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ACCURACY OF TRADITIONAL CONTINGENCY ESTIMATION IN THE CONSTRUCTION INDUSTRY

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ABSTRACT

Contingency amounts are allocated in the construction projects to deal with uncertainties arising during the projects. Contingency amounts are usually estimated traditionally by simply adding a percentage of the estimated contract amount. However, the traditional system of contingency estimation is heavily criticised as ineffective due to several reasons. Therefore, this research focuses on evaluating the level of accuracy of current contingency estimation techniques in the Sri Lankan context. This study adopted a mixed-method research approach. Empirical data were collected using expert interviews and questionnaire survey. Data collected from the expert interviews were analysed using manual content analysis. Descriptive statistics and inferential statistics were used to analyse the questionnaire survey data. Findings revealed that inexpensiveness is the highly motivating factor for the rigid usage of the traditional method to estimate contingency in the Sri Lankan context. Estimated contract amount, procurement method, payment method, and type of client were identified as highly influencing factors in contingency estimation. Finally, the hypothesis test of this study revealed that the traditional contingency estimation is ineffective. Since the traditional contingency estimation proved ineffective and highly inaccurate, experts in the industry should consider a flexible alternative approach in contingency estimation to improve the accuracy of the contingency amount.

Keywords: *Alternative method; Contingency; Estimation techniques; Traditional method.*

1. INTRODUCTION

Contingency is the percentage of a construction budget set aside to accommodate unknown factors and uncertainties connected to the construction projects (Lam and Siwingwa, 2017). Accordingly, a project's total financial commitment can be expressed by adding contingencies within an estimated budget which provides the basis for cost control and measurement of cost performances (Baccarini, 2005). The excess contingency allowance ensures that design and construction will be finished smoothly within the budget and schedule. However, the funds tied up as contingency prevent the parties from undertaking other activities such as contractors bidding for other projects and owners investing in new projects (Günhan and Arditi, 2007). Insufficient contingency leads to the additional financial commitment that allows seeking unexpected financial arrangements (Amade *et al.*, 2014). Hence, it is vital that a sufficient contingency amount

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must be allocated to a project to enable the parties to deal with uncertainties; and, at the same time, not tie up valuable funds (Nawar *et al.*, 2018).

Experts usually depend on traditional methods to specify the contingency amount based on subjectivity, experience, gut feeling, and instinct - they do not rely on a mathematical approach to support that decision (Touran, 2003). The public sector is a better example of the adaptation of the traditional method for contingency estimation. Government is a major investor in the construction industry at all levels and has a responsibility to act as industry regulator and legislator (Keith and Peter, 2004). In Sri Lanka NPA guidelines, in total cost estimation, the maximum allocation for physical contingencies is up to 10%. It further suggests that allowance for variations incur during the project are allocated within this limit. If the limit exceeds, approval should be taken from the appropriate level of authority mentioned in the manual. However, the uniqueness of each construction project and other factors induces several issues in this traditional contingency estimation (Karlsen and Lereim, 2005). Hence, researchers identified and analysed advanced mathematics and probabilistic methods used for estimating contingency to overcome this problem.

A recent study by Moselhi and Roghabadi (2020) shows that researchers developed models and identified tools and techniques globally to improve efficiency in contingencies estimation. However, in Sri Lanka, the contingency estimation technique is still an under-researched topic. Therefore, this research envisages evaluating the current rigid practice in contingency estimation in Sri Lanka to identify its effectiveness. The research aim here is to analyse the accuracy of the contingency estimation in the Sri Lankan context. The research aim was developed by reviewing the concept of contingency estimation in construction projects, identifying the significant factors considered for contingency estimation, analysing the different techniques used in contingency estimation in the world and Sri Lanka, and evaluating the accuracy level of contingency estimation in Sri Lanka.

