMO formula using coefficients Lmin, Mmax, Emax (Pp2) has shown increment of 16.7%, PPMO formula using coefficients Lmax, Mmin, Emax (Pp3) has shown increment of 16.18%.

5.13 Construction of Prestressed RCC bridge over Tinau River:
Base Date: 5th-June-2015
Original formula used is FIDIC formula: $Pf=A+Bu*(ln/l0)$ $+Bc*(Cn/Co)$ $+Br*(Rn/Ro)+Bg*(Gn/Go)+Bd*(Fn/Fo)+Bn(On/Oo)$.The values of coefficient are

A	Bu	Bc	Br	Bg	Bd	Bm
0.15	0.15	0.15	0.20	0.05	0.05	0.25

Ln, Cn, Rn, Gn, Fn, Bn are the current cost of unskilled labor, cement, reinforcement, gabion, fuel, and others index consumer price index) 30 days before each IPC. Lo, Co, Ro, Go, Fo, Bo are the cost of base date. The value of b, c, d has been chosen with three combinations and calculate the price adjustment factor using PPMO formula.

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(i) Pp1 has been calculated using coefficients b=0.25, c=0.40, d=0.20 where coefficient of labor is Maximum, Material Maximum and Equipment is minimum. In simpler form combinations have been denoted as Lmax, Mmax, Emin

(ii) Pp2 has been calculated using coefficients b=0.15, c=0.40, d=0.30 (Lmin, Mmax, Emax)

(iii)Pp3 has been calculated using coefficients b=0.25, c=0.30, d=0.30 (Lmax, Mmin, Emax)

Table 5: Comparison of Price adjustment factor of Prestressed RCC Tinau River Bridge

	Date of IPC	FIDIC Formula	Small works formula	PPMO formula		
		Pf	Ps	Pp1	Pp2	Pp3
Base value	5-Jul-15	**1.0000**	1.0000	1.0000	1.0000	1.0000
IPC 1	23-Mar-16	**1.0681**	1.0672	1.0449	1.0427	1.0493
IPC 2	29-Jun-16	**1.0773**	1.0941	1.0497	1.0502	1.0616
IPC 3	30-Sep-16	**1.0908**	1.1201	1.0760	1.0679	1.0928
IPC 4	28-Jan-17	**1.1092**	1.1067	1.1009	1.0987	1.1213
IPC 5	28-Mar-17	**1.1066**	1.0941	1.1031	1.1009	1.1230
IPC 6	19-May-17	**1.1400**	1.1176	1.1081	1.1050	1.1279
IPC 7	10-Jul-17	**1.1395**	1.1235	1.1099	1.1059	1.1298
IPC 8	13-Oct-17	**1.1545**	1.1512	1.1261	1.1245	1.1456
IPC 9	29-Apr-18	**1.2177**	1.1453	1.1879	1.1801	1.1995
IPC 10	5-Jul-18	**1.2177**	1.1453	1.1879	1.1801	1.1995
IPC 11	2-Jan-19	**1.2177**	1.1453	1.1879	1.1801	1.1995
IPC 12	28-Apr-19	**1.2177**	1.1453	1.1879	1.1801	1.1995

By application of FIDIC formula the price adjustment has increased by 21.77% up to last IPC from base value, Small works formula has shown increment of 14.53% up to last IPC. PPMO formula using coefficients Lmax, Mmax, Emin (Pp1) has shown increment of 18.79% from base value, PPMO formula using coefficients Lmin, Mmax, Emax (Pp2) has shown increment of 18.01%, PPMO formula using coefficients Lmax, Mmin, Emax (Pp3) has shown increment of 19.95%.

