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Price Fluctuations and the impact of the CIDA formula on the profits earned by the contractors of Civil Engineering Construction Projects implemented in Sri Lanka

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Abstract

The price fluctuation formula introduced by the Construction Industry Development Authority (CIDA) is widely used by the Sri Lankan construction sector to calculate price fluctuation of civil engineering construction projects because of its high standard, ease of use, and easy access provided to the information. The price fluctuations calculated using the formula carries some degree of uncertainty. This study was conducted to assess the degree of accuracy of the calculations made using the CIDA formula and the impact of the formula on the profits earned by contractors in civil engineering construction projects. The study adopted a qualitative research approach. Ten interviews were conducted with experts in the construction industry to identify the impacts of the formula on contractor profit and the strategies that would help manage those impacts. Thematic analysis using code based manual content analysis was used to analyse the collected data. The study findings reveal the difference between the actual price adjustment required and the price adjustment using the CIDA formula. The main reasons behind this difference are the use of inaccurate price indexes and the basic assumptions made to derive the CIDA formula. The effect of the CIDA price fluctuation formula method on contractor profit margins in civil engineering projects implemented in Sri Lanka was also investigated. To lower the overestimated price adjustments, modified cost adjustment factors and reliable price indexes are recommended as the main suggestions. Industry practitioners can adopt these suggestions to increase the effectiveness of the CIDA formula in civil engineering projects.

Keywords: CIDA price fluctuation formula, Contractor, Profit, Civil engineering construction, Sri Lanka

1. Introduction

Price fluctuations are inevitable in any construction project. In a major construction project, the changes in the prices of construction inputs, such as materials, labour, plant, and equipment have to be closely monitored as they can cause major deviation to original contract sum (Samarakoon and Wijewardena, 2021). The prices of construction inputs can increase because of natural disasters, high demand, and inflation (Silva, 2011). According to Sendooran (2005), the global downturn has continued to affect construction costs and reduce the profits earned by contractors (Nagi, 2002; Tan, 2008). Therefore, the use of bidding strategies based on future price fluctuation claims has been a contractor's mechanism to ascertain profit margin (Ho and Liu, 2004; Rooke, 2004).

Kangari (1988) found that 50% of the contractors in the construction industry failed because the profit margins they expected were unrealistic. The main problem faced by a bidder is the inability to

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predict the required mark-up precisely (Liyanage, 2005) to accommodate unforeseen price variations. These unforeseen price fluctuations have been a critical issue in civil engineering projects because of long project durations, high project investments (Kaare and Koppel, 2012), the high demand that exists for labour and materials, and frequent changes made to project scope (Hajjath and Rathnayake, 2019). According to Subasinghe (2009), the issue can be addressed by incorporating price fluctuation clauses in the contracts. Most contractors of long-duration projects with many work items use the price fluctuation formula, introduced by the Construction Indistry Development Authority (CIDA) of Sri Lanka, which at that time was known ICTAD (Institute of Construction Training and Development) to calculate price fluctuations because the traditional method is tiresome and lengthy (Jayalath, 2013).

In the CIDA price fluctuation formula, a coefficient factor constant (0.966) is used assuming that the contractor profit percentage is 15% of the project cost. However, the overhead and profit margin of a contractor, which can be as much as 35% of the project cost, will not be the same for all projects or contractors (Jayasinghe *et al*., 2015). Consequently, the price escalations calculated using the CIDA formula would not accurately represent the actual fluctuations (Samarakoon and Wijewardena, 2021). Because price fluctuations are unavoidable in long-duration construction projects (Jayasinghe *et al*., 2015), the CIDA price fluctuation formula requires a detailed study.

According to Jayasinghe *et al*. (2015), only a few past studies have been conducted on the impact of the CIDA formula on price fluctuations in the construction industry. They used a different value for the fixed coefficient factor used in the formula to address the shortcomings of the formula. Hajjath and Rathnayake (2019) explored the applicability of the formula in the road construction sector in Sri Lanka and developed a framework to calculate the price fluctuations. Samarakoon and Wijewardena (2021) amended the CIDA formula after comparing the contractor profit percentage obtained using it with that obtained using the formula that had been conventionally used in the building sector. Nevertheless, no past study has focused on the impcat of the CIDA formula on the profit percentage of a contractor involved in civil engineering construction in Sri Lanka.

Thus, the study aimed to determine the impact of the CIDA formula on contractor’s profit in civil engineering construction projects implemented in Sri Lanka when the payment for price fluctuations has been calculated using the formula. The objectives of the study were to examine how the contractors manage price fluctuations in civil engineering projects, identify how the payments made for price fluctuations affect contractor profit margins, and suggest strategies to overcome the impacts of the formula on contractor profit margins. The study findings will help industry practitioners to take proactive actions before using the CIDA formula to calculate price fluctuations in their civil engineering projects.

