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Contingency Use and Project Delivery Influence on Infrastructure Project Risk Assessment

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Abstract. Risk assessment and management in infrastructure projects considered one of the main factors that can enhance project success. Project team perceptions on risk identification are important to develop a risk mitigation strategy. Cost overruns are one of the critical risks in this industry, which have been mitigated by allocating a contingency amount to the initial cost estimate. The aim of this study was to understand the use of project contingency by the owner and contractor. Additionally, it analyzed the project delivery methods that entice the use of intensive project risk assessment procedures, especially in infrastructure construction projects. It was found as one of the factors that drive the use of risk assessment.

1 Introduction and Background

Project risk is an uncertain event or condition that, it occurs, has a positive or negative effect on any project's objectives. Owing to the unique and complex nature of infrastructure projects, uncertainty in cost and schedule overruns are vital. It is important and special for budget and schedule preparation, it helps to accommodate changes without affecting the project's cost and duration [1].

Cost overruns and late completion times in large infrastructure projects have been widely recognized as project performance risks impacts [2],[3]. Cost escalation can be affected by the length of the project implementation phase, project size, and project ownership type [4]. Therefore, accurately estimating project costs and contingencies is an important factor for successful project cost management from the start of the planning phase to the completion of construction [5]. Consequently, an institution like the Washington Department of Transportation (DOT), adopted a cost estimate validation process (CEVM). This method uses Monte Carlo simulation to assess the likelihood of completing a project within budget and schedule [3],[6].

Traditionally, project cost contingency was added by adding a base percentage to the overall project cost [7], but this method is arbitrary and difficult to implement, given various complexities and large scale of construction projects [8]. Also, past studies showed that, specifically in the construction industry, the need to use expert opinions, past experience, intuitive, and thumb rules. And it cannot be avoided completely due to a lack of statistical data [9],[10].

Managing different project risks, especially in the construction phase, is the most effective strategy that helps control cost and time escalations [1]. Akintoye and MacLeod (1997) [5] found that the construction industry in the UK has approached risk management in terms of individual intuition, judgment, and experience gained from previous contracts. Contractors have the tendency to contract out all the work packages in a project to sub-contractors and undertake contract management as part of a strategy to reduce or eliminate their risk. The more powerful and sophisticated risk assessment (RA) techniques, the more time and data are required. The construction industry is lagging behind in terms of big data management and analytics. Furthermore, most contractors are reluctant to use sophisticated risk assessment, analysis, and many management techniques.

Using risk assessment in highway projects improved construction performance. In this study, the statistical dependency correlation analysis showed that the use of risk assessment in the reported projects has improved project and construction management practices [11].

Project delivery selection is one of the critical factors for projects' success [12]. Traditional project delivery methods include, but are not limited to, the Design-Bid-build (DBB), Design-Build (DB), and Construction Manager as Agent and at Risk (CM/A or CM@R) [13]. State DOTs in the United States often use three fundamental project delivery methods: Design-Bid-Build (DBB, Design-Build, and Construction Manager-General Contractor (CMGC) [14].

As observed in the literature above, the use of risk assessment has been inconsistent among the different infrastructure construction projects. This can be attributed to several factors that have been identified through the different studies yet, there were no different answers about the association between the risk assessment use and these factors. Moreover, there have been many studies on the different methods of assigning contingencies. There is a lack of understanding of how the different stakeholders use their contingencies during the project. which in turn can later enhance the methods for developing these contingencies. Therefore, this paper, which is part of a larger study, will address the following objectives:

1. Understand the use of project contingency by the different stakeholders, mainly the owner and the contractor.
2. Analyze the project delivery method that entices the use of intensive project risk assessment procedures in infrastructure construction projects.

2 Methodology

The data collection was administered through a survey instrument to collect infrastructure projects' data from several infrastructure projects across the US. (North, East, Midwest, West, and South Regions) for a variety of infrastructure projects with different parameters. Some of these parameters are project type (Road, Bridge, Tunnel), project delivery method (DBB, DB, Other), Procurement methods (low bid, Best Value, other), Contract type (lump sum, unit price, etc.), Total Planned Costs (TPC), Total Planned Duration (TPD). All of these parameters along with specific risk management questions such as risk assessment use and tools, contingencies percentages, contingencies use were included in the data collection process.

