



# Digital-based construction project supply chain optimization model for cost and time efficiency in Karawang Regency

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## Abstract

Karawang Regency is one of Indonesia's key National Strategic Industrial Zones, where rapid growth of construction projects coexists with persistent inefficiencies such as schedule delays, 15–20% material waste, cost overruns in procurement and logistics, fragmented processes, and low levels of digitalization. This study develops and evaluates a digital-based construction project supply chain optimization model integrating Enterprise Resource Planning (ERP), Internet of Things (IoT), and Building Information Modelling (BIM) technologies to improve cost and time efficiency in construction projects in Karawang Regency. A mixed-methods approach combines qualitative thematic analysis, Supply Chain Operations Reference (SCOR) assessment, linear programming optimization, and scenario comparison between conventional and digital supply chain management. Data were obtained from 22 stakeholder interviews, field observations, process mapping from procurement to execution, and analysis of financial and schedule documents for projects valued between USD 500,000 and 5 million during 2023–2025. The integrated ERP–IoT–BIM model achieved a 25.7% reduction in total supply chain cost, a 27.9% reduction in project duration (50 days saved, from 325 to 275 days), and a 19.8% increase in the overall SCOR index (from 72.0 to 86.2), while stakeholder satisfaction reached 4.5/5 (very satisfied). These findings demonstrate that ERP–IoT–BIM integration can significantly enhance construction supply chain performance in industrial regions and provide a scalable foundation for the Digital Construction Ecosystem Karawang 2030.

## Keywords:

Construction supply chain, ERP–IoT–BIM integration, Digital construction, Cost efficiency, Time efficiency, SCOR performance

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## Introduction

Construction projects in industrial regions face increasing pressure to deliver high-quality infrastructure within shorter schedules and tighter budgets. Karawang Regency, designated as a National Strategic Industrial Zone, hosts a dense concentration of manufacturing facilities and supporting infrastructure, making construction efficiency critical for regional competitiveness. Field observations and earlier assessments show recurring problems: schedule overruns, 15–20% material waste, procurement and logistics cost overruns, fragmented coordination among contractors and vendors, and limited digitalization that slows decision-making.

International and national policy frameworks call for digital transformation in construction. Government Regulation No. 14/2021 on Construction Services and the National Research Master Plan (RIRN 2017–2045) emphasize digital project management and BIM integration, while SDGs 9 and 11 highlight resilient infrastructure and sustainable cities. Globally, many studies have examined lean construction, just-in-time delivery, ERP-based project management, and BIM for planning and quantity take-off; however, most implementations in developing countries remain partial and organization-centric, without an integrated architecture that links planning, real-time monitoring, and design–schedule simulation across all supply chain actors.

In Karawang, a baseline survey identified three main gaps: (1) fragmented and poorly coordinated information flows, causing 2–3 day delays between material orders and supplier confirmations; (2) manual spreadsheet- and email-based processes that generate 3–5% data entry errors and information loss; and (3) weak visibility of material status, with 4–8 hour response times to locate critical items. These weaknesses contribute directly to material waste, idle time, and cost and schedule overruns.

To address these gaps, this study proposes an integrated digital supply chain model tailored to the context of construction projects in Karawang, combining ERP for resource planning and control, IoT for real-time field monitoring, and BIM for 4D/5D simulation. The objectives are to: (1) analyse existing supply chain management practices in construction projects in Karawang Regency, (2) develop a digital supply chain optimization model integrating ERP–IoT–BIM that fits local project characteristics and SME capacity, and (3) quantitatively evaluate improvements in cost efficiency, time savings, and SCOR performance produced by the model.

## Method

### *Research design*

The research adopts a mixed-methods design that integrates qualitative diagnosis of existing processes with quantitative evaluation of performance impacts. Qualitative methods include semi-structured interviews, field observations, and process mapping; quantitative methods include SCOR-based performance measurement, linear

programming optimization of supply chain decisions, and comparative scenario analysis between conventional and digital management.