2. Literature Review

2.1 Price Fluctuations in the Construction Industry

Price fluctuations describe both the rise and fall of resource and service prices and those that may result in payments from the employer to the contractor and vice versa (Jayasinghe *et al*., 2015). According to Deo

(2007), price fluctuations can be used to forecast the future cost of a project or bring past expenses up to date. Price escalation refers to the increase in the contract price due to exceptional circumstances occurring during contract implementation (Government Procurement Policy Board (GPPB), 2008, p.1). According to Subasinghe (2009, p.5), price fluctuations are a risk, and the factors affecting it are unavoidable and difficult to forecast. Gavin (2008) identified inflation as the primary factor affecting price fluctuations in civil engineering construction. Government taxes (Peiris, 1993), rules and regulations (Ashworth, 1991), political influence (Sally, 2006), internal conflicts (Peiris, 1993), and other factors, such as the escalation of the price of agricultural products (Central Bank, 2013), which also affects construction price fluctuations, are considered internal factors.

Economic crises, material price variations, fuel price variations, and market environments are the major external factors affecting price fluctuations (Hanna and Blair, 1993). According to Mossa (2013), poor estimation, improper planning, improper implementation and schedule changes are the main internal causes of price fluctuations in Ethiopian road construction projects, while the increase in the material prices, increase in the global demand for construction materials, fluctuation of the exchange rates, and the limited capacity of the material producers are the main external causes. Lioudis (2018) highlighted factors such as demand and supply, production cost, and interest percentage as the factors affecting price fluctuations in construction projects.

When project inputs increase in price, project scope will require changes, project cost will become unpredictable, instructions will require changes, the design stage will get prolonged, claim entitlements will change, costs will escalate, resource scarcities will occur, the quality of the estimation process will become poor, the planning and estimating of the project will become difficult, and regular price fluctuations will occur, leading to the termination of the project (Nwuba, 2004). If price fluctuations are not incorporated into the contract, the employer will suffer from poor quality work, while the contractor may encounter cash flow issues, lower the standards, delay project completion, and possibly engage in unethical acts (Mishra and Regmi, 2017).

The price fluctuations may be recoverable or non-recoverable depending on the contractual arrangements (Liyanage, 2005). Non-recoverable contracts, i.e. fixed-price contracts, do not contain price fluctuation clauses, and the contractors will pass on any additional costs to the employer through high mark-up added during the bidding stage to accommodate future price variations (De Mel, 2008). In recoverable contracts, the parties involved in construction use traditional and formula methods to compensate for the price fluctuations.

In the traditional method, only the actual cost due to the contractor is paid. By contrast, the formula method pays an amount based on the value of the work done (Liyanage, 2005). According to Jayaweera *et al.* (2015), the formula developed by CIDA (then known as ICTAD) is the most commonly used method in Sri Lanka, which has been designed to protect both the borrower and contractor from price fluctuations by allowing the contractors to offer more realistic prices during bidding (Asian Development Bank, 2018).

2.1 CIDA Formula for Price Fluctuations

According to Hajjath and Rathnayake (2019), in Sri Lanka, CIDA and FIDIC formulae are widely used in foreign-funded and locally funded road projects, respectively. They emphasised the benefits of using the CIDA formula in construction contracts because it benefits both the client and contractor while being easy, user-friendly, and applicable to any contract type. CIDA (2007) makes price fluctuation provisions under Clause 13.7, titled "Adjustment for Changes in Cost (in construction)". The amount of price fluctuations, which relates to the changes in the costs of construction inputs such as labour, materials, and machinery or plant, and calculated using the formula mentioned in the clause has to be added or deducted from the contractor's payments. Procurement Guidelines (2006) state that a price fluctuation formula should be included in the bidding documents and contract agreements of all Sri Lankan construction projects that are more than three months in duration. The cabinet has granted its approval for the CIDA formula. Because of its inherent features, the government recommends the use of the formula as a standard approach in the calculation of price fluctuations in civil engineering projects (Subasinghe, 2009). The formula for contracts exceeding 10 million is given in Equation 1 (Construction Industry Development Authority (CIDA, 2008).

$$F=\frac{0.966(V-Vna)}{100}\sum\frac{Px\,(Ixc-Ixb)}{Ixb}$$

Where,

F =Price adjustment for the period
V=Valuation of work done during the period
Vna=Value of the non-adjustable element
Px=Percentage cost contribution of Input X
Ixc=Current index of Input X
Ixb=Base index of Input X

