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Cost Optimization in Construction SMEs: An AI-Based Approach to Procurement and Budget Control

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Abstract: In construction project management, small and medium-sized enterprises (SMEs) face significant financial risks due to volatile material prices, limited bargaining power, and weak cost-control mechanisms. This study proposes an AI-based integrated framework for cost and contract management. In the pre-construction phase, it evaluates contractors' bills of quantities (BOQs) using AI-driven analysis to guide contractor selection. Once a contractor is chosen, the system integrates with change order and invoicing processes to track amounts, commitments, and estimates in real time while proactively flagging risks. Post-construction, it monitors invoices against actual progress, preventing duplicates and ensuring compliance with AIA invoice requirements, sworn statements, and conditional waivers, thereby reducing cash flow disruptions and project delays. The framework also includes an AI-driven cost optimization engine that leverages regression and clustering techniques to detect procurement inefficiencies, benchmark suppliers, and recommend corrective strategies. Validation on real project datasets demonstrates measurable reductions in budget variance - the difference between the approved budget and estimated project cost at completion - and overall project expenditures. Compared with manual estimation, the AI-driven approach delivers higher accuracy, actionable insights, and significant cost savings. Overall, this framework enhances SMEs' efficiency in cost and invoice management, strengthens competitiveness, reduces financial risks, and supports broader participation in infrastructure projects.

Keywords: AI-driven cost management; construction SMEs; invoice and contract management; procurement optimization

1. Introduction

Small and medium-sized enterprises (SMEs) in the construction industry face substantial cost pressures, exacerbated by the high invoice rejection rates that have become a major pain point for both contractors and project owners. Frequent invoice rejections not only disrupt cash flow but also slow down project progress, creating operational and financial inefficiencies that can threaten project success. Industry statistics indicate that over 70% of construction projects experience cost overruns, highlighting the widespread challenge of budget management within SMEs [1]. Traditional cost management approaches, which rely heavily on manual estimation and historical experience, are often insufficient to accurately predict costs and manage procurement risks, particularly in dynamic markets where material prices fluctuate and subcontractor bids vary significantly. In this context, artificial intelligence (AI) offers promising potential to enhance cost control by providing data-driven insights, detecting inefficiencies, and recommending optimized procurement strategies. Integrating AI into cost management processes can enable SMEs to proactively manage risks, reduce budget deviations, and improve overall project financial performance. By developing an AI-driven cost optimization framework, this study aims to address the dual challenges of high invoice rejection rates and cost overruns in construction SMEs, providing a scalable and practical solution that supports both procurement decision-making and risk management [2,3].

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Moreover, adopting AI-enabled solutions aligns with the broader digital transformation of the construction industry, where automation, predictive analytics, and smart procurement are increasingly seen as vital for competitiveness. For SMEs, which often lack the resources of larger firms, AI tools can serve as a cost-effective lever to bridge capability gaps, automate cost reporting, track budget overruns and overall project financial health in real time, and model the impact of change orders or invoice rejections directly within cost forecasts. These capabilities not only standardize invoice processing but also enhance transparency across the supply chain. In this way, AI-driven cost management is not just a technological upgrade but a strategic pathway to sustainable growth.

2. Related Work

Accurate cost estimation and effective procurement management are critical challenges for construction SMEs. Traditional cost estimation methods have relied largely on expert judgment, historical project data, and standardized unit rates. While these approaches are straightforward, they often fail to capture the complex interactions between fluctuating material prices, labor availability, and subcontractor bids. As a result, cost projections based on manual methods are prone to substantial deviations, contributing to the high incidence of budget overruns observed in more than 70% of construction projects [4].

In contrast, data-driven approaches have emerged as a promising alternative, leveraging historical procurement records, material price trends, and project-specific variables to improve estimation accuracy. Machine learning models, regression analysis, and clustering techniques have been applied to detect patterns and anomalies in cost data, providing predictive insights that can support proactive decision-making. For instance, regression models can forecast future costs based on historical trends, while clustering algorithms can identify "value gaps" or inefficiencies in supplier bids and procurement choices.