2. LITERATURE REVIEW

2.1 SIGNIFICANCE OF CONTINGENCY IN CONSTRUCTION PROJECTS

Contingency is the additional amount allocated above the base estimate as a reserve of money in a construction project (Lam and Siwingwa, 2017). There is no standard definition for contingency in the literature, but in general, it is defined as the source of funding for unexpected events occurring during construction projects (Günhan and Arditi, 2007). Therefore, contingency provides flexibility to the project. It also allows value addition to a project by implementing design changes and scope changes within the budget (Ford, 2002). The generally accepted contingency amount in a construction project is identified as design contingency, construction contingency, and client contingency (Patrascu, 1988). Design and construction contingencies are used to cover the additional costs during the pre-construction and construction phases, respectively (Günhan and Arditi, 2007). The client contingency is the risks brought up by the employer, mainly due to some change in taste or scope of the project. Furthermore, client contingency can be experienced during both the construction and design phases, from inception to completion (Lam and Siwingwa, 2017).

Contingency is also regarded as one of the best strategies to deal with numerous construction risks (Elbarkouky *et al.,* 2016). Therefore, contingency is used in conjunction with other construction risk reduction techniques. Accordingly, various methods are proposed in the literature to use contingency sum to use as a management tool (Lam and Siwingwa, 2017). Proper constancy estimation and identifying a suitable content estimation method are crucial because an improper contingency estimation method can lead to overestimating and underestimating the contingency amount. In the overestimated scenario, the funds tied up as 'contingency' prevent the parties from undertaking other activities such as contractors bidding for other projects and owners investing in new projects (Günhan and Arditi, 2007).

On the other hand, underestimating contingency amounts creates issues such as cost overrun, time overrun, payment delay, and the need for sudden financial loans (Amade *et al*., 2014). However, underestimation of the contingency amount is a significant concern in the researchers' view. Lam and Siwingwa (2017) conducted a hypothesis test. They showed that the allocated contingency amounts are insufficient to cover the actual contingency amount, which is the sum of the actual amount spent at the end of the project as a contingency.

2.2 FACTORS CONSIDERED FOR CONTINGENCY ESTIMATION

Construction industry projects are subject to larger amounts of risks due to their unique features such as long period, a large number of stakeholders and labours, complicated process, financial intensity, and dynamic environment (Bahamid and Doh, 2017). However, all the risk factors are not considered for the contingency estimation because variables or factors considered for contingency estimation must be simple, and hence, unnecessary parameters should be avoided (Baccarini, 2006). Lam and Siwingwa (2017) identified the project's complexity and estimated that project cost at a detailed design stage as critical factors considered for determining contingency sum - a larger and more complex project has a higher chance of having an inadequate estimated cost. In addition, duration, location and type of work (new build or refurbishment) influence the contingency estimation (Jimoh and Adama, 2014), while design completeness and scope changes are identified as other leading contributors to the contingency amount deviations (Buertey *et al*., 2013).

McLain *et al*. (2014) recognised geotechnical conditions as another factor that needs to be considered for contingency estimation. Ahiaga-Dagbui and Smith (2005) study validate these arguments by identifying inclement weather, unsuitable ground conditions, scope changes, and client's cash flow problems as factors affecting contingency amount. Economic factors such as tax rate, exchange rate, and price fluctuations also influence determining contingency in construction projects (El-Karim *et al*., 2015).

2.3 CONTINGENCY ESTIMATION METHODS

Contingency estimating methods are categorised into three groups: deterministic, probabilistic, and modern methods (Bakhshi and Touran, 2014). Table 1 presents the detailed breakdown of these methods and their comparison in various criteria to summarise several literature findings.

The traditional method is the most common and simplest method used in contingency estimation (Baccarini, 2005). In this method, a percentage of the estimated contract amount is added as a contingency amount. This percentage is derived either from expert opinions or a fixed percentage set by the institution (Baccarini and Love, 2014). The traditional method has been used for a long time even though alternative methods are proposed with better benefits (Bello and Odusami, 2008). This traditional method is also referred to as the 'deterministic method' and highly criticised in the literature (Baccarini and Love, 2014). The traditional method expresses a single figure of the amount rather than the range, as the term deterministic implies (Bakhshi and Touran, 2014). Since this method ignores formal risk assessment, it is suitable for a project with a low budget, having less time to prepare an estimate, and when the insufficient budget is allocated for estimation. However, these methods fail to address the unique characteristics of a specific project like complexity, market condition, and location (Olumide *et al*., 2010).

