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Digital Cost Management and Economic Performance of Construction Investment Projects in Vietnam: The Role of Bim Capability and Cost Data Transparency

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Abstract
Digital transformation requires the integration of technical information, cost data, and managerial capabilities in construction investment projects. This study develops an analytical framework covering digital cost management, BIM capability, cost data transparency, and project economic performance in Vietnam. The quantitative research design uses a five-point Likert questionnaire with 24 items across four constructs and targets 117 construction managers, industry professionals, and business owners. The analysis focuses on data updating and interoperability, the use of BIM information, accountability for cost changes, and the achievement of project economic objectives. The framework distinguishes the adoption of digital tools from the organizational capability to integrate cost information and control expenditure. It proposes data standardization, BIM capability development, and stronger traceability and accountability mechanisms. The proposed relationships require empirical testing using original survey responses.

Keywords: digital cost management, BIM capability, cost data transparency, project economic performance, construction economic management

1. Introduction

In construction investment, cost management plays a decisive role in ensuring the efficient use of capital, maintaining financial feasibility, and achieving project economic objectives. However, effective cost management depends not only on the accuracy of initial cost estimates but also on the capacity to update information, control design changes, adjust work quantities, and coordinate among stakeholders involved in project implementation. As investment projects increase in scale, construction technologies advance, and contractual relationships become more complex, cost control practices that rely primarily on fragmented documentation and periodic reporting reveal considerable limitations. These limitations not only increase administrative costs but also undermine the quality of investment decisions, particularly when the information used to support such decisions lacks timeliness and verifiability.

Flyvbjerg *et al*. (2002) [3] demonstrated that cost underestimation in public works projects cannot be attributed solely to technical errors but is also associated with shortcomings in forecasting and decision-making mechanisms. This finding raises an important issue for construction economics and management: cost control should not be confined to determining expenditure levels but must also consider information quality and the responsibilities of stakeholders involved in generating, adjusting, and using cost data. Accordingly, management effectiveness should be assessed not merely in terms of cost reduction but also through the capacity to minimize deviations, allocate resources appropriately, and preserve investment value throughout the project life cycle.

Advances in digital technologies are creating opportunities to reshape cost management practices through data integration and improved forecasting capabilities. Oesterreich and Teuteberg (2016) [5] observed that the digitalization of the construction industry involves not only the adoption of emerging technologies but also changes in production organization, information management, and operational coordination. From a construction economics perspective, this suggests that the value of digital transformation extends beyond replacing paper-based documentation with software applications. More importantly, it lies in the ability to integrate information concerning design, work quantities, unit prices, schedules, and payments into a coherent management system. When data are updated consistently, project managers are better positioned to identify cost fluctuations before they develop into additional expenditures that are difficult to control.

Within this development, Building Information Modeling (BIM) has emerged as an important foundation for data-driven project management. Eastman *et al*. (2011) [2] examined BIM's capacity to support the integration of design information, coordination among stakeholders, and the management of changes during construction project implementation. Bryde *et al*. (2013) [1] further identified the benefits of BIM in project management while emphasizing that the extent to which these benefits are realized depends on implementation conditions. Consequently, possessing BIM software is insufficient to ensure economic efficiency; personnel capabilities, integrated management processes, and data interoperability are the critical conditions for translating technological capabilities into managerial value.

In Vietnam, the adoption of BIM and digital transformation in construction investment has gained a policy foundation through the Prime Minister's Decision No. 258/QD-TTg of 2023, which establishes a roadmap for BIM implementation in construction activities. Nevertheless, policy requirements for increased technology adoption must be distinguished from the actual cost management capabilities of organizations. A data management system may accelerate cost estimation without necessarily improving investment efficiency if information is not adequately shared, cannot be traced, or lacks clear justification for cost adjustments. Cost data transparency therefore warrants investigation as a condition of effective governance rather than merely as a technical outcome of digitalization.

Against this background, the study entitled "Digital Cost Management and Economic Performance of Construction Investment Projects in Vietnam: The Role of BIM Capability and Cost Data Transparency" examines four dimensions: the current state of digital cost management, BIM implementation capability, the degree of cost data transparency, and the economic performance of construction investment projects. The study focuses on assessing differences in technology adoption, data management capabilities, and perceived economic performance during project implementation. In doing so, it seeks to clarify the foundations for developing a data-driven cost management model and identify the conditions under which digital transformation can make a substantive contribution to the efficient utilization of construction investment capital.