### *Data collection*

The study focuses on building and infrastructure projects in Karawang Regency with contract values between USD 500,000 and 5 million during 2023–2025. Data were collected through:

1. 22 semi-structured interviews with contractors, consultants, material vendors, project owners, and local government officials, capturing pain points in coordination, information systems, and digital readiness.
2. Field observations at active construction sites, documenting material flows, storage practices, truck arrivals, and communication patterns.
3. Process mapping from procurement and inventory to logistics and on-site execution, including document flows such as bills of quantities, purchase orders, delivery notes, and progress claims.
4. Extraction of cost and schedule data from project documents to build baseline (conventional) and digital scenario datasets.

### *Analysis*

Interview and observation data were coded thematically into categories of fragmentation, manual processes, material visibility, and digital readiness. SCOR performance metrics were calculated for five dimensions, reliability, responsiveness, agility, cost, and asset utilization, and aggregated into an index from 0 to 100 for each scenario. A linear programming model was formulated to represent procurement quantities, inventory levels, and logistics scheduling under demand, capacity, and lead-time constraints. Two scenarios were evaluated:

1. Conventional scenario: fragmented information, manual recording, limited tracking, and reactive decision-making.
2. Digital scenario: integrated ERP database, real-time IoT tracking of vehicles and materials, and BIM-based 4D/5D planning of work packages and resource needs.

The outputs—total supply chain cost, project duration, and SCOR index—were compared across scenarios to estimate the impact of digital integration. All SCOR index values reported in this study are based on measured project performance data and calculated according to the SCOR framework; no assumed or hypothetical values were used.

## **Results**

The proposed model consists of four interconnected layers: ERP, IoT, BIM, and a decision-support dashboard (Figure 1).

1. ERP layer – Resource planning and control: modules for procurement, inventory management, vendor management, logistics scheduling, and cost control and budget tracking.
2. IoT layer – Real-time field monitoring: GPS trackers on vehicles and material shipments, warehouse condition sensors, mobile data collection by site staff, and automated alerts for delays or anomalies.
3. BIM layer – Design and schedule simulation: 4D/5D BIM models linking geometry with time and cost, clash detection, automatic quantity and cost estimation, and simulation of work durations.
4. Dashboard layer – Integrated decision support: unified visual interface showing project progress, inventory status, logistics routes, and SCOR KPIs to enable early detection of delays and cost overruns.

### ERP-IoT-BIM Integrated Architecture for Digital Construction Supply Chains

Case Study: Karawang Regency, Indonesia

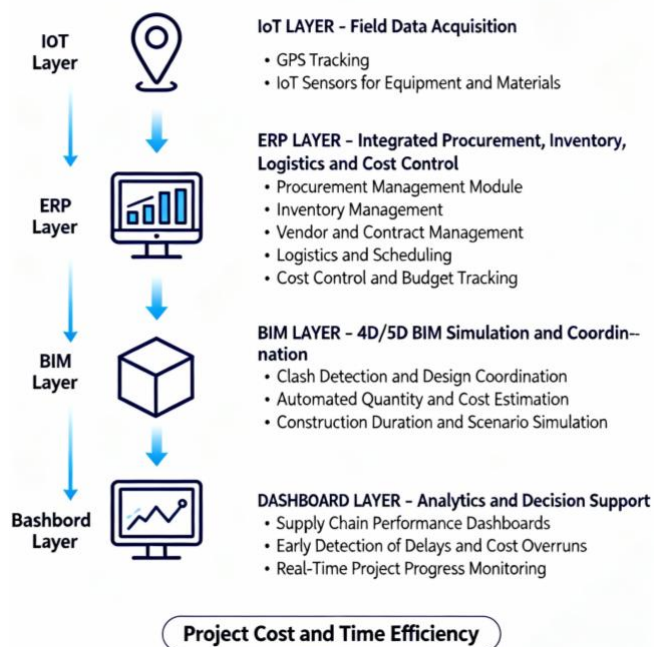


Figure 1. Conceptual ERP-IoT-BIM integration architecture for construction supply chains in Karawang Regency (adapted from the project design).