Table 1: Detailed breakdown of contingency estimation methods along with the comparison

Contingency Estimation Methods	(Criteria)	Simple to Execute	Specific Risk Factors in Project Considered	Considered Subjective Uncertainty (Experts' Opinion)	Cost Consuming	Time Consuming	Need of Estimator Knowledge on Selected Field	Reliance on Past Data
Deterministic Methods	Predefined Percentages	✓						
	Expert Judgment	✓		✓				
Probabilistic Methods	Expected value		✓					✓
	Regression							✓
	Monte Carlo Simulation		✓		✓			✓
Modern Mathematical Methods	Fuzzy Techniques		✓	✓	✓	✓	✓	
	Artificial Neural Network		✓	✓	✓	✓	✓	

3. METHODOLOGY

The study used the mixed approach because it helps in-depth exploration of a research problem (McCusker and Gunaydin, 2015) by integrating quantitative and qualitative data (Uprichard and Dawney, 2019). The first part of the study used a qualitative approach to identify the different types of contingencies estimation methods and factors considered during contingency estimation (McCusker and Gunaydin, 2015). The second part of the study used a quantitative approach to identify the significant factors considered for contingency estimation and the effectiveness of the traditional contingency estimation (Creswell, 2017). The required qualitative data were collected by interviewing experts based on their experience (Fellows and Liu, 2015). Accordingly, face-to-face semi-structured interviews were held with experts who had more than ten years of working experience in construction projects in Sri Lanka to validate the literature findings and assess new facts. Table 2 lists the interviewees' profiles. The empirical results of the interviews were analysed using manual content analysis.

Table 2: Details of Delphi round 1 respondents

Nr.	Designation	Experience in Construction Industry
1	Senior Quantity Surveyor	15 Years
2	Project manager	10 Years
3	Quantity Surveyor	11 Years
4	Project manager	17 Years
5	Engineer	10 Years
6	Senior Quantity Surveyor	19 Years
7	Quantity Surveyor	10 Years
8	Engineer	10 Years
9	Senior Quantity Surveyor	11 Years
10	Project manager	11 Years

The significance level factors considered for the contingency estimation were identified using a questionnaire survey. The questionnaires were distributed among 40 respondents working on construction projects. Among the 33 returned questionnaires, 30 were duly filled. The survey respondents, who had to have more than five years of working experience in construction projects in the profession of quantity surveying, engineering and project management, were selected using purposive sampling based on their professional qualifications, experience, knowledge, and willingness to participate in the survey. Table 3 presents the details of the respondents. The survey findings were analysed using the relative importance index (RII) and were calculated using Equation 01:

$$RII = \frac{\sum(Wn)}{N \; x \; A} \qquad (01)$$

Where W = rating given to a factor by each of the respondents; n = frequency of the responses; N = total number of responses; A = highest weight.

Table 3: Details of Delphi round 2 respondents

Profession	Experience in Construction Industry (Years)					
	1-5	6-10	11-15	16-20	21-25	Total
QS	3	5	2	1	1	**12**
Engineer	7	4	4	1	-	**16**
Project Manager	1	-	1	-	-	**2**
Total	**11**	**9**	**7**	**2**	**1**	**30**

Quantitative data, such as the contract amount and the contingency amount of 34 projects, were collected and analysed using a hypothesis test to achieve the overall aim of the study. The hypothesis test was identified as the most suitable method, as it was used in a similar survey of Lam and Siwingwa (2017), which concluded that contingency amount is insufficient in Zambia.

4. FINDINGS AND ANALYSIS

4.1 DIFFERENT CONTINGENCY ESTIMATION METHODS

The interviewees validated all six (06) contingency estimation methods identified from the literature review as applicable to the Sri Lankan context. The traditional method, regression, expected value, Monte Carlo Simulation, Artificial neural network, and fuzzy logic techniques are the contingency estimation methods identified from the literature review and expert interviewees. In order to determine the awareness of contingency estimation methods and their usage in the local construction industry, the questionnaire survey respondents were asked to respond about their involvement in the construction projects with traditional contingency estimation methods vs alternative contingency estimation methods. Accordingly, 94% of the respondents were involved in the projects that used the traditional method, while the remaining 6% of the respondents were involved in the projects with alternative contingency estimation methods.