The CIDA price adjustment formula uses five parameters: input percentage Px, PI (Ixc and Ixb), cost adjustment factor (CAF) K, Rest Adjustment Factor (RAF) R, and assessed valuation (V-Vna) (Jayasinghe *et al.*, 2015). De Mel (2008) stated that according to Jayasinghe *et al.* (2015), the two key assumptions that had to be made when using the CIDA formula, namely 90% of the project value corresponds to major costs with the balance corresponding to minor costs, and the major costs were recovered when 40% of the work items had been completed (CIDA,2008), were inaccurate. The assumptions have several shortcomings, which cause the calculated price fluctuations to exceed the actual price fluctuations considerably (Suraweera, 2001). Thus, Jayasinghe *et al.* (2015) believe that the price adjustment calculated using the CIDA formula increases the profit margin of the contractor.

2.2 Impact of the CIDA Formula on Contractor Profit Margins

The study conducted by Jayasinghe *et al.* (2015) identified the shortcomings of the CIDA formula, which overestimated the price fluctuations. The uniform distribution of input percentages (Mel, 2013), calculation of price adjustments based on the assessed valuation and not on cost changes, unavailability of norms to use in the calculation of input percentages, disregard of market trends, dependence of PI (Ixc and Ixb) on demographical factors (Jayaweera *et al.*, 2015), high taxes imposed on imported materials, and the use of the same CAF and RAF for every project type are the drawbacks of the formula.

According to Jayasinghe *et al*. (2015), the alteration of input percentages, price indexes, and assessed valuations are impractical because their linkages with the price adjustments will vary significantly from project to project. Thus, they amended coefficient factor (0.757); and the allowable CAF (51.2%) and RAF (12.6%) to reduce the overestimated amount. Jayaweera *et al.* (2015) also recommended making coefficient factor equal to 0.855 for government-funded intelligent building projects. According to Samarakoon and Wijewardena (2021), the CIDA formula does not provide the actual price escalation in terms of the profit percentage of the contractor. Furthermore, in case of high-end contractors, the actual amount that has to be paid is lower than the amount calculated using the CIDA formula, whereas in the case of low-end contractors, the actual amount is less than the amount calculated. Thus, the authors suggested that the CAF (K) values should be selected according to the CIDA grading of the contractors to make it fair for the contractors who had low overheads and profit and changing the PI published in the CIDA bulletin based on the demand, accessibility, and transportation of the input concerned.

2.3 Importance of Price Escalations in Civil Engineering Projects

Infrastructure development projects are important for developing countries although the amount of investment they require is much higher than that is required by building projects (Kaare and Koppel, 2012). In the developing countries, price fluctuations are also important because of their dependence on external factors (MCCartney, 2011). Civil engineering projects have long project durations and require large capital investments. Thus, these projects become risky when price fluctuations occur. During the civil war that raged Sri Lanka for several years, much of the infrastructure in the country was damaged or destroyed (World Bank, 2016),. The road capacity of the country cannot meet the transport demand (World Bank, 2016).

Material price fluctuations have a significant impact on the use of the CIDA formula for road projects. The prices of materials such as bitumen, fuel, cement, and reinforced steel, the materials mostly used in road construction, fluctuate over short periods, highlighting the importance of including a price adjustment clause in the contract of a road project irrespective of the length of the contract (ADB, 2018). According to Mossa (2013), high project costs, cash flow problems, delays, and disputes cause price escalations in road projects. The author has suggested the incorporation of fluctuation/escalation clauses into the contract, use of locally available materials in the designs, regular monitoring of the project costs, and the development of project-wide contingencies and risk management protocols to manage the price escalations in Ethiopian federal road construction projects.

To minimise the adverse effects of price fluctuations, Subasinghe (2009) suggested using the CIDA price fluctuation formula in civil engineering contracts because it is easy to apply to long-duration projects. According to Hajjath and Rathnayake (2019), the CIDA formula should consider the changes in the price indexes, total input percentage according to the contribution made by each type of material, and coefficient factor (0.966) to obtain accurate results when used in road construction projects. However, the author highlighted that the formula did not consider the consumer price index (CPI) and provisional sum items stated in the contract and that the

CIDA bulletin was received late, the accuracy of each index was low because of its dependence on the location, and highway schedule of rates (HSR) was outdated. The use of many precast structures increases in heavy vehicle traffic, inclusion of road furniture, requirement for skilled labour, and the use of gravel also affect the results obtained using the CIDA formula (Hajjath and Rathnayake, 2019).