The collected data were analyzed through descriptive statistics. The goal is to obtain general data tendencies such as mean, median and standard deviation, and other inferential statistics such as correlation analysis, Chi-Square tests, and Fisher's exact tests. These tests used to analyze specific hypothetical questions. The total number of responses received was 246, some of which contained responses for more than one project. Out of these responses, 48 responses had completed the survey questions used in this paper analysis.

3 Discussion and results

This section will focus only on the results that pertain to the paper's objective, which addresses the contingency use by the owners and contractors. Additionally, the factors that might entice the use of risk assessment tools like project delivery methods.

3.1 Contingency Use Results

After analyzing the survey responses, the results showed that most of the owner's contingency was directed towards the cost changes as related to the following; additional work and unknowns, bid item overruns, contract changes for environmental cleanup, claims and change orders, unforeseen environmental mitigation, right-of-way cost increases, asphalt cement and fuel adjustments, owner-directed changes, utility relocation, undefined damages discovered during reconstruction (because of issuing/ incomplete data of road/bridges and state of the art condition, etc.), changes site conditions, additional deterioration of highways/bridges during final design, inspection, and engineering costs.

On the other hand, after analyzing the survey responses, most of the Contractor contingency in these infrastructure projects reported in survey responses were directed towards the cost changes as related to the following: escalation, weather-hurricanes, minor owner-directed changes, quantity variations, permit delay, and design delay, proprietary information, materials cost increases, fuel increases, unforeseen environmental mitigation, and acts of nature, all potential risks that are not mitigated by the owner, design growth, quantity growth, labor availability & cost, equipment availability, schedule risk, liquidated damages, differing site conditions, force majeure issues, funding availability, difficult owner and owner's representative, predicted damages, unforeseen circumstances, the added value for the extended pavement design life, material/fuel cost increase, change orders, workers compensations, utilities, material escalation, environmental, scheduling complexities; and minor overruns.

3.2 Project Delivery Methods and the Use of Risk Assessment in Project

As mentioned earlier, the responses were obtained for three types of project delivery methods: design bid build (DBB), design-build (DB), and others. The data analysis was carried out only for DBB and DB project delivery methods. The goal was to investigate if there is a significant correlation between the project delivery methods and the use of RA in the chosen projects. The hypothesis behind the analysis can be explained as in the following:

H_o: There is no dependency correlation between the project delivery method and the use of risk assessment in the chosen construction project.

H_a: There is a dependency correlation between the project delivery method and the use of risk assessment in the chosen construction project.

After running a Chi-square analysis as shown in Table 1, there is not enough evidence to reject the alternative hypothesis. About 85% of the projects using a DB project delivery method used RA, whereas only 53% of the projects using the DBB project delivery method used RA. This indicates that the use of RA is more prevalent, significant and important in projects using the DB project delivery method. This could impact the cost and schedule of these projects more significantly than the projects using the DBB project delivery method. Following the chi-square test, Fisher's exact test was used here because of low cell counts in certain cells. Fisher exact test also indicated low probability value, and provided the basis for rejection of the null hypothesis at alpha (α) value of 0.05, which further supports the conclusions from Chi-square test.

Table 1. Project Delivery Methods and the Use of Risk Assessment in Project

Using risk assessment	Project Delivery Method			
Frequency Row Pct Col Pct	DBB	DB	other	Total
	31	17	5	53
Yes	58.49	32.08	9.43	
	53.45	85.00	83.33	
	27	3	1	31
No	87.10	9.68	3.23	
	46.55	15.00	16.67	
Total	58	20	6	84
Statistic		DF	Value	Probability
Chi-Square		2	7.4947	0.0236
Likelihood Ratio Chi-Square		2	8.1750	0.0168
	Fisher's Exact Test			
Table Probability (P)			0.0019	
Pr <= P			0.0177	

4 Conclusion

This paper, as part of a bigger study, was focused on understanding how the different stakeholders (Owners and contractors) use their contingencies in infrastructure projects. Moreover, the study also aimed to identify some of the major factors that can entice the use of Risk assessment tools during project planning and management like the project delivery method. The results showed that unforeseen site conditions (e.g. changing site conditions, unforeseen environmental mitigation, unforeseen circumstances) are a common ground for contingency spending among both parties. However, most of the contractor's contingency spending is more directed towards unpredictable cost escalation items (material costs, fuel costs, design growth). This research also showed that DB project delivery is one of the major factors behind using RA in project planning and management. This can be attributed due to the additional risks that a Design-Builder might take when being responsible for both design and construction. For future study, authors are interested to explore other delivery methods analysis utilizing more quantitative risk assessment tools.

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