Except for the respondents' personal involvement, their general awareness of these contingency estimation methods were also identified from the questionnaire survey as interpreted in Figure 1.

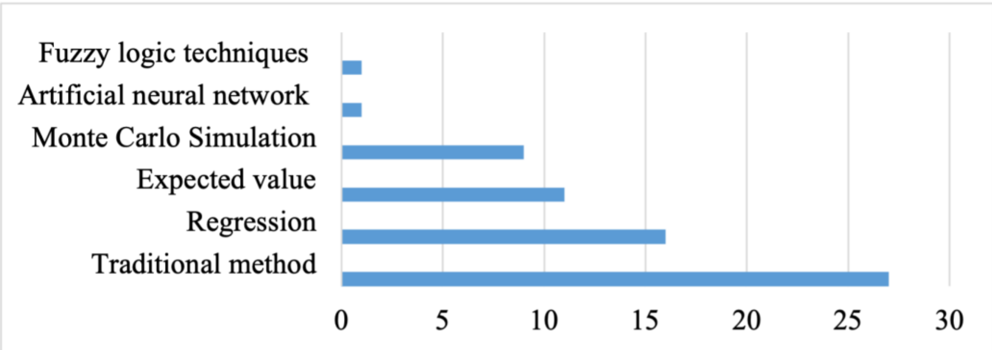

Figure 1: Awareness of contingency estimation methods

As per Figure 1, a considerable gap exists between the traditional methods and other methods. The regression method stands at the second position with 50% awareness of the respondents; a 34% difference occurs between the first two methods. Almost all the respondents were unaware of the last two methods, i.e., fuzzy logic and Artificial Neural network. However, the main criticism regarding contingency estimation is the rigid use of the traditional method without experimenting with other techniques. Many (84%) questionnaire respondents agreed that traditional methods are overwhelmingly used in projects without seeking alternative methods for contingency estimation.

The literature review identified cost, time, easiness, and simplicity as reasons for this higher tendency towards traditional methods. Besides, three factors were identified through interviews, i.e., lack of knowledge about the alternative methods, uncertain or not proven benefits about using the alternative methods, and lack of critical need for change. Questionnaire survey respondents were asked to priorities these findings, and Table 4 provides the results.

Table 4: Motives for the use of traditional contingency estimation method

Factors	RII value	Significance	Rank
Low cost	0.952	High	1
lack of knowledge about the alternative methods	0.841	High	2
Uncertain benefits about using the alternative methods	0.828	High	3
No critical need for change	0.817	High	4
Time saving	0.800	High	5
Simple and easy method	0.648	Medium	6

Low cost was the most significant motivating factor for the rigid use of the traditional contingency estimation method and ranked 1st with the RII of 0.952, whereas a simple and easy method was identified in the 6th rank with the RII of 0.648. However, it was not identified as the least significant factor but at medium level significance. All other factors were identified in the range of highly significant, according to the RII value.

4.2 Factors Considered for Contingency Estimation

Table 5 presents the factors considered during the contingency estimation calculation, including 11 literature findings and three additional factors identified from the expert interview. Interviewees validated that all 11 factors identified from the literature review are applicable to the Sri Lankan context. The procurement method, payment method, and conditions of the contract are the additional factors identified by the interviewees, as indicated by the red coloured text in Table 5, which also presents the RII value, significance level, and the ranking of each factor.