3. Methodology

The selection of an appropriate research strategy is directed by the research questions, research objectives, the extent of existing knowledge, available time and other resources and philosophical underpinnings (Saunders et al. 2009). Accordingly, Antwi and Hamza (2015) found that the qualitative research approach was the best for understanding multiple dimensions such as types of people in a group, how they think and interact, what kinds of agreements or norms were presented, and how these dimensions come together holistically to describe the group. Further, the qualitative research is used in situations where an in-depth analysis of the data is necessary (Ritchie et al., 2014), when little is known about a topic or phenomenon from the literature (Creswell, 2014).

The objectives of this study, described earlier, required a free flow of ideas, opinions, and perceptions from those who had consistency and depth relating to the practical aspects of price escalation with the CIDA formula. With only few past studies on the subject area available, this study adopted a qualitative research design conforming to the research requirements.

Both qualitative approach and semi-structured interviews are not a generic approach for data collection, but a standard method to collect in-depth and significant data required for the study (Singh and Masuku, 2014). Semi-structured interviews correspond with the qualitative research design for answering the questions of the orientation “how” and “why”. Semi-structured interviews are associated with the ontological and epistemological stance that reality is socially constructed and interpreted in line with the worldviews of participants (Mason, 2004). The flexibility in semi-structured interviews makes it possible to cross-check and validate information from previous interviews (Bryman and Bell, 2015) and offers the researcher an opportunity to approach different interviewees in varied ways while still covering the same questions. Hence, an interview guideline was used to safeguard consistency (Brewster et al., 2015) based on the research questions and literature findings. The interview guideline ensures that the interview addresses themes identified in advance in the literature as crucial to the research questions (Kvale, 1996; Mason, 2004). Thematic analysis was conducted manually using codes, which helps to categorise, summarise, and tabulate the collected data (Creswell 2013; Lune and Berg 2016).

According to Jansen (2010), Hossain (2011), Du Toit and Mouton (2013), and Gentles *et al*. (2015), a small sample is labelled for the methodological strategy followed by qualitative studies that describe the diversity of certain cognitions or behaviours in a population through semi-structured interviews. According to Chan (2000), the type of experts selected for interviewing primarily determines the success of the study. Purposive sampling was used in the study to select the experts. The experts had to have more than 10 years of experience with the use of CIDA formula in civil engineering projects (Campbell et al., 2020). They had to possess an extensive understanding of the CIDA formula and be willing to participate in interviews. Each expert was interviewed for 60–90 min. Hence, the sample size was limited due to unfamiliarity and inadequacy of knowledge in research area of price fluctuation and use of CIDA formula in construction industry, explanation and clarification of the participants required while collecting data due to unfamiliarity, difficulty in taking a large representative sample with knowledge as well as construction expertise for collecting data, and difficulty in accessing some data sources due to nature and confidentiality reasons. Further, as the data saturation was reached after the 9th interview, the number of respondents were confined to 10, when no new data would be forthcoming (Saunders *et al*., 2018). Table 1 presents the profiles of the interviewees.

Table 1: Profiles of the Interviewees

Name	Designation	Category	No. of Years of experience
R1	General Manager	Consultant	23
R2	Claims Manager	Contractor	10
R3	Chief Executive Officer	Consultant	15
R4	Chief Quantity Surveyor	Contractor	12
R5	Chief Quantity Surveyor	Consultant	20
R6	Chief Quantity Surveyor	Consultant	17
R7	Chief Quantity Surveyor	Consultant	12
R8	Chief Quantity Surveyor	Contractor	18
R9	Chief Quantity Surveyor	Consultant	20
R10	Chief Quantity Surveyor	Contractor	16

4. Findings and analysis

The literature review findings on the effect of price fluctuations on projects, price fluctuation management by contractors, increased in contractor profit when the CIDA price fluctuation formula was used, and suggestions to increase the accuracy of the formula were mostly related to building projects implemented in Sri Lanka. Therefore, the interviews were used to validate the applicability of these findings in civil engineering projects implemented in Sri Lanka.

4.1 Reasons for Price Fluctuations in Civil Engineering Projects

The causes of price fluctuations in civil engineering projects implemented in Sri Lanka identified from the literature and at the interviews are listed in Table 2.