5.14 PUSPALAL (mid-hill) Highway Project:

Base Date: 7th-June-2015

Original formula used is PPMO formula. PPMO formula is taken as Pp=a+b*(Ln/Lo)+c*(Mn/Mo)+d*(En/Eo) where Ln, Mn, En are the NRB index of Labor, Material and Equipment respectively taken 30 days before IPC date and Lo, Mo, Eo are the base index of Labor, Material and Equipment respectively. Apart from this, the coefficient of b, c and d are not known here in this study. The limits have been set by the Project for the value of b, c and d as

A	B	C	d
0.15	0.15 to 0.25	0.40 to 0.50	0.20 to 0.25

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Original formula "Poriginal" has been calculated using coefficients b=0.20, c=0.45, d=0.20. These coefficients are proposed by contractor of this project. PPMO formula is compared using different combinations
(i) Pp1 has been calculated using coefficients b=0.15, c=0.50, d=0.20 (Lmin, Mmax, Emin)
(ii) Pp2 has been calculated using coefficients b=0.25, c=0.40, d=0.20 (Lmax, Mmin, Emin)
(iii) Pp3 has been calculated using coefficients b=0.15, c=0.45, d=0.25 (Lmin, Mmid, Emax)
PPMO formula has been compared with small works formula and expressed in graph of figure 8.

By the PPMO formula using original coefficients the increment of price adjustment factors up to last IPC is 17.91%. PPMO formula using coefficients Lmin, Mmax, Emin (Pp1) has shown increment of 17.20% from base value, PPMO formula using coefficients Lmax, Mmin, Emin (Pp2) has shown increment of 18.62%, PPMO formula using coefficients Lmin, Mmid, Emax (Pp3) has shown increment of 17.81%. By using Small Works formula, the increment of price adjustment factors up to Last IPC is 14.98%.
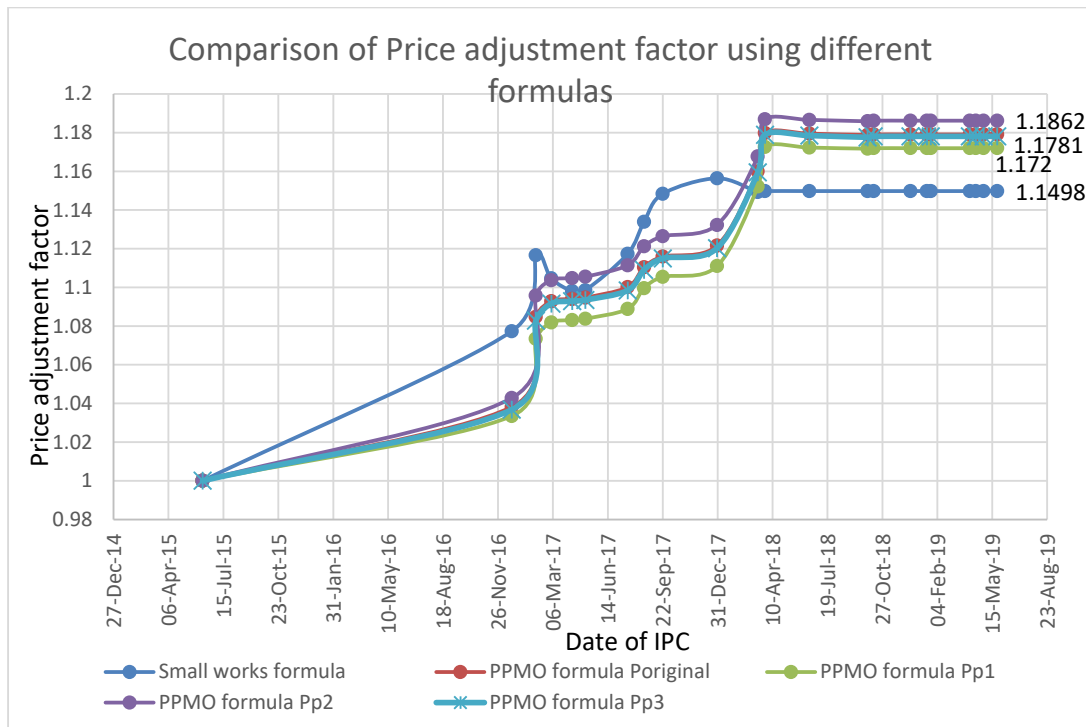
Fig.8: Comparison of Price adjustment factor in Midhill Highway Project Gauri Khola Bridge along Sisapur Bhawanipur Road in Rupandehi District

Base Date: 12th-March-2017
Original formula used is PPMO formula. PPMO formula is taken as Pp=a+b*(Ln/Lo) +c*(Mn/Mo) +d*(En/Eo) where Ln, Mn, En are the NRB index of Labor, Material and Equipment respectively taken 30 days before IPC date and Lo, Mo, Eo are the base index of labor, material and equipment respectively. Apart from this, the coefficients of b, c and d are not known here in this study. The limits have been set by the project for the value of b, c and d as

A	B	C	D
0.15	0.15 to 0.25	0.30 to 0.40	0.20 to 0.30

Original formula "Poriginal" has been calculated using coefficients b=0.25, c=0.30, d=0.30 which is combination of (Lmax, Mmin, Emax). These coefficients have been proposed by contractor of this project. PPMO formula has been compared using different combinations.

