CHAPTER 15

A Study on BIM & Blockchain Integrated Time and Cost Overruns in Construction Projects

Zoya Ghayas, Sainath Yakathpure**, Ameya Phadke** and Jonardan Koner****

ABSTRACT

Time and Cost overruns are major challenges in the construction sector, causing project delays, budget escalations and reduced stakeholder confidence. In India, because of bureaucratic constraints, financial limitations and unorganised implementation, the challenges are amplified. The use of technology such as Building Information Modelling (BIM) and Blockchain offers solutions that can improve the effectiveness of projects. BIM can be an efficient tool to coordinate projects and plan with advanced visualisation and accurate scheduling, and Blockchain enables transparent data management and automation through smart contracts, however, the potential of their combination is underexplored. This study empirically examines the combined impact of BIM and Blockchain technology adoption on the performance of construction projects. Data was derived from structured surveys of professionals, supported by literature, and analysed using triangulation framework to establish benchmarks. Partial Least Squares Structural Equation Modelling (PLS-SEM) was utilised to analyse links between BIM and Blockchain adoption, governance efficiency and time and cost performance. Results show that BIM enhances time performance through improved planning and coordination, while blockchain increases governance efficiency in cost controls. It is concluded that effective mitigation of time and cost deviations requires a methodical approach of combining these technologies with practical relevance.

Keywords: Blockchain, Building information modelling, Construction management, Cost and time overruns, Project performance.

1.0 Introduction

The construction sector, while is on a steady growth spur, is also hugely affected by systemic inefficiencies in the delivery of the construction projects.

**Corresponding author; Student, School of Construction, NICMAR University, Pune, Maharashtra, India (E-mail: p24700629@student.nicmar.ac.in)*

***Student, School of Construction, NICMAR University, Pune, Maharashtra, India (E-mail: p24700621@student.nicmar.ac.in; p24700622@student.nicmar.ac.in)*

****Professor, School of Construction, NICMAR University, Pune, Maharashtra, India (E-mail: jonardankoner@nicmar.ac.in)*

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The widespread time and cost overruns observed in the projects in this sector result in a ripple effect on the economy. Statistics show that nearly half the infrastructure projects go over budget and face a minimum of 20% to an astonishing 80% of schedule lag which severely impacts the development of national infrastructure. The causes of these overruns are multifaceted; however, the most important contributors are derived to be Inefficient planning processes, opaque transactions and financial flows, lack of labour force (affecting 35% of projects according to KPMG 2022), fluctuating material prices (adding 15-30% to the budget according to Delloite 2021), and administrative incompetence. In India, factors like fragmented stakeholders and claims and disputes, result in urban projects facing land acquisition delays and subsequent increased risks, needing tailor made and out of the box solutions.

In light of these predominant factors, emerging technologies like Building Information Modelling (BIM) can be used for early clash detection, better project and schedule visualisation and real-time progress tracking. Whereas blockchain technology can be adept at reducing data tampering by using a decentralized structure, while enabling the implementation of smart contracts and increased transparency of records. These technologies, when used effectively can give a synergistic boost to the projects addressing both technological and contractual aspects of project cost and time overruns. This significantly benefits urban development to reduce primary issues while maintaining the adaptability for complex metropolitan projects.

2.0 Literature Review

Time and cost overruns are common issues in construction projects worldwide, regardless of a country's level of development. A lot of studies reflect that most common factors affecting overruns are technical issues, poor management, financial hurdles and major institutional obstacles. Prior research has indicated that reasons for such are poor planning and stakeholder management, frequent design changes and slow decision making (Doloi et al., 2012; Sambasivan & Soon, 2007; Sweis et al., 2008). Developing countries face challenges in bureaucracy, insufficient funding and fragmented leadership which increases risk (Shah, 2016).

Over time people have tried to find the root causes and measure them with surveys and statistics. Shah (2016) argued that factors affecting these delays are pretty much same however their importance changes based on situations like procurement method, quality of contactors or payment methods. Another study of Gómez-Cabrera et al. (2024) demonstrated that most overruns occur during execution phase because of poor site supervision, frequent

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changes in in scope and payment delays. It can be noted that the usual approach towards these delays and overruns are correcting problems after they arise rather than preventing them.