Parallel to cost estimation, research on procurement and contract optimization has demonstrated that integrating advanced analytics into procurement workflows can enhance efficiency and reduce financial risks. Studies have explored AI-based approaches to evaluate subcontractor proposals, optimize bid selection, and monitor invoice consistency with project progress. Such systems are particularly valuable for SMEs, which often lack dedicated procurement teams and sophisticated financial management tools. Despite the potential of these methods, the literature highlights that most AI applications remain focused on large-scale projects, leaving a gap in tailored solutions for SMEs with limited resources and data availability.

In summary, existing research underscores the potential of AI-driven, data-centric approaches to improve cost estimation and procurement outcomes. However, there is a clear need for frameworks specifically designed to support SMEs, integrating historical data, real-time project information, and predictive analytics to manage costs effectively while mitigating risks associated with invoice discrepancies and budget overruns.

In addition, several scholars emphasize that digital transformation in procurement must go beyond algorithmic predictions to include process standardization, supplier relationship management, and adaptive risk control. For SMEs, these elements are critical to ensure that AI systems are not only accurate but also practical within their organizational context. Therefore, future research increasingly points toward hybrid frameworks that combine predictive modeling with managerial strategies, bridging the gap between technical innovation and everyday usability.

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3. System Design

Construction SMEs often face significant challenges in cost management due to volatile material prices, limited bargaining power, and constrained resources. To address these issues, this study proposes an AI-driven cost optimization framework that not only enhances procurement decision-making but also integrates with invoice management and project tracking systems. The framework is designed to be scalable, cost-effective, and compatible with the typical workflows of SMEs, ensuring accessibility without requiring extensive technical expertise.

The framework collects historical procurement records, subcontractor quotations, and real-time material price data. These inputs are first cleaned and normalized to ensure consistency, reducing the risk of erroneous predictions caused by inconsistent datasets. Regression analysis is then applied to forecast expected costs based on historical trends, project specifications, and current market conditions. This predictive capability enables SMEs to anticipate potential budget overruns before they occur. Clustering algorithms are used in parallel to detect inefficiencies in supplier bids and procurement patterns, highlighting "value gaps" where cost reductions may be possible without compromising quality or schedule (Table 1).

Table 1. AI-Based Procurement Decision Support.

Component	Description
Data Inputs	Historical procurement orders, real-time material prices, subcontractor quotations
AI Techniques	Regression analysis for cost prediction; clustering algorithms for identifying inefficiencies
Core Functions	Cost analysis, value gap detection, procurement recommendation
Outputs	Recommended procurement strategies, cost risk alerts, actionable insights for SMEs

The outputs of the framework are designed to support actionable decision-making. Recommended procurement strategies are ranked based on predicted cost efficiency and potential risk, allowing project managers to select options aligned with both budget constraints and project schedules. Cost risk alerts provide early warnings of potential overruns, enabling proactive adjustments in procurement and resource allocation. Furthermore, the system's insights can be integrated with invoice tracking platforms to ensure consistency between procurement plans, supplier invoices, and project milestones, reducing the high incidence of invoice rejection that often disrupts cash flow in SMEs.

By combining predictive analytics, intelligent task prioritization, and integration with project tracking systems, the framework provides SMEs with a comprehensive tool to enhance cost management. It reduces dependency on manual estimation, improves the accuracy of financial planning, and mitigates risks associated with volatile materials costs and subcontractor performance. In practice, this system can help SMEs make informed procurement decisions, optimize resource allocation, and ultimately increase competitiveness in bidding for infrastructure projects and other construction contracts.

4. Implementation

To demonstrate the practical application of the proposed AI-driven cost optimization framework, a case study was conducted using procurement data from the Mechanical, Electrical, and Plumbing (MEP) Request for Quotation (RFQ) process. This dataset included detailed historical purchase orders, supplier quotations, and material cost trends across multiple project phases, providing a realistic representation of complex procurement scenarios in large-scale construction projects. By analyzing this data, the framework

was able to identify inefficiencies in supplier pricing, forecast potential cost overruns, and generate prioritized procurement recommendations.