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(i) Pp1 has been calculated using coefficients b=0.25, c=0.40, d=0.20 (Lmax, Mmax, Emin)
(ii) Pp2 has been calculated using coefficients b=0.15, c=0.40, d=0.30 (Lmin, Mmax, Emax)
PPMO formula has been compared with small works formula.

Table 6: Comparison of Price adjustment factor in Construction of Bridge over Gauri Khola

		Small works formula	PPMO formula		
	Date of IPC	Ps	Poriginal	Pp1	Pp2
Base value	12-Mar-17	1.0000	**1.0000**	1.0000	1.0000
IPC 1	8-May-18	1.0537	**1.0835**	1.0939	1.0892
IPC 2	30-Jun-18	1.0597	**1.0941**	1.1077	1.1032
IPC 3	1-Jan-19	1.0870	**1.1172**	1.1270	1.1206
IPC 4	19-Apr-19	1.0938	**1.1219**	1.1307	1.1221
IPC 5	24-May-19	1.1051	**1.1272**	1.1371	1.1283
IPC 6	5-Jul-19	1.1157	**1.1272**	1.1371	1.1283

By the PPMO formula using original coefficients (Lmax, Mmin, Emax) the increment of price adjustment factors up to last IPC is 12.72%. PPMO formula using coefficients Lmax, Mmax, Emin (Pp1) has shown increment of 13.71% from base value, PPMO formula using coefficients Lmin, Mmax, Emax (Pp2) has shown increment of 12.83%. By using Small Works formula, the increment of price adjustment factors up to Last IPC is 11.57%.

5.15 Ungrida River Bridge at Sainamaina-9 Baikhutti Devapar in Rupandehi District
Base Date: 7th-May-2017
Original formula used is PPMO formula. PPMO formula is taken as $Pp=a+b*(Ln/Lo) +c*(Mn/Mo) +d*(En/Eo)$ where Ln, Mn, En are the NRB index of Labor, Material and Equipment respectively taken 30 days before IPC date and Lo, Mo, Eo are the base index of Labor, Material and Equipment respectively. Apart from this, the coefficient of b, c and d are not known here in this study. The limits have been set by the project for the value of b, c and d as

A	b	C	d
0.15	0.15 to 0.25	0.30 to 0.40	0.20 to 0.30

Original formula "Poriginal" has been calculated using coefficients b=0.20, c=0.40, d=0.25. These coefficients were proposed by contractor of this project. PPMO formula has been compared using different combinations.
(i) Pp1 has been calculated using coefficients b=0.25, c=0.40, d=0.20 (Lmax, Mmax, Emin)
(ii) Pp2 has been calculated using coefficients b=0.15, c=0.40, d=0.30 (Lmin, Mmax, Emax)
(iii) Pp3 has been calculated using coefficients b=0.25, c=0.30, d=0.30 (Lmax, Mmin, Emax)
PPMO formula has been compared with small works formula.

Table 7: Comparative Price adjustment factor in Construction of Ungrida River Bridge

		Small works formula	PPMO formula			
	Date of IPC	Ps	Poriginal	Pp1	Pp2	Pp3
	7-May-17	1.0000	**1.0000**	1.0000	1.0000	1.0000
IPC 1	25-Mar-18	1.0288	**1.0777**	1.0786	1.0768	1.0713
IPC 2	2-Jul-18	1.0376	**1.0889**	1.0912	1.0866	1.0809