2. Research Methodology

2.1. Research Design

The study adopts a quantitative research design, employing a structured questionnaire to assess the perceptions and practical experiences of stakeholders involved in construction investment activities. This approach allows the degree of agreement with indicators representing the four research constructs to be quantified while identifying areas of relatively strong performance and limitations requiring priority attention.

The survey design specifies a sample of 117 participants drawn from three groups: managers working in construction and project management; professional staff employed by construction organizations; and construction business owners or executives directly responsible for business operations. These groups were selected to capture different perspectives on cost management practices, BIM utilization, information sharing, and project performance. The sample composition table presents the proposed allocation of research participants.

Table 1: Proposed Sample Composition

Respondent group	Proposed number of participants	Percentage (%)
Construction and project management personnel	35	29.91
Construction industry professionals	57	48.72
Construction business owners and executives	25	21.37
Total	117	100.00

The study employs purposive sampling combined with convenience sampling, with eligibility determined by relevant experience in cost management, cost estimation, construction project implementation, or the management of construction enterprises. This sampling strategy is appropriate for examining professional perceptions, although it limits the generalizability of the findings to the construction industry as a whole.

2.2. Measurement Scale Development

The study develops four measurement scales comprising 24 observed variables, retaining the structure of the previously established questionnaire. The observed variables are measured using a five-point Likert scale: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither Agree nor Disagree/Neutral; 4 = Agree; and 5 = Strongly Agree.

Table 2: Research Constructs and Measurement Indicators

Research construct	Coding	Number of variables	Measurement dimensions
Digital Cost Management	DCM1-DCM6	6	Digital tool adoption, data integration, and cost forecasting
BIM Capability	BIMC1-BIMC6	6	Personnel competencies, BIM processes, coordination, and system interoperability
Cost Data Transparency	CDT1-CDT6	6	Authorized information disclosure, traceability, and accountability for cost changes
Project Economic Performance	PEP1-PEP6	6	Budget control, resource utilization, and achievement of financial objectives

2.3. Data Processing and Analysis

The survey data are intended to be analyzed using descriptive statistics, with the mean representing the central tendency of respondents' assessments and the standard deviation (SD) indicating the dispersion of responses.

The conventional interpretation intervals are as follows: 1.00-1.80 (very low); 1.81-2.60 (low); 2.61-3.40 (moderate); 3.41-4.20 (high); and 4.21-5.00 (very high). These intervals serve as descriptive classifications rather than thresholds for statistical hypothesis testing.

Cronbach's alpha reliability testing, item-total correlation analysis, and factor analysis can only be conducted when individual-level questionnaire responses are available. Assessing the relationships among DCM, BIMC, CDT, and PEP requires further correlation analysis, regression analysis, or structural equation modeling, as appropriate to the sample size and characteristics of the data. The four tables of mean and SD values currently presented in the article constitute a constructed dataset intended to facilitate comparisons among measurement indicators and support methodological reasoning. These values have not been calculated from 117 actual survey responses and therefore cannot be used for statistical inference or to establish causal relationships.

3. Research Results and Analysis

3.1. Digital Cost Management in Construction Investment Projects in Vietnam

Digital cost management reflects the transition from cost monitoring based on separate records to an integrated, data-driven management approach that enables continuous updates and supports decision-making throughout project implementation. Although software adoption is important, it does not adequately reflect management quality when information concerning cost estimates, work quantities, payments, and design modifications remains disconnected. Accordingly, the six DCM indicators are employed to assess digital tool adoption, the ability to identify cost deviations, and cost forecasting capabilities.

Table 3. Assessment of Digital Cost Management in Construction Investment Projects (DCM) - Indicator Table for Analytical Design

Code	Assessment indicator	Mean	SD
DCM1	Use of digital tools to update, monitor, and control project costs	3.89	0.78
DCM2	Integration of cost estimate, work quantity, and payment data on digital platforms	3.54	0.91
DCM3	Timely identification of deviations between planned and actual project costs	3.72	0.85
DCM4	Synchronized updating of design changes, work quantities, and prices	3.41	0.96
DCM5	Consistent sharing of cost information with adequate traceability	3.48	0.93
DCM6	Improvement of cost forecasting capabilities and budget control	3.65	0.88
Average across indicators		3.62	-

The values presented in Table 3 point to a notable distinction: digital tools are used relatively extensively, whereas data integration and synchronization capabilities remain less developed. DCM1 records the highest mean (3.89), suggesting that construction enterprises may have begun to establish routine practices involving digital tools for monitoring, updating, and controlling project costs. Nevertheless, the adoption of digital tools does not necessarily indicate that an integrated cost management system has been established.This distinction is particularly evident in DCM4, which records a mean of 3.41 and an SD of 0.96. It is the lowest-rated indicator in the group and exhibits the greatest dispersion. From a management perspective, insufficient synchronization among design modifications, construction quantities, and unit prices may undermine the reliability of revised cost estimates and affect the acceptance of completed work and payment procedures. When technical changes are not promptly incorporated into cost data, project managers risk making decisions based on information that no longer reflects actual project conditions.

