Modular Prefabrication and Accounting Transaction for Internal Control: A Modular-Lean-Control Integration Model

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ABSTRACT

Conventional projects struggle with complex accounting, weak controls, and fragmented payments that hinder administration and reporting, whereas modular prefabrication simplifies production and transaction processes. This study examines the influence of modular prefabrication on the simplification of accounting transactions and strengthening the internal control of the project, as well as formulating an applicable modular-lean-control integration model. The study employed a qualitative-quantitative case study on a prefabricated modular project, using interviews, project documents, and financial records, with value stream mapping, risk-control matrix, and pre-post quantitative comparisons for analysis. The results showed a decrease in transaction points from ±120 points to ±48 points (a decrease of around 60%), an acceleration of payment verification time from ±14 days to ±4 days (acceleration up to 70%), a reduction in administrative costs by 40-50%, and an increase in financial reporting accuracy of up to ±98%. These findings indicate that the integration of modular prefabrication with lean construction principles and based internal control can result in more effective control structures through module batch mechanisms and physical-cost verification gates. This research contributes to the development of integrative conceptual models that are relevant to industrial practice and academic research.

Keywords*: Accounting Transactions, Internal Control, Lean Construction, Modular Prefabrication.*

INTRODUCTION

Construction projects have traditionally been characterized by high operational and administrative complexity, a situation that stems primarily from the conventional, on-site approach to construction. In this model, project activities are fragmented into numerous small work packages, each handled by different subcontractors, suppliers, and specialized labor units. This fragmentation is compounded by complex financial flows, where payments are often partial, staggered, or contingent upon verification of completed work stages. The direct consequence is a significant burden on project accounting systems, which must process large volumes of transaction documents, conduct multi-layered verification, and reconcile costs that are distributed across multiple actors and phases. These challenges lead to increased administrative costs, frequent payment delays, and a higher probability of errors in financial reporting. Inefficiencies in financial management in such contexts not only reduce operational effectiveness but also undermine project transparency and accountability, creating additional risk for stakeholders (Lantang & Raimanu, 2020; Sasongko et al., 2025).

In recent years, the adoption of lean construction principles and modular prefabrication has emerged as a widely studied solution to address inefficiencies inherent in conventional construction. Lean construction emphasizes the elimination of waste, continuous improvement of processes, and optimization of resource allocation, while modular prefabrication moves significant portions of production off-site into controlled

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factory environments (Harita, 2025). These approaches provide a promising pathway to improve productivity, reduce on-site errors, and compress project timelines. Despite their growing popularity, most existing studies focus heavily on technical dimensions such as construction speed, cost reduction, material efficiency, and scheduling improvements, often overlooking the systemic implications for project accounting and internal control mechanisms. Modularization, by fundamentally changing how and where construction occurs, alters transaction flows, cost recognition points, and verification processes, yet its potential to simplify and enhance financial management remains underexplored (Ermawijaya, 2021; Biney et al., 2025; Fritze & Jockel, 2025).

The literature further reveals a significant theoretical gap: although the operational and technical benefits of lean and modular construction are well documented, there is limited integration between these studies and the field of management accounting. Research on internal control in construction traditionally emphasizes compliance with administrative procedures and documentation standards, without examining how the design of production processes can influence the efficiency and effectiveness of financial controls (Monteiro et al., 2021). Consequently, conventional project accounting systems often fail to capitalize on the opportunities provided by modular production to streamline transaction processing, reduce verification steps, and strengthen internal controls. This lack of integration suggests that a conceptual framework linking modular construction with project financial management could provide substantial benefits, both in terms of operational efficiency and the reliability of financial reporting (Hermes, 2015; Wibowo, 2025; Mehdipoor et al., 2025).

Off-site modular construction offers a strategic opportunity to fundamentally improve the financial management and internal control of construction projects. By producing standardized modules in a controlled factory environment, projects can achieve a higher degree of process uniformity and predictability. Such standardization enables the grouping of financial transactions into batch-based verification systems, reduces the total number of individual transactions, and allows for the design of more structured and traceable financial controls. Verification procedures can be tied to physical evidence of production in the factory, reducing reliance on subjective inspection at the construction site. Furthermore, integration between production schedules and payment flows allows for smoother cash management, faster payment approvals, and more accurate allocation of project costs across work packages. In practice, this means that modular construction not only improves operational outcomes such as quality, schedule adherence, and material efficiency but also has the potential to significantly reduce administrative burdens and enhance financial transparency (Wuni & Shen, 2020; Said et al., 2024).