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IPC 3	19-Dec-18	1.0679	**1.1195**	1.1222	1.1168	1.1126
IPC 4	18-Jan-19	1.0642	**1.1192**	1.1220	1.1164	1.1124
IPC 5	10-Mar-19	1.0664	**1.1213**	1.1251	1.1175	1.1167
IPC 6	24-May-19	1.0819	**1.1280**	1.1320	1.1240	1.1223
IPC 7	12-Jul-19	1.0922	**1.1280**	1.1320	1.1240	1.1223

By the PPMO formula using original coefficients the increment of price adjustment factors up to last IPC is 12.80%. PPMO formula using coefficients Lmax, Mmax, Emin (Pp1) has shown increment of 13.20% from base value, PPMO formula using coefficients Lmin, Mmax, Emax (Pp2) has shown increment of 12.40%. and using coefficients Lmax, Mmin, Emax (Pp3) showed increment of 12.23%. By using Small works formula, the increment of price adjustment factors up to Last IPC is 9.22%.

5.16 Inguriya River Bridge along Sainamaina-11 Palpa Laugha Pani Road in Rupandehi District:
Base Date: 12-March-2017
Original formula used is PPMO formula. PPMO formula is taken as $Pp=a+b*(Ln/Lo) +c*(Mn/Mo) +d*(En/Eo)$ where Ln, Mn, En are the NRB index of labor, material and equipment respectively taken 30 days before IPC date and Lo, Mo, Eo are the base index of Labor, Material and Equipment respectively. Apart from this, the coefficient of b, c and d are not known in this study. The limits have been set by the project for the value of b, c and d as

A	B	C	d
0.15	0.15 to 0.25	0.30 to 0.40	0.20 to 0.30

Original formula "Poriginal" was calculated using coefficients b=0.25, c=0.40, d=0.20 (Lmax, Mmax, Emin) These coefficients are proposed by contractor of this project. PPMO formula was compared using different combinations.

(i) Pp1 has been calculated using coefficients b=0.15, c=0.40, d=0.30 (Lmin, Mmax, Emax)
(ii) Pp2 has been calculated using coefficients b=0.25, c=0.30, d=0.30 (Lmax, Mmin, Emax)
PPMO formula has been compared with small works formula.

Table 8: Comparison of Price adjustment factor in Construction of Bridge over Inguriya River

		Small works Formula	PPMO formula		
	Date of IPC	Ps	Poriginal	Pp1	Pp2
Base value	12-Mar-17	1.0000	**1.0000**	1.0000	1.0000
IPC 1	18-Dec-17	1.0507	**1.0332**	1.0359	1.0349
IPC 2	11-May-18	1.0567	**1.0970**	1.0973	1.0906
IPC 3	11-Jul-18	1.0537	**1.0939**	1.0892	1.0835
IPC 4	17-Jan-19	1.0597	**1.1270**	1.1206	1.1172
IPC 5	18-Mar-19	1.0870	**1.1331**	1.1243	1.1233
IPC 6	13-Jul-19	1.0885	**1.1371**	1.1283	1.1272

By the PPMO formula using original coefficients Lmax, Mmax, Emin the increment of price adjustment factorup to last IPC is 13.71%. PPMO formula using coefficients Lmin, Mmax, Emax (Pp1) has shown increment of 12.83% from base value, PPMO formula using coefficients Lmax, Mmin, Emax (Pp2) has shown increment of 12.72%. and using coefficients Lmax, Mmin, Emax (Pp3) has shown increment of 12.23%. By using Small Works formula, the increment of price adjustment factors up to Last IPC is8.85%.

5.17 Design & Build of Rapti Nadi Bridge, Sisniya:

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Base Date: 10-April-2016, Original formula used is PPMO formula as $Pp=a+b*(Ln/Lo)+c*(Mn/Mo)+d*(Fn/Fo)$ where Ln, Mn are the NRB index of Labor, Material and Fn is the cost of fuel respectively taken 30 days before IPC date and Lo, Mo are the base index of Labor, Material and Fo is the base value of Fuel respectively. The coefficient of b, c and d are not known. The limits have been set by the project for the value of b, c and d as

A	B	C	D
		0.30 to 0.40	0.20 to 0.30
0.15	0.15 to 0.25		

Original formula "Poriginal" has been calculated using coefficients b=0.25, c=0.40, d=0.20 (Lmax, Mmax, Emin) These coefficients have been proposed by contractor of this project. PPMO formula has been compared using different combinations.