Building Information Modelling or BIM has emerged as major change which helps with better project coordination and visualization and better data management. Studies have shown that using BIM 4D or even 5D contribute to early clash detection, accurate quantity estimation and rea-time progress tracking which significantly improves schedule and budget management (Azhar, 2011; Zhang & Gao, 2013; Andújar-Montoya et al., 2020). This helps to reduce rework and change orders and smoothen stakeholder collaboration. Though it still doesn't resolve problems pertaining to payment delays, data mismanagement and contractual disputes.

In recent times, blockchain has been seen to have potential to work with BIM to tackle trust and transparency aspects. Blockchain's decentralized structure makes data flow reliable and it can also implement smart contracts which can automatically enforce rules to reduce claims and disputes (Elazhary & Hosny, 2022). Moreover, blockchain not only enable secure and transparent transactions but also traces it which improves governance and helps to maintain steady cashflow (Nawari & Ravindran, 2019).

Although there are numerous studies on BIM and Blockchain individually, there isn't a study which evaluates its combined effect yet. Scientometric analysis does not show significant overlap in their themes hence its full potential remains unexplored (Çevikbaş & Işık, 2021). There isn't a complete framework as to how BIM's real time data sharing and blockchain's smart contracts can catch up to assess risks before making it overcomplicated to work with it.

The bibliometric study undertaken using VOSviewer on 60 research papers revealed that BIM and blockchain technologies are used individually in research papers, forming separate research clusters.

All in all, it is evident that neither of the technologies can work out complications and assess overrun risks by itself and requires co-operation of the other. There may be mixed opinions, lack of evident studies and complete framework but it is certain that BIM-blockchain integration will increase day-to-day efficiency and reduce management issues, which highlights the relevance of the study.

2.1 Research objectives

The aim of this paper is to evaluate the impact of integrated digital technologies on the Indian construction sector to minimize the inefficiencies. Through an extensive literature review supported by primary data collected through structures surveys, this study employs a triangulation approach to evaluate 12 performance metrics of a typical complex metropolitan project- to establish a credible and comprehensive analytical ground. The current situation

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lacks the coordination between technological applications and progressive project management solutions, which is what this study strives to provide by correlating empirical evidence with on-ground industry perceptions. The aim is to be able to identify areas where practices lack transparency and assess relevance of technology to demonstrate the integrated approach can help to deliver projects in transparent, effective and efficient manner in metropolitan regions which have complex environments of the system.

3.0 Research Methodology

This study follows a quantitative and empirical research approach to examine how Building Information Modelling (BIM) and Blockchain technologies can help reduce time and cost overshoots in projects in the construction industry. Considering that digital adoption in construction is still developing, and that there is limited practical research on blockchain in particular, the study takes both an exploratory and explanatory orientation. The methodology is designed to understand not only the direct contribution of these technologies to project performance, but also how they may support better governance, coordination and decision-making in projects.

Primary data was derived through a detailed survey using a structured questionnaire. The survey targeted professionals involved in project execution, including project managers, planning engineers, site engineers, consultants and contract administrators, with experience in areas like project controls, governance processes and digital tools. A total of 50 relevant responses were derived and the suitability of the obtained results for exploratory analysis was arrived at using Partial Least Squares Structural Equation Modelling (PLS-SEM).

The questionnaire was designed to capture information related to key performance factors such as time overruns, cost overruns, payment delays, dispute resolution, rework and overall project efficiency. Furthermore, respondents' perceptions and experiences with regard to BIM adoption and blockchain-aided governance mechanisms were also gathered to arrive at a more wholistic outcome. The response was recorded using percentage ranges, time bands and Likert-Type scales, which were then converted to numerical values within a fixed scale range to perform quantitative analysis on.

Additionally, secondary data, used to establish benchmark improvement ranges and to support the interpretation of the findings were derived from peer-reviewed journals, industry reports and professional publications related to BIM, Blockchain, construction governance and project performance.