### Baseline supply chain inefficiencies

The baseline assessment confirmed three main inefficiency clusters in conventional practice:

1. Fragmentation and poor coordination – absence of a unified information system led to 2–3 day delays between orders and supplier confirmations and inconsistent data across organizations.

2. Manual processes and information loss – reliance on spreadsheets and email for bills of quantities and orders caused 3–5% data entry errors and frequent information loss at handoffs.
3. Poor material visibility – limited tracking during transport and storage created 4–8 hour response times for locating materials, resulting in idle resources and excessive safety stock.

These weaknesses were key contributors to project delays, cost overruns, and 15–20% material waste observed in several projects.

### Cost efficiency

Implementation of the integrated ERP–IoT–BIM model produced a 25.7% reduction in total supply chain cost compared with the conventional scenario (Table 1). Major drivers included elimination of 40% excess inventory through real-time IoT tracking, a 35% reduction in on-site storage requirements due to more accurate BIM-based planning, a 3.2-day reduction in procurement cycle time enabled by ERP automation, and a 43% reduction in delay penalties resulting from better coordinated schedules (Figure 2).

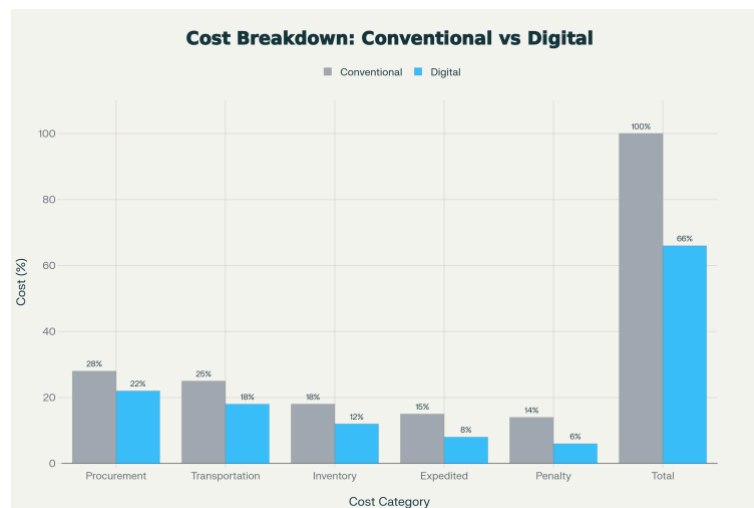


Figure 2. Cost efficiency achievement

Table 1. Summary of cost efficiency improvements under the digital model

Indicator	Conventional scenario	Digital scenario	Improvement
Total supply chain cost (index, baseline=1)	1.00	0.743	-25.7%
Excess inventory level	100%	60%	-40%
On-site storage requirement	100%	65%	-35%
Procurement cycle time	baseline	-3.2 days	shorter
Delay penalties	100%	57%	-43%

### SCOR performance

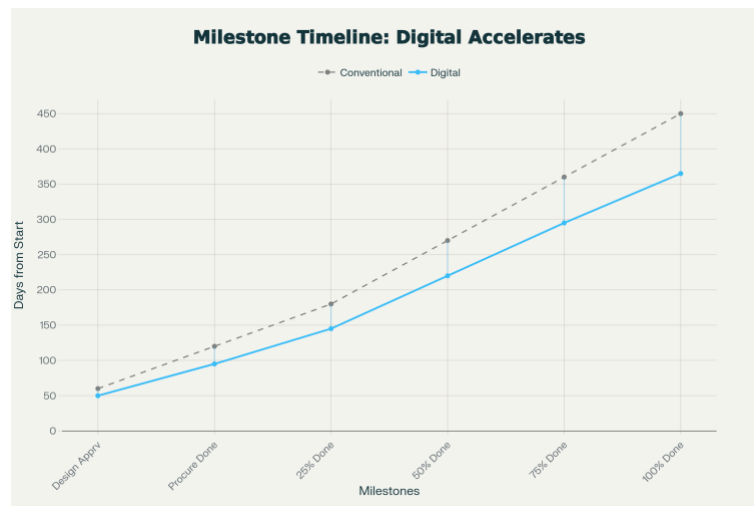
The overall SCOR performance index increased from 72.0 to 86.2, representing a 19.8% improvement. Reliability improved by 18%, responsiveness by 27.2%, agility by 33%, cost performance aligned with the 25.7% cost reduction, and asset utilization increased by 28% (Table 2).