(i) Pp1 has been calculated using coefficients b=0.15, c=0.40, d=0.30 (Lmin, Mmax, Fmax)
(ii) Pp2 has been calculated using coefficients b=0.25, c=0.30, d=0.30 (Lmax, Mmin, Fmax).
PPMO formula has been compared with small works formula.

By the PPMO formula using original coefficients Lmax, Mmax, Fmin the increment of price adjustment factors up to last IPC is 21.83%. PPMO formula using coefficients Lmin, Mmax, Emax (Pp1) has shown increment of 21.66% from base value, PPMO formula using coefficients Lmax, Mmin, Emax (Pp2) has shown increment of 22.57 %. By using Small Works formula, the increment of price adjustment factors up to Last IPC is 14.22%.
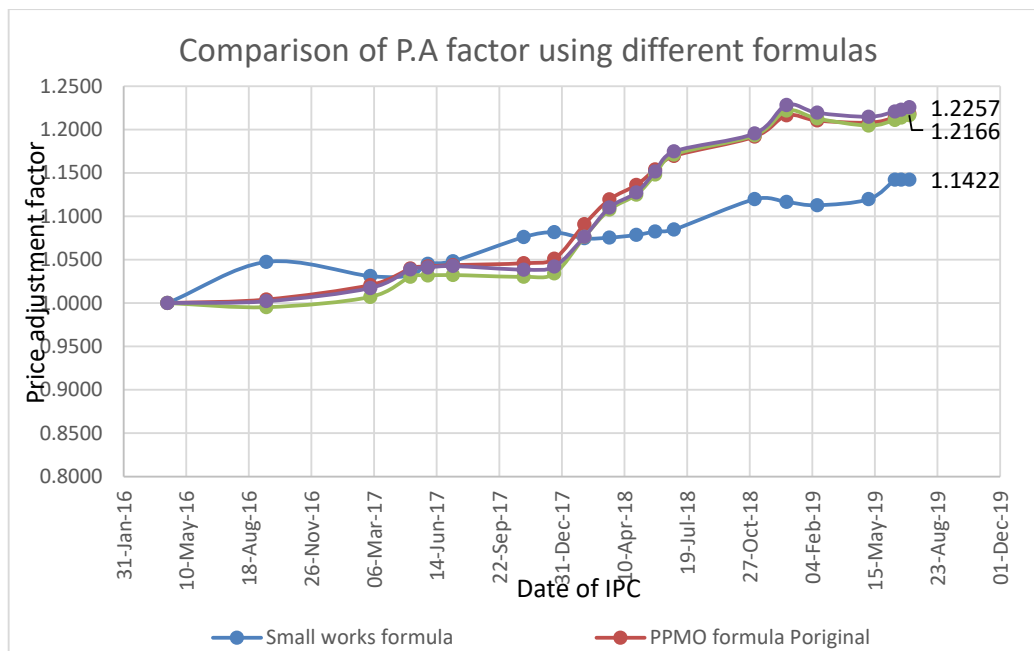

Fig.9: Comparison of Price adjustment factor at Rapti Nadi Bridge, Sisniya Chainpur Khadbari Road Project

Base date: 10-May-2011, Original Formula used is Small Works formula as $Ps=Ac+Bc*(Lmc/Lmo)$. Where Ac=0.15 and Bc=0.85 Lmc is consolidated consumer price index at current IPC and Lmo is consolidated consumer price index at base date. From NRB economic bulletin the value of Lmo for the base date and Lmc for 30 days before IPC date has been taken. Small works formula has been compared with PPMO formula given by $Pp=a+b*(Ln/Lo)+c*(Mn/Mo)+d*(En/Eo)$.
(i)   Pp1 has been calculated using coefficients b=0.25, c=0.40, d=0.20   where coefficient of labor is maximum, material maximum and equipment is minimum. In simpler form combination can be denoted as Lmax, Mmax, Emin
(ii) Pp2 has been calculated using coefficients b=0.15, c=0.40, d=0.30 (Lmin, Mmax, Emax)

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(iii) Pp3 has been calculated using coefficients b=0.25, c=0.30, d=0.30 (Lmax, Mmin, Emax)

By using Small Works formula, the increment of price adjustment factors up to Last IPC is 31.85%. By the PPMO formula using coefficients Lmax, Mmax, Emin (Pp1) has shown increment of 25% from base value, PPMO formula using coefficients Lmin, Mmax, Emax (Pp2) has shown increment of 19.8%, PPMO formula using coefficients Lmax, Mmin, Emax (Pp3) has shown increment of 23.9%.