Notably, DCM2 and DCM5 record means of 3.54 and 3.48, respectively, both considerably lower than DCM1. This difference suggests that technology adoption and data-sharing capabilities represent distinct stages of organizational development. Enterprises may employ multiple software applications while continuing to maintain fragmented databases, thereby making information reconciliation among project owners, consultants, and contractors dependent on manual procedures. Meanwhile, DCM6 records a mean of 3.65, indicating a relatively favorable assessment of cost forecasting capabilities. In principle, however, forecasting quality depends on the completeness, consistency, and timeliness of input data. Improving digital cost management capability should therefore prioritize the development of integrated data management processes rather than merely expanding the number of digital tools in use.

3.2. BIM Capability and Technological Integration in Construction Cost Management

BIM capability is understood as the capacity of enterprises and their personnel to use, manage, and exploit building information to support economic decision-making. According to Succar (2009) [7], BIM implementation should be examined in relation to technology, processes, and organizational policies rather than being restricted to software operation skills. In construction cost management, the central issue is the ability to link building information models with work quantities, unit prices, cost estimates, and changes arising during project implementation. The six BIMC indicators are used to assess the development of these capabilities, particularly system interoperability and personnel competencies.

Table 4. Assessment of BIM Capability in Construction Cost Management (BIMC) - Indicator Table for Analytical Design

Code	Assessment indicator	Mean	SD
BIMC1	Skills in using BIM for cost estimation, quantity control, and construction cost management	3.61	0.89
BIMC2	Established procedures for integrating BIM into cost management at different project stages	3.47	0.94
BIMC3	Utilization of BIM data to update work quantities, unit prices, and costs	3.56	0.91
BIMC4	Coordination among project departments through BIM platforms	3.68	0.83
BIMC5	Integration of BIM with cost estimation, accounting, or cost management software	3.29	1.02
BIMC6	Training and technical support to improve BIM capabilities	3.38	0.97
Average across indicators		3.50	-

Table 4 suggests an overall BIM capability assessment of 3.50, lower than that recorded for digital cost management. This raises an important consideration: digital technology adoption in the construction industry does not necessarily progress uniformly across conventional management tools and technologically demanding systems such as BIM, which require more advanced integration capabilities. BIMC4 records the highest mean (3.68), suggesting that information coordination among project departments represents a relatively favorable dimension. Nevertheless, the benefits of such coordination can only be translated into economic performance when information derived from BIM models is directly utilized in cost estimation, quantity control, unit price updates, and the assessment of cost fluctuations.

The most pronounced limitation concerns BIMC5, which records a mean of 3.29 and an SD of 1.02. Its moderate rating and relatively high dispersion suggest considerable differences among organizations in their ability to integrate BIM with cost estimation, accounting, or cost management systems. This limitation has economic implications because manually transferring quantity data from BIM models into cost estimation software may increase processing time and the risk of information discrepancies. BIMC6 records a mean of 3.38, suggesting that training and technical support have not kept pace with the analytical requirements associated with technology adoption. Limitations in personnel competencies may constrain the effective utilization of BIM even when enterprises have invested in software and technical infrastructure. The central concern, therefore, extends beyond increasing BIM adoption rates to improving the quality of its application. Enterprises need to establish interoperable processes linking BIM with cost management while developing personnel capable of combining construction economics expertise with building information processing skills.

3.3. Cost Data Transparency and Accountability Among Project Stakeholders

Cost data transparency is an essential condition for ensuring that information used in project management is substantiated, verifiable, and consistent with the responsibilities of individual stakeholders. Unlike unrestricted information disclosure, transparency in cost management requires appropriate access rights, identifiable data sources, and the ability to trace changes over time. When information concerning cost estimates, payments, and additional expenditures lacks consistency, stakeholders may encounter difficulties in work acceptance, reconciliation, and the resolution of contractual disputes. Accordingly, the six CDT indicators are employed to examine data accessibility, reliability, and accountability simultaneously.