Based on this background, this study aims to analyze the effect of the application of modular prefabrication on the simplification of project accounting transactions and the strengthening of internal control, as well as formulate an applicable modular-lean-control integration model. This study's contribution is not only theoretical in bridging the disciplines of construction management and management accounting, but also practical as an implementation guideline for the off-site construction industry.

LITERATURE REVIEW

Modular Prefabrication in Construction Projects

Modular prefabrication represents a fundamental shift in construction delivery, moving from traditional on-site, sequential workflows toward an industrialized, factory-based production model (Rongbo, 2025). The core principles of modular design flexibility, scalability, and standardization are essential to its success across various applications. Flexibility allows adjustments to be made relatively easily because modular buildings comprise standardized units that can be reconfigured or expanded without requiring major structural changes (Adeyemi et al., 2024). Batch-based production is among the most defining features of this method. Prefabrication develops a way of breaking down building elements into components that can be produced off-site, usually in a controlled factory environment; once completed, they are transported to the site, enabling faster and

more organized delivery. This enables components, including wall panels, precast beams, and volumetric modules, to be produced in sequential batches, replicating manufacturing logic rather than craft-based construction.

Standardization is the backbone of this approach. Using uniform building components that can be mass-produced in a factory setting not only enhances efficiency but also ensures a high level of quality control consistency that is especially critical in cost-constrained projects where quality compromises are common. The off-site nature of modular construction fundamentally reshapes the operational structure of projects. Most modules between 80–95% are manufactured off-site, making this method more efficient, cost-effective, sustainable, and faster than traditional construction, though it requires detailed planning, high initial investment, and careful management of transportation constraints (Chourasia et al., 2023). This front-loaded planning logic compels early coordination between design, procurement, and logistics, fundamentally restructuring organizational roles across the project lifecycle. Comparative evidence further confirms the performance advantages: modular construction allows for simultaneous production and site preparation, which reduces overall project duration, minimizes labor costs, and directly enhances cost efficiency (Feldmann, 2022).

Simplification of Project Accounting and Internal Control

Construction project accounting is inherently complex. Each project carries its own cost structures, payment milestones, subcontractor hierarchies, and change-order events, generating a high volume of financial transactions requiring constant verification and reconciliation. Cost Management in Prefabricated Construction (CMPC) encompasses many interlinked considerations, including initial design costs, supply chain costs, maintenance, and assembly, making a holistic cost management system essential to capture all economic, social, and environmental aspects (Zhou et al., 2024). In conventional construction, this complexity is amplified by the unstructured, ad-hoc nature of on-site production, where procurement events, labor claims, and design variations arise unpredictably throughout the project timeline. Modular prefabrication introduces a structural mechanism to reduce this transactional fragmentation. Because production occurs in controlled factory batches, cost events become aggregated and synchronized with clearly defined production milestones rather than scattered arbitrarily across the project timeline.

This batch-aligned cost structure directly supports the strengthening of internal controls. In modular construction, payment processes must be carefully devised, as owners need assurance that their funds are directly linked to constructing the relevant units, making milestone-based verification mechanisms critical to protecting all parties against financial risk (Salama et al., 2020; Saputra et al., 2024). The gate-based verification inherent to factory production, where modules must pass quality checks before transport, creates natural internal control checkpoints that can be aligned with payment authorization.

Lean accounting further reinforces this logic: when operations are organized around value streams, cost structures become easier to manage and require minimal additional allocation (Čečević & Đorđević, 2020). When modularization imposes batch discipline on production, it enables a corresponding simplification in accounting workflows, accelerates invoice verification, and reduces the risk of unauthorized or unverifiable transactions, ultimately strengthening the overall internal control environment of construction projects.

Integration of Modular Prefabrication with Lean Accounting Control

The integration of modular prefabrication, lean construction, and accounting control systems has attracted growing academic attention as a pathway to resolving persistent inefficiencies in construction financial management. Modular construction can be considered a hybrid of manufacturing and construction and, given its high degree of

prefabrication, offers ideal conditions to address the industry's long-standing productivity problem by implementing lean production principles (Feldmann, 2022).