The reasons given in bold text in the table were identified by the experts at the interviews. The interviewees confirmed that all of the causes identified from the literature were applicable to civil engineering projects implemented in Sri Lanka. All 10 interviewees agreed that inflation, government taxes, rules and regulations, economic crises, fuel price variations, exchange rate fluctuations, costs of production, increased global demand for construction materials, limited capacity of the material producers, political impacts, internal conflicts, poor estimation, and improper project planning cause price fluctuations in civil engineering projects. Although the literature is silent about it, the interviewees agreed that when the transport system is inefficient, the prices of the materials used in road construction projects inevitably escalate.

Gavin (2008) identified that inflation is the leading cause of price fluctuations. R3 stated, '*the escalation of material prices results in cost overruns that may amount to a 10%–15% increase in the initial contract sum*'. Some interviewees did not agree with Central Bank (2013) findings that the escalation of the prices of agricultural products causes price fluctuations in construction projects. The interviewees were of the view that cultural impacts and natural disasters can cause price fluctuations in civil engineering projects. Agreeing to this, R5 stated, '*with the cultural impacts and natural disasters directly affecting the cost of living and with the labour cost being one-third of the construction cost*', these factors could cause significant price fluctuations.

Table 2: Reasons for Price Fluctuations in Civil Engineering Projects

Reasons	Literature findings	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Inflation	(Gavin, 2008)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Government taxes	(Peiris, 1993)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Rules and regulations	(Ashworth, 1991)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Economic crises	(Hanna and Blair, 1993)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fuel price variations	(Hanna and Blair, 1993)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Exchange rate fluctuations	(Mossa, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Escalation of the prices of agricultural products	(Central Bank, 2013)		✓	✓	✓	✓					✓
Increased cost of production	(Lioudis, 2018)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Market environments	(Hanna and Blair, 1993)										
Increased global demand for construction materials	(Mossa, 2013), (Lioudis, 2018)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Limited capacity of the material producers	(Mossa, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Inefficient transportation systems		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Political impacts	(Sally, 2006)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Internal conflicts	(Peiris, 1993)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cultural impacts						✓	✓		✓	✓	✓
Natural disasters					✓	✓	✓	✓	✓	✓	
Poor project estimation	(Mossa, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Improper project planning	(Mossa, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Improper project implementation	(Mossa, 2013)	✓	✓	✓	✓	✓					✓
Project schedule changes	(Mossa, 2013)			✓	✓	✓				✓	✓

4.1 Effect of Price Fluctuations on Civil Engineering Projects

Table 3 lists the effects of price fluctuations on civil engineering projects implemented in Sri Lanka as identified from the literature and agreement of respondents on these issues. All the interviewees agreed with Mishra and Regmi (2017), Mossa (2013), and Nwuba (2004) that poor-quality work, cash flow issues, delayed project completion, disputes, instruction changes, claim entitlements, cost escalations, resource shortages, poor estimation process, and project planning challenges are the impacts caused on civil engineering constructions by price fluctuations. Nwuba (2004) identified project scope changes, unpredictable project costs, long design stages, and project terminations as the impacts of on civil engineering constructions. R6 rejected that price fluctuations make the estimation process poor stating, '*it would be valid if the contract does not allow for price fluctuations when the bidder would keep a high mark-up for the profit to compensate for the price escalation*". However, R5 stated '*unlike in building projects, in civil engineering projects, price fluctuations would not cause project scope changes and long design stages*".

Table 3: Effect of Price Fluctuations on Civil Engineering Projects

Effect	Source/s	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Poor-quality work	(Mishra and Regmi, 2017)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cash flow issues	(Mossa, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Delayed project completion	(Mishra and Regmi, 2017)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Disputes among parties	(Mossa, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Changes made to project scope	(Nwuba, 2004)	✓	✓	✓	✓				✓	✓	
Unpredictable project costs	(Nwuba, 2004)	✓		✓	✓			✓	✓	✓	✓
Changes made to instructions	(Nwuba, 2004)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Long design stages	(Nwuba, 2004)	✓	✓			✓			✓		
Claim entitlements	(Nwuba, 2004)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cost escalations	(Mossa, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Resource shortages	(Nwuba, 2004)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Disregard of quality during the estimation process	(Nwuba, 2004)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Difficulties experienced in planning the project	(Nwuba, 2004)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Termination of the project	(Nwuba, 2004)	✓	✓	✓					✓	✓	✓

Most of the interviewees agreed that price escalations have a significant impact on the initial contract sum of civil engineering projects because of their complexity and long durations. According to R8, in a civil engineering project, the cost overruns, which are caused mainly by price escalations, could be 30%–40% of the initial contract sum.