Triangulation framework was adopted to arrive at comprehensive results, wherein the primary data was first used to identify the key problem areas in construction projects. Solution effects were individually derived from studying the responses of the primary data

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and the collected secondary data, which were then integrated to generate the triangulated values. Representing realistic performance improvements.

Partial Least Squares Structural Equation Modelling (PLS-SEM) with SmartPLS software was then used to perform the data analysis, selected methodically for its proven effectiveness in analysis complex relationships, ability to handle a moderate sample size to generate effective results and its overall suitability in exploratory research. The measurement model was sequentially evaluated for indicator reliability, internal consistency, convergent validity, and discriminant validity, where all constructs were specified as reflective, as indicators contributed to the underlying latent variables. The structural model was evaluated using bootstrapping with 5000 subsamples to test the significance of hypothesised relationships. Path coefficients, significance levels, and coefficients of determination (R^2) were analysed to understand the influence of BIM, Blockchain, and governance efficiency on time and cost performance.

Overall, the adopted methodology integrates empirical evidence, literature validation, triangulation, and statistical modelling to provide a systematic and reliable assessment of digital technologies in construction project performance.

4.0 Data Collection and Data Analysis

4.1 Data collection

Data was obtained from both primary and secondary sources to assess the effect of BIM and Blockchain on construction project performance. Primary data was used to capture real project conditions and the perspective of on-field experts, while the secondary data offered credible benchmarks and theoretical bases. This combination ensured that the determined value of the benchmarks is reliable for practical applications.

4.2 Primary data collection

Primary data was collected through a questionnaire-based survey, seeking responses from construction professionals, primarily project managers, planning engineers, site engineers, consultants, and contract administrators. The respondents were selected on the basis of their direct involvement in project execution and exposure to project controls and practices, along with an exposure to digital tools.

A total of 50 relevant responses were collected. The survey covered details regarding the occurrence of time overrun, cost overrun, use of resources, governance delays and perceived effects of the adoption of BIM and Blockchain. The responses were collected through percentage scales, time scales, and Likert-type scales, which were standardised for quantitative analysis.

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Table 1: Primary Data – Key Project Performance Observations

Sl.	Performance Metric	Primary Data – Problem (%) / Days	Primary Data – Solution Effect (Survey)
1	Time Overrun	10–20 %	BIM: 6–10 % reduction
2	Cost Overrun	5–10 %	BIM: 1–5 % to 6–10 %
3	Resource Utilisation	65–75 %	BIM: ~75–80 %
4	Rework / Change Orders	5–10 %	BIM: Moderate reduction
5	Dispute Resolution Time	60–120 days	BC: 16–30 days faster
6	Payment Delay	30–60 days	BC: 16–30-day reduction
7	Procurement Lead Time	31–60 days	BIM: Minor–moderate
8	Cash-Flow Variance	±15–25 %	BC: Improved predictability
9	Safety Incidents	0.5–1.0	BIM: Marginal improvement
10	RFI Closure Time	10–20 days	BIM: 5–10 days
11	Client Satisfaction	3.5–4.0 /5	Digital tools: 4.0–4.5
12	Governance Transparency	Low	Strong agreement (BC)

Source: Created by authors

Table 2: Secondary Data – Literature-Based Benchmarks

Performance Metric	Literature-Reported Improvement
Time Overrun	BIM reduces delays by 10–15 %
Cost Overrun	5D BIM reduces deviation to 3–8 %
Resource Utilisation	Improved to 80–85 % using 4D BIM
Rework	~40 % reduction via clash detection
Dispute Resolution	Reduced to 30–45 days
Payment Processing	20–40-day cycles via smart contracts
Procurement Lead Time	25–40 days
Cash-Flow Predictability	±8–10 % variance
Safety Incidents	Reduced to 0.3–0.6
RFI Closure Time	Reduced to 5–10 days
Client Satisfaction	Improved to 4.3–4.5
Governance Transparency	Tamper-proof and auditable records

Source: Created by authors

4.3 Secondary data collection

Secondary data was derived and studied from peer-reviewed journals, industry reports, conference reports, and professional publications that were associated with BIM, Blockchain, construction governance, and project performance. Secondary data was collected with the aim of understanding the existing performance benchmarks and the impacts associated with digital intervention.