Lean accounting serves as the conceptual bridge between production logic and financial reporting. Lean accounting is the controlling, measuring, and managing method that reflects lean thinking and production, enabling conscious decisions by providing precise, understandable, and applicable information, deleting unnecessary stages related to traditional cost control, and encouraging long-term optimization of activities (Cesaroni & Sentuti, 2014). When lean principles are applied within a modular production environment, cost flows become inherently more structured, traceable, and batch-oriented than in conventional construction.

Recent literature by Garcés et al. (2025) highlights risk assessment, sustainability, analytical network processes, and decision-making as key drivers for optimizing construction projects, with building information modeling and lean construction addressing programming, cost, quality, and waste issues. Digital lean construction further shows that lean work packages, as minimal management units, enhance accountability, efficiency, and reduce rework (Liu et al., 2024). The integration of modular prefabrication with lean control relies on batch production, gate verification, and lean value-stream alignment. Batch production ensures financial accountability, gate verification strengthens internal control, and value-stream alignment links accounting to operations. Lean accounting reports both financial and operational data, highlighting cost-saving opportunities without affecting performance, aiding stakeholders with limited financial expertise (Ditkaew, 2022). This forms the conceptual basis for developing an integrated modular-lean-control framework.

RESEARCH METHODS

This study uses a qualitative-quantitative case study to examine the relationship between modular design, internal control systems, and accounting transaction performance. The research focuses on PT X, which implemented a modular vertical residential project worth IDR 45 billion over 18 months (2023–2024), producing 240 off-site modules for on-site installation. The company was selected for its experience in both conventional and modular projects, willingness to provide complete financial and operational data, project completion, and sufficient scale to illustrate complex accounting transactions (Wuni et al., 2022).

Data was collected through three main techniques. First, semi-structured interviews with project managers, financial managers, accounting staff, and heads of internal control sections (7 informants in total) to explore changes in processes and control mechanisms. Each interview lasts 60-90 minutes and is recorded with the consent of the informant. Second, project documentation, including module production schedules, contracts, standard operating procedures, and quality management system documents. Third, analysis of financial documents in the form of invoices, proof of payment, project cost statements, and internal financial statements from conventional projects (as a baseline) and modular projects.

Value Stream Mapping (VSM) is applied to map the flow of accounting transactions before (conventional projects) and after the implementation of modular prefabrication. The VSM procedure involves identifying units of analysis in the form of accounting transactions from payment request to final record, mapping the current state for conventional projects by documenting all transaction stages and associated documents, and classifying activities into value-adding activities that directly contribute to accurate recording and timely payments, and non-value-adding activities such as redundant documentation, repetitive verification, and excessive administrative coordination. Metrics are measured, including the number of transaction points, lead time, cycle time, and process time, followed by mapping the future state for modular projects and conducting a gap analysis.

The Risk-Control Matrix (RCM) is constructed with the following procedures. First, identification inherent in each stage of accounting transactions (recording errors, double

payments, verification delays, fraud). Second, likelihood assessment using a scale of 1-5 from rarely occurs (1) to occurs (5). Third, impact assessment using a scale of 1-5 from low (1) to critical impact (5). Next, the risk rating is calculated by multiplying the likelihood and impact scores to determine risk priorities. The effectiveness of controls is then evaluated based on design effectiveness (the adequacy of control design) and operating effectiveness (the consistency of implementation), using a scale ranging from ineffective (1) to very effective (5). Finally, controls are mapped within the risk framework to identify components that require strengthening.

A comparative analysis was conducted on key performance indicators between conventional and modular projects, including the number of transaction documents and verification points, average payment verification time, administrative costs (document processing and coordination), and financial reporting accuracy, measured by report corrections and end-of-period cost discrepancies. Data validity was ensured through source and method triangulation, while interview findings were cross-validated with official company documents and reconfirmed with key informants. The reliability of the analysis was strengthened by the use of internally audited company documents.

RESULTS

Impact of Modular Prefabrication on Transactions and Internal Control

This section presents the results of the study, focusing on the impact of modular prefabrication on project accounting transactions and internal control systems. The analysis compares conventional on-site construction projects with modular projects to highlight changes in transaction flow, verification processes, administrative costs, and financial reporting accuracy (Salama et al., 2020). Both qualitative and quantitative findings are presented, including value stream mapping of transaction processes, assessment of internal control effectiveness, and comparative performance metrics, providing a comprehensive view of how modular prefabrication influences project management and financial control.