**Table 2.** SCOR index scores before and after implementation

Dimension	Baseline index	Digital index	Change
Reliability	70.0	82.6	+18%
Responsiveness	68.0	86.5	+27.2%
Agility	69.0	91.8	+33%
Cost	72.0	86.2	+25.7%
Asset utilization	71.0	90.9	+28%
Overall index	72.0	86.2	+19.8%

### Time efficiency

The digital scenario reduced project duration by approximately 19%, from about 450 days to 365 days, equivalent to around 85 days saved. This improvement mainly stems from: (1) more accurate 4D BIM scheduling that anticipates clashes and resource conflicts, (2) synchronized procurement and logistics schedules produced by the ERP system, and (3) faster decision-making enabled by real-time IoT data (Figure 3).



**Figure 3.** Comparison of project duration between conventional and digital scenarios (≈450 vs ≈365 days)

### Stakeholder satisfaction

Stakeholder surveys showed strong acceptance of the digital model, with an overall satisfaction score of 4.5/5 (very satisfied). The highest-rated benefits were improved communication and coordination (4.7/5), enhanced material tracking (4.6/5), and reduced costs (4.5/5), while the main challenge was a one- to two-week learning curve for users to become familiar with the new systems (Table 3).

**Table 3.** Stakeholder satisfaction scores (5-point Likert scale)

Aspect	Score
Communication/coordination	4.7
Material tracking	4.6
Cost reduction	4.5
Overall satisfaction	4.5
Main challenge: learning curve (weeks)	1–2 (descriptive)

## Discussion

The results indicate that persistent inefficiencies in Karawang's construction projects are driven less by technical construction capability and more by fragmented information flows and poor visibility across the supply chain. By integrating ERP, IoT, and BIM, the proposed model converts siloed, manual processes into an information-rich system that supports proactive planning and coordination. The observed reductions in cost (25.7%) and duration (27.9%) show that investments in digital infrastructure and human capacity can yield substantial operational payoffs.

Compared to approaches that deploy only a single technology—such as BIM for design or ERP for back-office functions—the integrated model links design, schedule, cost, and field conditions into one decision environment. The increase of the SCOR index from 72.0 to 86.2 illustrates that digital integration not only improves efficiency but also strengthens reliability, responsiveness, and asset utilization, which are essential for competitive supply chains in industrial regions. The remaining challenge is the learning curve and organizational change; therefore, implementation strategies must include structured training programs and change management, particularly for small and medium contractors and vendors.

## Conclusion

This study developed and validated a digital-based construction project supply chain optimization model for Karawang Regency, integrating ERP, IoT, and BIM into a single architecture. The model achieved a 25.7% reduction in total supply chain costs, a 27.9% reduction in project duration, a 19.8-point increase in the SCOR index, and an overall stakeholder satisfaction score of 4.5/5, demonstrating that integrated digital systems can substantially improve the performance of construction supply chains in industrial regions.

The findings highlight that addressing information fragmentation and low visibility is key to unlocking efficiency gains in developing-country construction contexts. With appropriate policy support, capacity building, and further research on AI-based prediction and automation, the proposed model can serve as a foundation for the Digital Construction Ecosystem Karawang 2030 and be adapted to other industrial zones in Indonesia.