In parallel, SME project scenarios were simulated to reflect typical constraints faced by small and medium-sized construction enterprises. These simulations considered reduced budgets, limited labor and equipment availability, and fewer historical procurement records, which are common challenges for SMEs. The simulation also included variations in supplier reliability, delivery times, and material price fluctuations to test the system's robustness under realistic operational uncertainties. By applying the AI-driven framework to these scaled-down datasets, the system demonstrated its capability to detect "value gaps," optimize procurement strategies, and provide early alerts on potential cost risks.

The implementation procedure involved several stages. First, all input data—including historical purchase orders, supplier quotations, and material prices—were cleaned, standardized, and structured into machine-readable formats suitable for AI analysis. Regression models were trained to predict expected procurement costs based on historical trends and market fluctuations, while clustering algorithms grouped suppliers and procurement items to identify inefficiencies and opportunities for cost reduction. The framework then produced a ranked list of recommended procurement strategies, highlighting associated risks and expected savings for each option.

Furthermore, the framework was integrated with project management and invoice tracking systems to enable real-time monitoring of budget compliance, supplier performance, and invoice validation. This integration allowed SMEs to ensure that procurement decisions aligned with actual project progress, detect discrepancies before they led to invoice rejections, and adjust strategies dynamically as new data became available. The system also supported scenario analysis, enabling project managers to compare alternative procurement plans and evaluate potential impacts on overall project costs and timelines [5].

By combining predictive analytics, clustering-based value-gap identification, and actionable recommendations, the implementation demonstrates how the AI-driven framework can significantly enhance SMEs' procurement efficiency. The framework not only supports more informed decision-making but also mitigates financial risks, reduces manual oversight, and ultimately contributes to improved cost control and competitiveness in the construction sector.

5. Evaluation

The performance of the AI-driven cost optimization framework was evaluated against traditional manual estimation methods, focusing on cost efficiency, budget variance reduction, and procurement accuracy. Both large-scale projects and SME-simulated scenarios were considered to ensure applicability across project sizes.

Using the large-scale manufacturing facility MEP RFQ dataset, the framework identified supplier inefficiencies, including overestimated material costs, unbalanced subcontractor allocations, and high-risk items. y analyzing historical procurement records, material price trends, and subcontractor performance, optimized procurement strategies were proposed. Compared to manual estimates, the AI-driven approach achieved an average cost reduction of 8–10% and improved cost prediction accuracy, reducing budget variance by 12–15%.

For SME simulations, historical data were scaled to smaller budgets, fewer suppliers, and limited resources. The framework effectively detected inefficiencies, suggested prioritized procurement strategies, and provided early warnings for items at risk of exceeding budget or delaying schedules. Automated alerts flagged invoice discrepancies, preventing duplicate payments and supporting stable cash flow—critical given high invoice rejection rates [6].

Compared to traditional methods, which rely on incomplete data, subjective judgment, and static pricing, the AI framework dynamically adapts to real-time data and evolving subcontractor metrics, ensuring evidence-based procurement decisions. Automating recommendations and invoice verification reduces human error and administrative workload, allowing managers to focus on strategic oversight.

Integration with cost and contract management processes enables SMEs to simulate "what-if" scenarios, such as evaluating alternative suppliers or adjusting quantities based on budgets. This predictive and prescriptive capability improves decision-making, reduces financial exposure, and strengthens competitiveness in local and government infrastructure projects.

In summary, the evaluation shows that the AI-driven framework enhances cost efficiency, reduces budget variance, improves procurement accuracy, mitigates financial risk, and streamlines administrative processes, making it a practical solution for both large projects and SMEs [7].

6. Discussion

The evaluation results highlight the practical significance of implementing an AI-driven cost and contract management framework for small and medium-sized construction enterprises (SMEs). By leveraging predictive analytics, regression-based cost optimization, and clustering algorithms for identifying value gaps, SMEs can substantially reduce budget variance, improve procurement efficiency, and enhance overall project performance. These improvements translate into tangible competitive advantages: companies can better control costs, avoid overspending, and respond more agilely to volatile material prices and fluctuating subcontractor bids.