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4.4 Integrated triangulation analysis

To improve the level of reliability, a **three-layer triangulation method** has been used. The project's problems have been identified on the basis of primary data; the effects of solution have been independently obtained from both the primary and survey response and well and secondary literature and the values for the three layers of triangulation have been calculated as the conservative convergence points indicating the potential for improvement.

Table 3: Triangulated Values Represent Conservative Convergence Points between Practitioner-reported Improvements and Literature-validated Performance Gains

Sl.	Performance Metric	Primary Data – Problem (%) / Days	Primary Data – Solution Effect (Survey)	Secondary Data (Literature)	Triangulated Value
1	Time Overrun	10–20 %	BIM: 6–10 % reduction	BIM: 10–15 %, BC: <8 %	**≈ 12 % reduction**
2	Cost Overrun	5–10 %	BIM: 1–5 % to 6–10 %	5D BIM: 3–8 %	**≤ 8 % variance**
3	Resource Utilisation	65–75 %	BIM: ~75–80 %	4D BIM: 80–85 %	**≈ 82 % efficiency**
4	Rework / Change Orders	5–10 %	BIM: Moderate reduction	BIM: ~40 % theoretical	**≈ 3–5 % rework**
5	Dispute Resolution Time	60–120 days	BC: 16–30 days faster	BC: 30–45 days	**≈ 40–45 days**
6	Payment Delay	30–60 days	BC: 16–30-day reduction	BC: 20–40 days	**≈ 25–35 days**
7	Procurement Lead Time	31–60 days	BIM: Minor–moderate	BIM: 25–40 days	**≈ 35–45 days**
8	Cash-Flow Variance	±15–25 %	BC: Improved predictability	BC: ±8–10 %	**± 8–10 %**
9	Safety Incidents	0.5–1.0	BIM: Marginal improvement	BIM: 0.3–0.6	**≈ 0.4–0.6**
10	RFI Closure Time	10–20 days	BIM: 5–10 days	BIM: 5–10 days	**≈ 7 days**
11	Client Satisfaction	3.5–4.0 /5	Digital tools: 4.0–4.5	Literature: 4.3–4.5	**≈ 4.4 /5**
12	Governance Transparency	Low	Strong agreement (BC)	Tamper-proof records	**High (qualitative)**

Source: Created by authors

4.5 PLS-SEM analysis

The analysis in the paper was done using the SmartPLS Software. The constructs in the model were all specified as reflective for the approach. The steps in the analysis included model specification, assessment of the measurement model and assessment of the structural model

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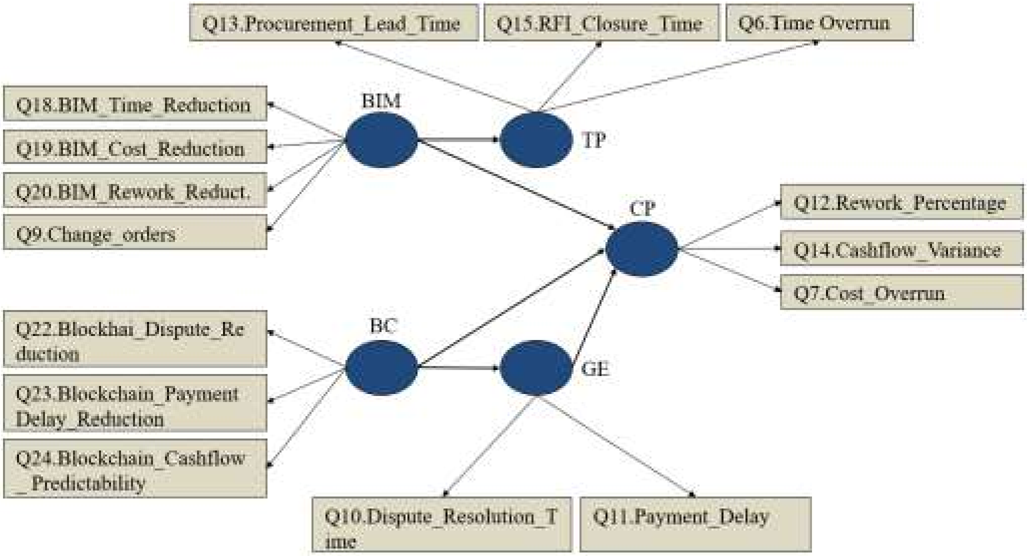
4.5.1 Initial measurement model