4.2 Price Fluctuation Management by the Contractors of Civil Engineering Projects

Table 4 presents the strategies used by contractors to manage price fluctuations in civil engineering projects implemented in Sri Lanka. Three of the strategies (written in bold text) were identified at the interviews and the others during the literature review. The interviewees confirmed that all the causes identified from the literature were applicable to civil engineering projects implemented in Sri Lanka. Most of the interviewees disagreed with R2 that price fluctuations could be minimised by getting the subcontractors or suppliers to supply materials or any other resources for a fixed price during the construction period. R5 stated, '*because civil engineering projects are of long durations, the subcontractors/suppliers find it difficult to supply materials at fixed prices throughout the project*'.

Although the literature is silent about using effective bidding strategies and allowing the contractors to purchase materials, to minimise the impacts of price fluctuations, all the interviewees believed that the two strategies are effective in managing price escalations in civil engineering projects. R2 stated, '*contractors can purchase materials in bulk at the beginning of the project and use high mark-ups for expensive items and low mark-ups for the other items to maintain the tender sum at a competitive level'*. The strategies can vary with the scope and nature of the project according to R2.

Table 4: Strategies for managing Price Escalations

Strategy	Source/s	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Adding high mark-ups	(De Mel, 2008)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Incorporating price fluctuation clauses in the contract	(Liyanage, 2005), (Mossa, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Using locally available materials in the designs	(Mossa, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Regular monitoring of the costs incurred, throughout the project, using the data collected from previous projects	(Mossa, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Using a risk management protocol	(Mossa, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Using effective bidding strategies		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Letting the subcontractors to manage the risks			✓	✓	✓			✓			
Letting the employer to supply materials				✓	✓	✓	✓	✓	✓	✓	✓

However, as most of the interviewees stated, civil engineering contractors prefer contracts that allow for price escalations because of their reluctance to take risks that can adversely affect their profitability. The interviewees also highlighted that in most civil engineering projects, the formula method is preferred to the traditional method even though the formula method does not produce accurate results. The contractors tend to manage the escalation of construction material prices by transferring the risks to their clients.

4.3 Methods of increasing Contractor Profits while using the CIDA Price Fluctuation Formula

All the interviewees agreed that the CIDA formula helps the contractors to recover their losses caused by price escalations. Most of them, however, believed that the formula allows the contractors to increase their profits. Table 5 presents the drawbacks of the CIDA formula identified from the literature. The interviewees could not identify any additional drawbacks.All 10 interviewees agreed that the literature findings are applicable to civil engineering projects.

When price adjustments are calculated based on the assessed valuation, it can have an effect on the inputs that do not contribute to price adjustments. R4 stated, '*even inputs with small percentage value with no contribution to price fluctuation would result in a significant higher value for price adjustments and therefore, the price adjustments should be based on the cost change rather than on the assessed valuation'*. The items in the bill of quantities that do not require price adjustments will not boost the contractor profit margin. According to most of the interviewees, the contractor puts weights on inputs that are most likely to inflate in the future. Moreover, when a uniform distribution of input percentages is assumed disregarding the inputs that are not used during the given assessment period, causes the contractor profit to increase. R3 emphasised the importance of having norms because allowing the contractor to calculate the input percentages directly is a critical issue in civil engineering constructions.

Agreeing with the literature review findings, R4 stated, '*PIs are location-dependent and that when a PI common to all areas of the country is used in the calculations, the calculated price fluctuations might not be accurate*'. Agreeing to this, R4, R7, and R10 stated that price variations that are dependent on project location, discounts received for the bulk purchase of materials, the use of depreciated tools and equipment, and the use of stocks from other projects might have an impact on the PIs stated in the CIDA monthly bulletin.

R2 suggested that bidding strategies, such as quoting high rates for the expensive items and low rates for the other items and bulk purchase of materials at the early stages of the project would increase contractor profit. R4 stated '*most of the high-profile contractors in Sri Lanka practise the bidding strategies and that they know how the construction material prices would fluctuate'*. Although R5 believed that the increase in the profits earned by contractors are not due to the drawbacks of the CIDA formula, where purchasing mass quantities of materials in the formula so that the contractors may not benefit from increased payments.

As highlighted by most of the interviewees, the price escalation percentage is higher in civil engineering projects than in building projects because of the bulk purchase of materials. R8 stated, '*in Sri Lanka, the average of the price escalation percentage in civil engineering projects is more than 15%'*. It is mainly due to the material price inflation in the market where the contractor takes its benefit by early material purchase and high input percentages.