5.18 Overall Comparison of price adjustment factor:

Table 9: Overall Comparison of percentage increase in price adjustment factor

Contract	Base date	Date of last IPC taken for study	Formula used in contract	FIDIC formula	Small works formula	PPMO formula		
						Lmax, Mmin, Emax	Lmin, Mmax, Emax	Lmax, Mmax, Emin
Nepalgunj-Kohalpur Road-1	13-Oct-12	15-May-17	FIDIC	**8.90%**	25.40%	16%	13.40%	15.50%
Nepalgunj-Kohalpur Road-2	13-Oct-12	1-Oct-15	FIDIC	**1.17%**	11.80%	10.10%	8.00%	9.20%
Bhairahawa-Lumbini-Taulihawa Road Project	22-Sep-16	31-Jul-19	FIDIC	**11.36%**	8.80%	16.99%	16.70%	16.18%
Tinau River Bridge	5-Jun-15	28-Apr-19	FIDIC	**21.77%**	14.53%	18.79%	18.01%	19.95%
Gauri khola Bridge	12-Mar-17	5-Jul-19	PPMO	-	11.57%	13.71%	12.83%	**12.72%**
								Lmid, Mmax, Emid
Ungrida Khola Bridge	7-May-17	12-Jul-19	PPMO	-	9.22%	13.20%	12.40%	12.23%	**12.80%**

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						Lmid, Mmid, Emin	Lmin, Mid, Emax	Lmax, Mmin, Emin	Lmin, Mmax, Emin
Inguriya Khola Bridge	12-Mar-17	13-Jul-19	PPMO	-	8.85%	**13.71%**	12.83%	12.72%	
Rapti River Bridge	10-Apr-16	9-Jul-19	PPMO	-	14.22%	**21.83%**	21.66%	22.57%	
Mid hill Project	7-Jun-15	24-May-19	PPMO	-	14.98%	**17.91%**	17.81%	18.62%	17.20%
Chainpur-Khandbari Road Project	10-May-11	1-Sep-15	Small works formula	-	**31.85%**	25.00%	19.80%	23.90%	

From the table 9, It is seen that the contracts whose base date is before 2015, The price adjustment factor calculated by FIDIC formula is lowest, followed by PPMO formulas and Price adjustment factor obtained by small works formula is highest. And in the contracts whose base date is after 2015, the price adjustment factor calculated by FIDIC formula is highest, followed by PPMO formulas and Price adjustment factor obtained by small works formula is lowest. Thus, it cannot actually be defined which formula gives more value of price adjustment factor. It depends upon the condition such as time, index and cost.

In PPMO formula if the coefficients are set by the client, the price adjustment factor using coefficients of labor "Lmax'' is more likely to give higher value of Price Adjustment factor than using "Lmin''.

6. CONCLUSION:

There are different formulas used in different contracts. In contracts using FIDIC formula, the cost of labor is increasing with respect to time and it is more predictable that labor cost will increase in future. The cost of bitumen and fuel are unpredictable as the cost is fluctuating more with respect to time. In contracts using PPMO formula the index of Labor, Material and Equipment is used. The index of labor increase with time and it is more predictable than Material and Equipment index as they are fluctuating with respect to time.

Comparing the price adjustment factor using different formulas it can be seen that the value of price adjustment factor using different formulas are different. Also, it can be seen that during the course of time the price adjustment factor calculated using different formulas is different. Thus, it cannot be generalized that which formula could give minimum value of price adjustment. It depends upon the condition such as time, index and cost. As most of the respondents in our study preferred to use PPMO formula so it is suggested to use PPMO formula in the construction contracts. In PPMO formula under the limits set by the client, if the coefficient of labor is chosen maximum it is likely that the price adjustment factor would be more.

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