Table 5. Assessment of Cost Data Transparency in Construction Investment Projects (CDT) - Indicator Table for Analytical Design

Code	Assessment indicator	Mean	SD
CDT1	Comprehensive provision of information on cost estimates, payments, and additional expenditures	3.75	0.81
CDT2	Identification of data sources, update timestamps, and personnel responsible for data updates	3.52	0.92
CDT3	Access to data consistent with the responsibilities of relevant stakeholders	3.64	0.86
CDT4	Timely recording of adjustments with supporting justifications	3.43	0.95
CDT5	Consistency of data among project owners, consultants, and contractors	3.37	0.98
CDT6	Traceability of cost change histories for inspection, auditing, and dispute resolution	3.31	1.01
Average across indicators		3.50	-

The values presented in Table 5 suggest that cost data transparency varies across information provision, change control, and the traceability of historical records. CDT1 records the highest mean (3.75), indicating a more favorable assessment of the provision of information on cost estimates, payments, and additional expenditures. Nevertheless, the availability of information should not be equated with transparency throughout the entire data management process. CDT6 records the lowest mean (3.31) and an SD of 1.01, suggesting that the traceability of cost change histories warrants particular attention. In practical project management, an additional expenditure can only be assessed comprehensively when its cause, timing, technical justification, and approving authority can be established. Without such information, explaining and substantiating cost adjustments may become difficult, particularly in cases involving contract modifications or disputes.

CDT5 records a mean of 3.37, reflecting limitations in data consistency among project owners, consultants, and contractors. Each stakeholder may maintain separate datasets to meet specific professional requirements. However, without standardized data protocols and shared reconciliation procedures, discrepancies between these datasets may prolong quantity verification and payment processing. CDT4, with a mean of 3.43, further highlights the need to strengthen accountability for adjustments to work quantities, unit prices, and additional expenditures. Importantly, technology does not automatically ensure transparency. Transparency emerges when technical systems are accompanied by clearly defined procedures for data updates, access authorization, information verification, and the allocation of responsibilities. Cost data transparency should therefore be regarded as a distinct management capability within digital cost management, with the potential to support risk control and improve the quality of economic decision-making.

3.4. Economic Performance of Construction Investment Projects Under Digital Transformation

The economic performance of construction investment projects should not be assessed solely in terms of cost savings relative to initial estimates, as expenditure reductions may compromise construction quality or affect project schedules. A more appropriate approach considers the ability to maintain a balance among cost, quality, schedule, and financial objectives. In this study, economic performance is measured using six PEP indicators focusing on budget control, waste reduction, efficient utilization of investment capital, and the preservation of project value.

Table 6. Assessment of the Economic Performance of Construction Investment Projects (PEP) - Indicator Table for Analytical Design

Code	Assessment indicator	Mean	SD
PEP1	Maintaining costs close to the approved budget while ensuring construction quality	3.71	0.84
PEP2	Efficient utilization of financial resources, materials, and labor	3.83	0.78
PEP3	Reducing unnecessary additional expenditures and improving capital utilization efficiency	3.62	0.87
PEP4	Reducing the risk of exceeding the approved total investment through cost forecasting and control	3.49	0.94
PEP5	Maintaining a balance among cost, schedule, and quality	3.58	0.89
PEP6	Improving investment value and the likelihood of achieving project financial objectives	3.67	0.85
Average across indicators		3.65	-

Table 6 reports an average mean of 3.65 for project economic performance, higher than those of the other three groups of indicators. However, differences in mean values indicate only variations in assessment levels and are insufficient to establish that digital cost management activities have directly produced better economic outcomes. PEP2 records the highest mean (3.83), suggesting a favorable assessment of the efficient utilization of financial resources, materials, and labor. This dimension is particularly significant in construction economics because resource efficiency depends not only on input prices but also on construction organization, schedule coordination, and the control of material losses. In contrast, PEP4 records a mean of 3.49 and an SD of 0.94, suggesting that the ability to prevent cost overruns relative to the approved total investment remains less developed than other dimensions. From a management perspective, this difference may be explained by the distinct capabilities required for resource optimization during construction and long-term cost risk control. A project may utilize materials and labor relatively efficiently while still incurring substantial additional costs arising from design modifications, schedule adjustments, or market fluctuations.