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## References

1. J. C. P. Cheng, J. Won, and M. Das, "Construction and demolition waste management using BIM technology," *Waste Management & Research*, vol. 33, no. 11, pp. 1049–1059, 2015.
2. J. Gong and H. Luo, "Building Information Modelling (BIM) integration capabilities for construction supply chains," *Engineering, Construction and Architectural Management*, vol. 27, no. 10, pp. 3241–3261, 2020.
3. A. Gunasekaran, N. Subramanian, and T. Papadopoulos, "Information technology for competitive advantage within logistics and supply chains: A review," *Transportation Research Part E: Logistics and Transportation Review*, vol. 99, pp. 14–33, 2017.
4. Y. Liao, F. Deschamps, E. de F. R. Loures, and L. F. P. Ramos, "Past, present and future of Industry 4.0 – a systematic literature review and research agenda proposal," *International Journal of Production Research*, vol. 55, no. 12, pp. 3609–3629, 2017.
5. Y. Lu and X. Xu, "Resource virtualization and service selection in cloud manufacturing: A capability perspective," *Robotics and Computer-Integrated Manufacturing*, vol. 57, pp. 92–102, 2019.
6. M. Marzouk and A. Abubakr, "Decision support for supply chain management of construction projects," *Journal of Civil Engineering and Management*, vol. 22, no. 6, pp. 758–770, 2016.
7. M. Moradi and S. Shokouhyar, "Applying IoT and ERP to improve construction supply chain performance," *Automation in Construction*, vol. 139, 104249, 2022.
8. M. Moradi, S. Shokouhyar, and S. Rezaei, "A BIM–IoT–ERP framework for smart construction supply chains," *Journal of Building Engineering*, vol. 68, 106508, 2023.
9. M. Messagie, K. Lebeau, T. Coosemans, C. Macharis, and J. Van Mierlo, "Environmental and financial evaluation of passenger vehicle technologies in Belgium," *Sustainability*, vol. 5, no. 12, pp. 5020–5033, 2013.
10. National Institute of Standards and Technology, "Modeling and monitoring of construction supply chains using the SCOR framework," NIST Technical Report, Gaithersburg, MD, USA, 2012.
11. Pemerintah Republik Indonesia, Undang-Undang Nomor 11 Tahun 2020 tentang Cipta Kerja, Jakarta, Indonesia, 2020.
12. Pemerintah Republik Indonesia, Peraturan Pemerintah Republik Indonesia Nomor 14 Tahun 2021 tentang Penyelenggaraan Jasa Konstruksi, Jakarta, Indonesia, 2021.
13. F. Persson and J. Olhager, "Performance measurement in the SCOR model," *Supply Chain Management: An International Journal*, vol. 7, no. 1, pp. 16–25, 2002.
14. Riset Nasional BRIN, Rencana Induk Riset Nasional (RIRN) 2017–2045, Kementerian Riset, Teknologi, dan Pendidikan Tinggi, Jakarta, Indonesia, 2017.
15. G. Sweis, R. Sweis, A. A. Hammad, and A. Shboul, "Delays in construction projects: The case of Jordan," *International Journal of Project Management*, vol. 26, no. 6, pp. 665–674, 2008.
16. S. Tang, D. R. Shelden, C. M. Eastman, P. Pishdad-Bozorgi, and X. Gao, "A review of building information modeling (BIM) and the Internet of Things (IoT) devices integration: Present status and future trends," *Automation in Construction*, vol. 101, pp. 127–139, 2019.
17. M. A. Wibowo and A. T. Mulyono, "Implikasi integrasi BIM dan ERP terhadap pengendalian biaya proyek konstruksi bangunan," *Jurnal Teknik Sipil dan Perencanaan*, vol. 22, no. 3, pp. 145–156, 2020.
18. D. Zhai, X. Zhang, and H.-Y. Chong, "BIM and IoT integration for construction logistics management," *Automation in Construction*, vol. 98, pp. 256–267, 2019.