Table 1. Accounting Transactions and Internal Control: Conventional vs Modular Projects

Indicator	Conventional Projects	Modular Projects	Changes	Implications for Internal Control
Number of accounting transaction points	±120 points	±48 points	Decline ±60%	Decreased recording errors. Control focuses more on high-value units.
Payment documents	High and fragmented	Consolidated batch-based modules	Significant decline	Document duplication is reduced. Trail audit is clearer.
Payment verification time	±14 days	±4 days	±70% decrease	Gate verification is more effective and standardized.
Administrative fees	High (baseline 100%)	50-60% of baseline	Decrease ±40-50%	Administrative efficiency strengthens cost control.

Value stream mapping identifies structural transformations in the flow of accounting transactions by consolidating transactions from discrete activities into module-based batches (Ramani & Lingan, 2021). The results are presented in Table 1. The application of prefabricated modular reduced the number of transaction points from ±120 points (conventional projects) to ±48 points (modular projects), or a decrease of about 60%. Transactions that were previously spread across various work packages are now consolidated in standardized batches of modules. In terms of time, the average duration of payment verification was reduced from ±14 days (conventional projects) to ±4 days (modular projects), or an acceleration of up to 70%. This is due to the reduced need for partial inspections in the field and the presence of an integrated verification gate between the physical completion of the module and the associated costs.

Table 2. Project Financial Process Performance Indicators Before and After Modular Prefabricated

Performance Indicators	Units	Before	After	The Impact of Lean Construction
Payment lead time	Day	±14	±4	Smoother and bottleneck-free transaction flows
Financial reporting accuracy	%	±92%	±98%	Elimination of rework and administrative correction
Report correction frequency	Wait/ period	Height	Low	Information waste is significantly reduced

The cost analysis, as seen in Table 2, shows a decrease in administrative costs by 40-50% from the baseline of conventional projects, especially in the reduction of administrative work, document processing, and coordination between units. The accuracy rate of financial reporting increased from ±92% (conventional projects) to ±98% (modular projects), indicated by reduced report corrections and cost differences at the end of the period (Salehipour et al., 2016). The risk-control matrix indicates that recording errors and double payments decreased significantly after the implementation of the batch system and module-based controls.

The reduction in payment lead time by about 70 indicates that the flow of financial transactions has become more streamlined and free from the administrative bottlenecks common in conventional construction projects. The increase in financial reporting accuracy to close to 98% shows a reduced need for correction and rereconciliation. From the perspective of internal controls, this improvement in performance reflects better and timelier quality of financial information. Lean construction not only plays a role in operational efficiency but also improves the reliability of the project's accounting system. Faster and more accurate financial processes contribute directly to strengthening managerial monitoring and decision-making functions (Wuni & Shen, 2020; Syathabi et al., 2024).

Table 3. Comparison of Project Internal Control Systems on Conventional and Modular Schemes

Internal Control Elements	Initial Conditions (Conventional)	Modular Conditions	Reinforcement Mechanism
Control point	Numerous and scattered	Less and focused	Batch-based control points
Physical verification cost	Partial and separate	Integrated	Physical-financial matching gate
Transaction Errors	Relatively high	Lower	The risk-control matrix is more effective
Monitoring	Reactive	Proactive	Transaction flow transparency

Strengthening the internal control system in modular projects is systemic, not just procedural. The transition from a large and scattered control point to a smaller, but focused control point shows an increase in the efficiency of the control design, as shown in Table 3. The integration of physical and cost verification through the verification gate allows for more reliable matching between construction progress and accounting logging. This condition shows that internal control becomes more effective when supported by a simple and standardized transaction structure. The risk-control matrix can be applied more precisely because it is concentrated on clear transaction units. These findings support the view that modular production process design is an important foundation for risk-based internal controls in off-site construction projects (Cantarelli et al., 2013; Wu et al., 2022).