4.4 Suggestions to increase the Accuracy of the CIDA Formula

According to the interviewees who were consultants, the contractor should be compensated only for the additional cost incurred due to price escalation without allowing for any profit. Table 6 presents the suggestions that can be implemented to address the drawbacks of the CIDA formula while minimising the additional profits that would be earned by the contractor. It include three suggestions made by the interviewees. In the table, the suggestions made by the interviewees are given in bold text. '*materials such as tar and asphalt should be included in the CIDA bulletin because they are frequently used in road construction projects*'. All the interviewees agreed that the heavy machinery should be categorised in the bulletin and assigned separate indexes.

The profit and overhead factor (K) for the contractor is taken as 15% in the formula. However, different contractors use different overhead and profit ratios. The ratios used by one particular contractor also can vary from project to project. All of the interviewees agreed that the contractors do not follow any particular standard to calculate their overhead and profit margins. R5 stated, 'the contractors can be required to use the CIDA grading system for construction companies to calculate K while keeping in mind the financial challenges faced by the contractors'. Further, the interviewee highlighted that the contractor grading system of CIDA has 11 categories, with C9 being the lowest grade and CS2 the highest grade

Table 5: Drawbacks of the CIDA Formula

Drawbacks	Source	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Assumption that the input percentages are uniformly distributed	(Mel, 2013)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Calculation of the price adjustments based on the assessed valuation	(Jayasinghe *et al.,* 2015),	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Unavailability of norms for use in input percentage calculations	(Jayasinghe *et al.,* 2015), (De Mel, 2008)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Use of the same PI in all projects irrespective of project location	(Jayasinghe *et al.,* 2015)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Use of the same CAF and RAF for all types of projects	(Jayasinghe *et al.,* 2015)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Assumption that the major cost amounts to 90 % of the project value	(De Mel, 2008), (Jayasinghe *et al.,* 2015)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Assumption that the major cost is recovered when the work items have been completed up to 40 %	(CIDA, 2008), (Jayasinghe *et al.,* 2015)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

According to R1, in the absence of any other accepted formula, consultants are compelled to recommend the CIDA formula method to calculate price fluctuations although the contractors can exploit the drawbacks of the formula to increase their profits. The interviewees, therefore, believed that a competitive bidding process that does not require the use of the CIDA formula was acceptable as it would allow the contractor to bid while allowing for price escalations. The CIDA formula can be revised to address its drawbacks and as R6 stated, '*training programmes could be conducted for industry personnel to make them understand the CIDA formula to ensure its correct application*', which will improve the construction practices.

5. Discussion

The relevance of the study was determined by comparing the literature review findings with the interview findings. The outcome of the interviews was consistent with the literature review findings.

Shou *et al*. (2006) identified that the financial failures of contractors due to inflation and price fluctuations was a critical risk associated with construction projects implemented in developing countries. Gavin (2008) identified inflation as the leading cause of price fluctuations. The interview findings of this study also revealed that inflation was the main reason for price fluctuations in civil engineering projects. Civil engineering construction uses materials and labour extensively, and thus inflation can be categorised as material and labour inflation. Inefficient transportation systems, cultural impacts, and natural disasters were identified at the interviews as causing price fluctuations in civil engineering projects.

Table 6: Suggestions to increase the accuracy of the price fluctuations calculated using the CIDA formula

Suggestion	Source	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Changing the PI given in the bulletin based on project location	(Samarakoon and Wijewardena, 2021)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Proposing different CAF values according to CIDA grading of the contractors	(Samarakoon and Wijewardena, 2021)			✓	✓	✓	✓	✓	✓	✓	✓
Changing the input percentage values once in 3 months	(Hajjath and Rathnayake, 2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Considering the time factor when applying the input percentages			✓	✓	✓	✓	✓	✓	✓	✓	✓
Using an updated HSR	(Hajjath and Rathnayake, 2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Using different indexes for the heavy machinery used depending on their category	(Hajjath and Rathnayake, 2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Making available the CIDA bulletin on time	(Hajjath and Rathnayake, 2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Considering the bulk purchase of materials in the calculation					✓	✓	✓	✓	✓	✓	✓
Using an acceptable method to calculate cost changes		✓	✓	✓	✓	✓	✓	✓	✓	✓	

Although the price fluctuations calculated using the CIDA formula may not be accurate (Ramus, 1982; Suraweera, 2001), De Mel (2008) stated that the contracts that do not allow the recovery of price fluctuations will pose risks to both the contractors and employers. The employer will suffer from poor-quality work while the contractor may face cash flow issues, compromise the standards, lead him to delay project completion, and adopt unethical practices. The experts who were interviewed confirmed that price fluctuations could pose the risks identified from the literature in civil engineering projects as well. Irrespective of whether the contract allows the recovery or non-recovery of price fluctuations, the contractor will attempt to transfer the risks to a third party. According to Liyanage (2005), De Mel (2008), and Mossa (2013), adding high mark-ups, including price fluctuation clauses in the contracts, and using locally available materials in the designs are some of the strategies used by the contractors to address price fluctuations. The early purchase of materials for later use, letting the suppliers to provide materials at a fixed price, and letting the employer to supply materials are the strategies identified at the interviews to address price fluctuations.