Figure 1: Initial PLS-SEM Model Specification



Source: Created by authors

Interpretation: The proposed initial model describes the relationships that have been hypothesised between BIM, Blockchain (BC), Governance Efficiency (GE), Time Performance (TP), and Cost Performance (CP).

4.5.2 Measurement model assessment – outer loadings

Table 4: PLS Algorithm – Outer Loadings

Construct	BC	BIM	CP	GE	TP
Q10_Dispute_Resolution_Time				0.78	
Q11_Payment_Delay				0.91	
Q12_Rework_Percentage			0.75		
Q13_Procurement_Lead_Time					0.87
Q14_Cashflow_Variance			0.72		
Q15_RFI_Closure_Time					0.68
Q18_BIM_Time_Reduction		0.64			
Q19_BIM_Cost_Reduction		0.65			
Q20_BIM_Rework_Reduction		0.26			

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Q22_Blockchain_Dispute_Reduction	0.77				
Q23_Blockchain_Payment_Reduction	-0.52				
Q24_Blockchain_Cashflow_Prediction	0.83				
Q6_Time_Overrun					0.51
Q7_Cost_Overrun			0.58		
Q9_Change_Orders		0.84			

Source: Created by authors

Interpretation: The results of the outer loading show that the chosen indicators have reasonably captured the constructs they represent. The moderate loading for the BIM and performance-related indicators demonstrates the varying adoption levels of technology in the projects, which is expected in the practical construction context.

4.5.3 Reliability and convergent validity

Table 5: Composite Reliability (CR) and AVE Output

Construct	Cronbach's Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted (AVE)
BC	-0.21	0.63	0.45	0.52
BIM	0.59	0.75	0.70	0.40
CP	0.43	0.43	0.72	0.47
GE	0.62	0.70	0.83	0.72
TP	0.50	0.61	0.74	0.49

Source: Created by authors

Interpretation: Governance Efficiency, Time Performance, and Cost Performance have good internal consistency. Although AVE values for BIM and Cost Performance slightly fall below the threshold of 0.50, the constructs have been retained as their composite reliability values were satisfactory and the study has been exploratory, as per PLS-SEM guidelines.

4.5.4 Discriminant Validity (HTMT)

Table 6: HTMT Matrix

	BC	BIM	CP	GE	TP
BC					
BIM	0.27				
CP	0.31	0.51			
GE	0.38	0.46	1.04		
TP	0.30	0.48	0.91	1.13	

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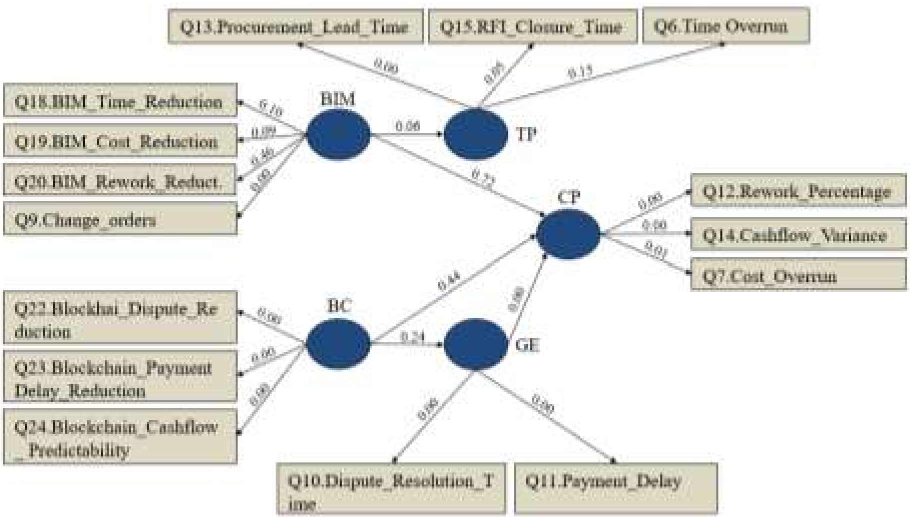
Interpretation: The majority of the HTMT values are within acceptable ranges. The high values between Governance Efficiency, Time Performance, and Cost Performance reflect conceptual duplication, which is anticipated in the first of construction projects because time and cost performance are directly affected by governance. Hence, the discriminant validity is acceptable for further analysis.