Table 5: Significance of factors affecting contingency estimation

Factors	RII value	Significant level	Rank
Estimated Contract amount	0.975	High	1
Procurement method	0.855	High	2
Payment method	0.848	High	3
Type of client	0.813	High	4
Contract period	0.772	High -Medium	5
price fluctuation	0.761	High-Medium	6
Complexity	0.752	High-Medium	7
Location	0.662	Medium	8
Type of wok (new/refurbishment/maintenance)	0.637	Medium	9
Geo technical condition	0.628	Medium	10
Exchange rate	0.600	Medium	11
Completeness of design	0.586	Low	12
Conditions on contract	0.538	Low	13
Weather condition	0.497	Low	14

Among the four highly significant factors, the *estimated contract amount* identified as most significant with the RII of 0.975. The *procurement method* and *payment method*, identified as 2nd and 3rd significant factors, respectively, were not identified from the literature but the interviews. Interviewees identified the procurement method as one of the important factors considered during the contingency estimation, with an example of design discrepancies related to contingency amount. According to the interviewees, the case of design discrepancies between tender drawings and as-built drawings always resulted in additional costs. If it is a traditional procurement method, the project cost will increase. However, the risk related to the design discrepancies does not exist in the design and build procurement method. Hence procurement method is a factor determining contingency estimation.

Similarly, the interviewees identified the payment method because payment varies between fixed-price contracts and measure and pay contracts. Even though interviewees newly identified *conditions of contract* as one of the factors, it was ranked 13th with the RII of 0.538, which falls under the low significance level.

4.3 EFFECTIVENESS OF TRADITIONAL CONTINGENCY ESTIMATION

More than 75% of the respondents mentioned during the questionnaire survey that the allocated contingency amount is not sufficient to cover the actual contingency amount. However, this conclusion is based only on the survey respondents' opinion. Therefore, findings were tested with the actual data from the past project. Accordingly, a Hypothesis test was performed to check whether the contingency estimated in past projects is sufficient to cover the actual contingency amount.

- The null hypothesis, H_0 = the traditional contingency sum, is sufficient for a building project in the Sri Lankan construction industry.
- Alternative hypothesis, H_1 = the traditional contingency sum, is insufficient for a building project in the Sri Lankan construction industry.
- In the traditional method, usually, 10% of the initial contract amount is allocated as a contingency. In addition, from the questionnaire survey, respondents indicated 3% deviation could be tolerated. Hence, the 13% level is selected as a sufficiency level.
- Now H_0 and H_1 can be rewritten as: H_0; $\mu \leq 13\%$ and H_1; $\mu > 13\%$, where μ = mean of actual contingency.

The samples for this test were collected in a convenience sampling method, and data were collected from more than 30 numbers of projects, which is the minimum requirement for an appropriate hypothesis test. Table 6 presents the data collected for the hypothesis testing. Accordingly, P6 and P14 have extremes value comparing the other values; hence P6 and P14 are excluded from the further calculations. In addition, the estimated contract amount presented in Table 6 excluded the amount deducted as value engineering benefit. The value of the test statistic is calculated by using Equation 02.

$$Z(test) = \frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}} \quad (02)$$

Where, $\bar{x}$ = mean of sample, μ_0 = mean of the population, σ = the standard deviation of the population, and n = the number of observations. Based on the collected data and using Equation 02, the test statics (Z) value is obtained as 2.73, where x ̅=17.35, μ_0=13, σ=8.70, and n=30.