Table 4. Key Performance Indicators Summary Modular Projects

KPI	Operational Definition	Measurement Method	Key Results
Transaction efficiency	Transaction point reduction ratio	VSM & document analysis	Down ±60% deals
Process speed	Average payment verification time	Payment cycle analysis	Down ±70% of the time
Transparency	Physical-financial transaction traceability	Audit trail & RCM	Significant increase
Reporting accuracy	Financial statement conformity level	Report reconciliation	Up to ±98%

Table 4 shows the integrative impact of modular prefabrication on project performance through measurable key performance indicators, showing that the improvement in project performance is not the result of tightening control alone, but rather a consequence of the integration of production design, lean processes, and accounting systems. Thus, this table reinforces the contribution of the research in showing that the strengthening of the internal control system can be achieved through structural transformations in the flow of project transactions (Otoo et al., 2023).

Conceptual Development of a Modular–Lean–Control Integration Model

The conceptual model is built on the proposition that the design of the production process is one of the critical determinants of the accounting transaction structure and the effectiveness of internal controls in off-site construction projects. In contrast to conventional approaches that treat accounting systems and internal controls as stand-alone administrative functions, this model places modular prefabrication as an upstream driver of systemic change. The uniqueness of this model lies in the argument that the internal control of a project is not optimal if it is only designed at the procedural level, but must be derived from the design of the production process and the transaction structure. The integration of modular prefabrication and lean construction is positioned as a structural enabler for transaction-based internal control systems, an approach that is still rarely explored in the construction management and project accounting literature (Ermawijaya, 2021).

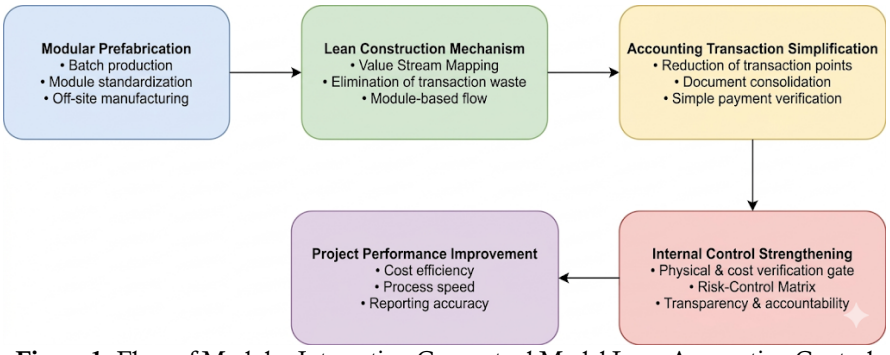

Figure 1. Flow of Modular Integration Conceptual Model Lean Accounting Control

The conceptual model of modular integration of lean accounting control, as presented in Figure 1, consists of several interconnected stages. Modular prefabrication serves as the technical input, characterized by batch-based production, module standardization, and a controlled manufacturing environment, which reduces work fragmentation and consolidates activities into defined production units. Modularization acts as a structural mechanism that minimizes process variation and operational uncertainty through standardized outputs and workflows (Ouda & Haggag, 2025). This technical foundation facilitates the application of lean construction principles as a process mechanism, particularly through value stream mapping to identify and eliminate transaction waste.

Module-based workflows simplify the detection and removal of inefficiencies, such as document duplication, partial verification, and excessive administrative coordination, allowing lean construction to translate modular technical advantages into workflow and information efficiency (Morato & Ferreira, 2024).

The resulting lean-modular workflow directly transforms the structure of project accounting transactions, serving as a financial mechanism. By consolidating activities, standardizing documents, and synchronizing physical and financial verification, work in batch modules reduces the number of transaction points, simplifies financial documentation, and accelerates payment verification. At this stage, the accounting system shifts from fragmented micro-activities to standardized and measurable units of value. This simplification of transactions also strengthens the internal control system as a managerial output. The batch module acts as the primary control unit, while verification gates ensure alignment between physical and financial data through a physical-financial matching mechanism. The Risk-control matrix becomes more efficient, mapping fewer but more significant transaction units. Control activities are reinforced through batch control and gate verification, information and communication are enhanced via standardized documentation and physical-financial integration, and monitoring activities benefit from real-time tracking and transparent audits, enabling early detection of deviations. This approach confirms that the effectiveness of internal controls depends not only on procedural implementation but also on the design of underlying processes (Espinosa-Jaramillo, 2024).

Ultimately, the integration of technical, process, financial, and control mechanisms improves project performance. Strengthened internal control, combined with simplified transactions and lean-modular workflows, leads to greater administrative cost efficiency, faster payment cycles, and higher accuracy in financial reporting. Thus, project performance emerges as the logical outcome of the modular-lean-control integration model (Ramadhania & Meirini, 2022).