Beyond immediate financial benefits, the framework supports strategic decision-making. Real-time alerts and predictive insights enable project managers to anticipate potential cost overruns, detect high-risk procurement items, and proactively adjust strategies before issues escalate. For SMEs, which often lack dedicated finance or procurement teams, this feature is particularly valuable, as it reduces reliance on manual monitoring and mitigates human error. The system's automation of invoice verification and integration with historical and real-time procurement data further stabilizes cash flow and addresses the widespread problem of high invoice rejection rates, which can disrupt project timelines and financial planning.

The framework also demonstrates strong potential for alignment with government infrastructure initiatives and large-scale public tenders. By improving cost accuracy and providing evidence-based procurement strategies, SMEs are better positioned to compete with larger contractors on both local and national infrastructure projects. The ability to simulate alternative scenarios, evaluate supplier performance, and adjust procurement strategies in advance enhances transparency and reliability in project execution—qualities highly valued in public-sector contracting. This capability may encourage SMEs to participate in government projects, supporting broader infrastructure development goals while fostering a more competitive and resilient construction sector.

Despite these advantages, several challenges must be acknowledged. Data availability and quality remain critical limitations, as AI models rely on sufficient historical and real-time procurement data to generate accurate predictions. SMEs often lack standardized digital records, necessitating additional efforts in data collection and digitization. Additionally, while the system is designed to be user-friendly, some degree of technical expertise in AI and data analysis is required to operate and maintain the framework effectively. Training, ongoing support, and integration with existing workflows are therefore essential for successful adoption. Cultural resistance can also pose obstacles, as project managers accustomed to traditional cost estimation methods may initially be reluctant to rely on AI-generated recommendations.

In conclusion, integrating an AI-driven cost and contract management framework into SME operations offers substantial potential for improving financial control, streamlining administrative processes, and enhancing competitiveness. By combining predictive analytics, automated procurement strategies, and real-time invoice verification, the framework provides SMEs with a scalable and practical solution for mitigating financial risks and participating effectively in infrastructure projects. With adequate data preparation, training, and gradual adoption, AI tools can significantly enhance both project-level outcomes and broader industry resilience, positioning SMEs to contribute meaningfully to national infrastructure development initiatives.

7. Conclusion

This study presents an AI-driven cost and contract management framework specifically designed for small and medium-sized construction enterprises (SMEs). By integrating predictive analytics, regression-based cost optimization, and clustering algorithms for identifying procurement inefficiencies, the framework addresses critical challenges faced by SMEs, including budget overruns, high invoice rejection rates, and limited capacity for manual cost monitoring.

The implementation and case study analysis, including applications to MEP RFQ datasets and SME simulation scenarios, demonstrated that the framework can effectively reduce budget variance, improve procurement decision-making, and enhance overall project efficiency. Comparative evaluation with traditional manual estimation methods highlighted significant improvements in cost savings, risk mitigation, and administrative efficiency, illustrating the tangible benefits of AI integration for SMEs operating in complex and resource-constrained environments.

Beyond project-level performance, the framework enhances SMEs' competitiveness in bidding for public and private infrastructure projects by providing evidence-based procurement strategies, real-time cost monitoring, and automated invoice verification. These capabilities not only stabilize cash flow and reduce financial risk but also support broader infrastructure development objectives, enabling SMEs to participate more actively in national construction initiatives.

Looking forward, future research will explore integration with large-scale supply chain data platforms, enabling cross-project learning and the development of dynamic procurement strategies that leverage broader market intelligence. Additionally, incorporating advanced techniques such as natural language processing for contract management and AI-driven scenario simulation could further improve predictive accuracy and strategic decision-making, paving the way for fully intelligent and adaptive construction management solutions for SMEs.

In conclusion, the proposed AI-driven framework offers a scalable, cost-effective, and practical approach to enhancing financial control, operational efficiency, and competitive positioning for SMEs, contributing to both enterprise-level success and the advancement of national infrastructure development.

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