Table 6: Details of hypothesis test projects

Project Name	Estimated Contract Amount	Estimated Contingency (a)	Final Contract Amount	Actual Contingency (b)	(a) – (b)
P1	848,747,593.00	10%	867,562,785.00	12.22	2.22%
P2	49,506,724.00	10%	45,411,850.77	1.73	-8.27%
P3	15,446,560.00	10%	15,142,923.60	8.03	-1.97%
P4	195,500,000.00	10%	202,166,453.00	13.41	3.41%
P5	245,000,000.00	10%	293,456,712.00	29.78	19.78%
P6	83,000,000.00	10%	143,554,901.00	82.96	72.96%
P7	333,500,000.00	10%	351,566,423.00	15.42	5.42%
P8	135,606,769.00	10%	163,009,554.44	30.21	20.21%
P9	83,129,025.00	10%	98,826,738.35	28.88	18.88%
P10	659,278,899.05	10%	701,478,007.19	16.40	6.40%
P11	215,849,580.00	10%	226,857,782.30	15.10	5.10%
P12	102,920,893.02	10%	132,648,124.06	38.88	28.88%
P13	107,595,678.75	10%	126,857,453.25	27.90	17.90%
P14	456,654,782.98	10%	632,655,323.78	48.54	38.54%
P15	78,355,623.55	10%	91,461,323.16	26.73	16.73%
P16	75213652.3	10%	81591273.58	18.48	8.48%
P17	30,684,362.22	10%	26,682,054.00	-3.04	-13.04%
P18	88,791,026.42	10%	101,065,431.90	23.82	13.82%
P19	196,257,143.45	10%	199,743,027.56	11.78	1.78%
P20	68,678,995.67	10%	72,682,932.00	15.83	5.83%
P21	330,145,764.65	10%	342,874,163.53	13.86	3.86%
P22	456,923,865.48	10%	492,865,429.34	17.87	7.87%
P23	215,674,265.00	10%	242,759,552.87	22.56	12.56%
P24	149,673,900.62	10%	147,221,886.76	8.36	-1.64%
P25	44,587,465.98	10%	46,917,836.33	15.23	5.23%
P26	127,491,731.48	10%	132,587,241.78	14.00	4.00%
P27	53,914,980.03	10%	60,826,781.46	22.82	12.82%
P28	541,826,402.62	10%	562,887,336.33	13.89	3.89%
P29	205,998,664.81	10%	200,892,965.44	7.52	-2.48%
P30	612,854,037.62	10%	653713982.6	16.67	6.67%
P31	310,642,711.11	10%	341275843.4	19.86	9.86%
P32	96,527,831.09	10%	102586391.3	16.28	6.28%
Average				**17.35%**	**7.35%**

If Z is greater than the critical value, the null hypothesis is rejected. The critical value for rejection with a 10% significance level is 1.956. The calculated value of Z is 2.73, which falls in the rejection area, and the null hypothesis is rejected. Hence, the traditional contingency sum is insufficient for a building project in the Sri Lankan construction industry. The average amount of actual contingency is 17.35% of the estimated contract sum, which is more than 7% higher than the actual estimated contingency amount. The hypothesis test also indicates that the contingency sum allocated in traditional methods is insufficient. Hence it can be concluded that the traditional contingency estimation method in Sri Lanka is ineffective.

5. CONCLUSIONS

This study focused on analysing the accuracy of the contingency estimation in the Sri Lankan context, which is rarely touched on in the literature. Similar to the literature, this study also identified six contingency estimation methods applicable to the Sri Lankan context. Among them, the traditional method of contingency estimation proved to have high awareness in the Sri Lankan perspective, whereas fuzzy logic techniques obtained very little awareness. Moreover, six factors were identified in this study as motivating factors for the rigid use of the traditional estimation method in Sri Lanka. Accordingly, low cost was the highly motivating factor for the rigid use of the traditional method. Fourteen significant factors affecting the contingency estimation were identified from this study, and the estimated contract amount was most significant. Finally, at the end of the hypothesis study, it was concluded that there is still a potential to increase the effectiveness of the tractional method of contingency estimation in Sri Lanka.

The contribution made by this study will considerably assist the industry to be aware of the importance of enhancing the effectiveness of the traditional method of contingency estimation in Sri Lanka. Furthermore, it is recommended to recognise the alternative contingency estimation methods available and adapt them to enhance the accuracy of the contingency estimation. The study makes a theoretical contribution by providing a benchmark for the accuracy of the traditional contingency method, especially for the Sri Lankan construction projects. Because, though several past studies have identified the rigid usage of this traditional method, they were not specific to the Sri Lankan situation and were not focused on analysing its accuracy. This study will be a helpful basis for further research to explore the alternative contingency estimation methods in the Sri Lankan perspective and to compare the effectiveness of them against the existing rigid method.

An investigation should address the research question, “are all increases from the estimated cost to be covered from the contingency?” This issue was not identified from this study’s hypotheses. One limitation of this study was that since data were collected within the Sri Lankan context, it may influence the generalisation of the findings from a global viewpoint.

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