4.5.5 Structural Model after Bootstrapp

Figure 2: Bootstrapped Structural Model



Source: Created by authors

Interpretation: The bootstrapped model shows how well the hypothesised relationship has been captured by resampling.

4.5.6 Path coefficient results

Table 5: Path Coefficient Matrix

Path	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
BC–›CP	-0.170	-0.125	0.221	0.771	0.441
BC–›GE	0.23	0.25	0.20	1.17	0.24
BIM–›CP	0.06	0.09	0.19	0.35	0.72
BIM–›TP	0.35	0.41	0.18	1.87	0.06
GE–›CP	0.59	0.57	0.152	3.89	0.00

Source: Created by authors

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Interpretation: Analysis of the structural model shows that the efficiency of governance is the core factor for enhancing the cost performance of construction projects. The efficiency of governance has a strong and significant relationship with cost performance, ($\beta = 0.591$, $p < 0.001$), which establishes the significance of efficiency of governance in managing cost overruns. Use of BIM technology has a marginally significant and positively significant relationship with time performance ($\beta = 0.353$, $p = 0.061$), which establishes the effectiveness of BIM in enhancing the efficiency of construction projects. The direct significance of BIM and Blockchain technology use in cost-performance was not significant statistically, indicating that the technology alone cannot drastically lead to cost savings. Instead, efficiency in planning and governance along with practical integration of technology can lead to actual effectiveness of BIM and Blockchain in construction projects.

5.0 Conclusion

Time and cost overrun have been significant issues in the construction industry, and significantly so in the Indian construction scenario, mostly because of the gaps in the areas of coordination, poor governance and slow and faulty financial processes. These issues were investigated by assessing the possibility of combining BIM and Blockchain

The primary data revealed. Construction projects face on an average, time overrun of 10-20%, cost overruns of 5-10%, longer payment terms, and longer dispute resolution times. Secondary data substantiated that Building Information Modelling increases accuracy, coordination, and resource allocation, whereas Blockchain was hypothesised to increase transparency and governance by creating undisputable records and smart contracts. Yet, none of these alone can eliminate time and cost overruns.

The triangulation analysis of the primary and secondary data has indicated realistic areas of improvement, simply with better use of resources, and improvement in payment delay and dispute resolution times, resulting in the possibility of minimizing time overrun by a significant 12%, cost variance within 8%. These indicate that the use of adopted technology can bring benefits when implemented in tandem project processes.

The results obtained through the analysis of PLS-SSEM supported the hypothesis of relationships between the constructs considered in the research. The positive impact of BIM adoption on time performance confirmed the effectiveness of BIM in enhancing planning and coordination activities. The efficiency of governance was the most influential indicative factor in determining the cost performance, supporting that the management of construction costs is mainly governed by the efficiency of the governance process. The effect of blockchain was identified as an indirect factor in enhancing the efficiency of the governance process to achieve better cost performance.

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6.0 Inference

On the whole, it can be concluded that the use of BIM improves time performance, the application of Blockchain improves transparency in governance, and the efficiency of governance finally determines cost performance. Therefore, to overcome time and cost variances, there is a need to use not only the technologies but also to integrate them into efficient governance and management frameworks

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