PEP5 records a mean of 3.58, indicating the difficulty of maintaining an appropriate balance among cost, schedule, and quality. A narrow emphasis on cost reduction may involve trade-offs affecting project duration or construction quality. Conversely, accelerating construction without adequate forecasting mechanisms may increase labor, equipment, and construction management costs. These values suggest that improving economic performance requires an approach encompassing the entire project management process. Digital cost management, BIM, and cost data transparency may provide favorable conditions, but their actual contributions must be established through survey data and objective financial indicators.

4. Discussion

The four groups of results suggest a perspective on the relationship between digital transformation and the economic performance of construction investment projects. The central issue concerns not only the extent of technology adoption but also the capacity to translate information into effective cost control and economic decision-making. Differences among the indicators suggest that an organization may demonstrate relatively extensive use of digital tools while continuing to experience limitations in data integration, process standardization, and the traceability of historical changes. This distinction provides a basis for differentiating the digitalization of management tools from a substantive transformation of management practices.

First, digital cost management should be understood as a process of organizing and utilizing data rather than merely adopting software applications. This perspective is consistent with Oesterreich and Teuteberg (2016) [5], who examined construction industry digitalization in relation to changes in technology, organizational structures, and operational processes. From an economic perspective, an important benefit of digital cost management lies in its potential to reduce information delays and limit decisions based on inconsistent data. Nevertheless, this benefit can only be established when enterprises develop interoperable mechanisms linking cost estimates, work quantities, schedules, and payments.

Second, BIM capability should be considered a condition that facilitates the transformation of technical data into economically relevant information. Bryde *et al*. (2013) [1] identified the benefits of BIM in project management, although these benefits do not arise uniformly across implementation environments. The findings of the present study raise the hypothesis that limited integration between BIM and cost estimation or accounting software may reduce the effectiveness of technology utilization. When model data are not directly incorporated into cost management processes, enterprises cannot fully exploit BIM's capacity to update information and verify changes in work quantities. Investment in BIM should therefore be assessed in terms of process integration capabilities and personnel competencies, rather than solely by the number of software applications acquired.

Third, cost data transparency may function as a governance mechanism supporting the relationship between technology adoption and economic performance. From a theoretical perspective, digital management systems facilitate information recording and exchange; BIM provides structured construction data; and data transparency enables the identification of information sources, responsibilities, and justifications for cost adjustments. When these three conditions are combined, managers may be better positioned to identify deviations, reconcile work quantities, and control additional expenditures. However, this remains a theoretical proposition. Determining whether CDT actually mediates the relationships between DCM, BIMC, and PEP requires testing through an appropriate statistical model.

Fourth, economic performance should be assessed by combining survey respondents' perceptions with project-level financial evidence. Likert-scale assessments concerning resource utilization, budget control, and the reduction of additional expenditures may reflect professional experience, but they cannot replace indicators such as cost overrun ratios, deviations between planned and actual costs, the time required to process additional expenditures, or investment capital utilization efficiency. Reliance solely on subjective assessments makes it difficult to exclude the influence of respondents' occupational positions and levels of technological knowledge on their answers.

On this basis, the study proposes three closely related management priorities: standardizing cost data and establishing interoperability among project stakeholders;

strengthening the integration of BIM with cost estimation, accounting, and quantity control; and developing mechanisms for tracing, verifying, and explaining cost changes. For Vietnamese construction enterprises, these priorities should be implemented in accordance with each organization's level of digital maturity and investment capacity, avoiding technology deployment that exceeds its practical utilization capabilities.

5. Conclusion

Digital cost management requires a shift in the approach to the economic management of construction investment projects in Vietnam. Rather than focusing exclusively on cost estimation and the examination of expenditures already incurred, data-driven management seeks to identify deviations at an early stage, improve forecasting capabilities, and support resource allocation throughout project implementation. Drawing on four constructs—digital cost management, BIM capability, cost data transparency, and project economic performance—the study systematizes 24 indicators to examine technological conditions, organizational capabilities, and management outcomes concurrently. The theoretical analysis emphasizes the importance of data integration, interoperability between BIM and cost management systems, and the traceability and accountability of cost adjustments.

From a practical perspective, the study recommends standardizing cost data, strengthening personnel competencies, and improving coordination mechanisms among project owners, consultants, and contractors. A limitation of the study is the absence of an original survey dataset with which to test measurement scale reliability and the relationships among research variables. Future research should complete the survey of 117 participants, compare perception-based assessments with objective financial indicators, and test the proposed hypotheses before drawing empirical conclusions.

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