DISCUSSION

The findings of a 60% reduction in transaction points (from ±120 to ±48 points) support the argument that modular design serves as a structural enabler for lean construction. Modular prefabrication structurally transforms the flow of project value, from a fragmented field activity-based production to a standardized production with a simpler transaction flow. This simplification enhances the effectiveness of the project accounting system (Goh & Goh, 2019; Hei et al., 2024).

These findings indicate that administrative complexity in construction projects is not only influenced by the scale of the project, but also by the design of the underlying production process. With the reduction in the number of documents and verification points, the control system becomes more focused on transactions of material value, thereby improving traceability and reducing misrecordings. From a risk-based internal control perspective, the modular application of prefabrication strengthens the components of control activities (through batch control and gate verification) and information & communication (through integrated physical-financial matching). Batch modules serve as clear control units, while physical-cost verification gates improve transaction traceability. The control environment has also become stronger as transaction responsibilities and authorizations are more defined. The modular-lean-control integration model proposed in this study places modular production design as the main trigger for transaction simplification, which is then reinforced by lean principles and internal control systems. This model explains that effective internal control depends not only on administrative procedures but also on the design of the underlying operational processes (Wrigley et al., 2021; Bouheraoua & Djafri, 2022; Liu et al., 2023).

This research contributes to the literature by integrating the study of modular construction and lean production theory into the domain of project management, accounting, and internal control systems, filling the theoretical gap between operational design and financial control systems. The empirical findings expand the understanding

that operational process design is an important determinant of the effectiveness of internal controls, beyond traditional approaches focused on administrative procedures. The proposed modular-lean-control integration model enriches theoretical perspectives on how production systems and accounting systems shape each other in the context of construction projects. Compared to previous research that highlighted the benefits of modular prefabrication in terms of construction time and cost, this study adds the dimensions of management accounting and internal control as a new contribution. Thus, this research expands the understanding of how construction innovations impact project managerial and financial systems holistically (Albaadani et al., 2025; Gazali et al., 2025; Vargas et al., 2025).

For construction industry practitioners, the results of this study provide an empirical basis that investments in off-site construction and modular prefabrication can yield significant financial and control benefits. Project management can use batch modules as the basic unit of cost and payment control, thereby reducing administrative burden and reporting errors (Cerezo-Narváez et al., 2020). The proposed model can also be used as a guideline in designing a project accounting and internal control system that is in line with the characteristics of modular construction. From a policy and educational perspective, this research can be a reference in the development of off-site construction best practice standards, particularly related to project financial governance. In addition, the resulting conceptual model can be used as a learning template, thesis, or thesis in the fields of construction management, management accounting, and industrial engineering.

CONCLUSION

The case study demonstrates that implementing modular prefabrication in off-site construction significantly improves production efficiency, simplifies project accounting transactions, and strengthens internal controls. Reductions in transaction points, faster payment verification, lower administrative costs, and higher financial reporting accuracy highlight that process design, not just project scale, drives operational and control efficiency. Integrating modular production with lean construction and risk-based internal control frameworks acts as a structural enabler for effective project governance. The findings imply that construction organizations can achieve more streamlined operations and reliable financial reporting by adopting modular-lean-control integration, though it requires upfront investment in standardization, documentation, and process redesign. This approach shifts the focus from adding control layers to designing inherently controllable processes, enhancing both efficiency and transparency.

However, this study has limitations. Its findings are based on a single residential project at PT X, limiting generalizability across different project types, scales, and organizational contexts. Retrospective comparison with conventional projects may introduce historical bias, and non-accounting factors such as organizational culture, technology readiness, and change resistance were not examined. Furthermore, the proposed conceptual model has not yet been empirically validated in diverse contexts. Future research should expand on these insights by conducting multi-case or cross-sectional studies across residential, commercial, and infrastructure projects to identify moderating factors. Quantitative studies using SEM or regression analysis can rigorously test causal relationships between modular design, lean practices, transaction simplification, and internal control effectiveness. Longitudinal research could evaluate long-term performance, learning effects, and control system evolution. Additionally, exploring digital technologies like BIM, blockchain, and IoT may reveal ways to enhance real-time transaction transparency and strengthen modular-lean-control integration, while cross-country studies can investigate the role of institutional and cultural factors in model effectiveness.

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