Hajjath and Rathnayake (2019) emphasised the benefits of using the CIDA formula in construction contracts because of its ease of use, user-friendliness, and applicability for any contract type, and the benefits it provides for both the client and contractor. However, Jayasinghe *et al.* (2015), Mel (2013), De Mel (2008), and CIDA (2008) found that the uniform distribution of input percentages, calculation of price adjustments based on the assessed valuation, non-availability of a standard for input percentage calculation, disregard of the location when calculating PI, use of the same CAF and RAF for every type of project, and the assumption that the major cost amounts to 90 % of the project value and that it can be recovered when the work items have been completed up to 40 % are the drawbacks of the CIDA formula that provide additional profits to the contractors. The interviewees agreed with the literature review findings and did not want to indicate any additional drawbacks of the formula.

Samarakoon and Wijewardena (2021) and Hajjath and Rathnayake (2019) recommended using PIs and CAF values based on project location and CIDA grading of contractors, respectively; making changes to input percentage values once in 3 months; and using separate indexes for heavy machinery depending on their types to increase the accuracy of the calculations done using the CIDA formula in building projects. The interviewees confirmed the applicability of the recommendations to civil engineering projects and proposed to consider the time factor when applying each input percentage and the bulk purchase of materials in the calculations, and the use of an acceptable method for calculating cost changes in civil engineering projects.

The active participation of the key parties in construction projects will be important for industry expansion (Noruwa, 2020). Because some civil engineering projects for infrastructure developments span in wide geographic areas, project coordination is a complex task. In such situations, excellent communication among team members and a database prepared using information collected from previous projects will help fast decision making and prevent the contractors seeking for undue profits. The contracting parties have to be conversant with the consequences of using the CIDA formula and manage the excessive profit margins of the contractors.

6. Conclusions and Recommendations

The study findings revealed that the parameters used in the CIDA formula and the assumptions on which the formula was based, caused inaccurate price fluctuations increasing the profits earned by a contractor. The critical drawbacks of the CIDA formula are due to the coefficient factor constant 0.966 used in the formula, assumptions that input percentages were distributed uniformly and that materials were purchased in bulk, the non-use of norms to calculate the input percentages, the disregard of the effect of assessed valuations, and the use of PIs that were common to all districts of the country. The suggestions on the changes required in the formula were made by considering the identified drawbacks. The study also reveal that by estimating K values using the CIDA grading system for construction companies, developing district-level indexes, using an acceptable method for calculating the cost changes within the given valuation period, changing the input percentage values once in three months, considering the time factor when applying each input percentage, using different indexes for different categories of heavy machinery, considering the bulk purchase of materials in the calculations, using an updated HSR, and making available the CIDA bulletin on time , the drawbacks of the CIDA formula can be addressed.

Furthermore, the suggestions made by interviewees, such as establishing a robust communication network among project team members and providing training to industry practitioners on the use of CIDA price fluctuation formula are essential for contractual parties to avoid the misinterpretation of the CIDA formula and alter the formula to suit a particular type of project. The contractors would benefit, if the CIDA price fluctuation formula could be used to calculate price escalation payments in civil engineering projects. Hence, to have a reliable and efficient method for calculating price fluctuations, the CIDA formula can be revised considering the suggestions made in the study. The data used in the formula should be updated regularly for the accuracy in final calculation.

The practical implications of the study are that the study findings will help industry practitioners to manage effectively the price fluctuation claims in civil engineering projects using the CIDA formula and the risk of price escalations. To avoid overestimated price fluctuations, the Sri Lankan government must focus on changing the CIDA formula, or the project teams can take steps to change the formula by changing the parameters. The study findings will help contracting parties to identify potential reasons for increased profits earned by the contractor so that suitable procedures can be implemented to avoid or minimise the overestimation of price fluctuations using the CIDA formula.

Unlike previous studies, this study investigated the causes and made suggestions for managing the contractor profit in civil engineering constructions using the CIDA formula, filling a gap in the literature. This study was limited in that it investigated only the price fluctuations using the CIDA formula in Sri Lanka, commonly considering both small and large-scale contractors. Hence, this can be extended in future to investigate on the effects of the CIDA formula on the profits separately to small and large-scale contractors.

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