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INTEGRATION OF DIGITAL TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE IN SERVICE DEVELOPMENT IN CONSTRUCTION LOGISTICS

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Abstract. This study examines the integration of digital technologies and artificial intelligence (AI) in the development of service systems within construction logistics. The research highlights the role of advanced digital solutions, including artificial intelligence, the Internet of Things (IoT), Building Information Modeling (BIM), cloud computing, big data analytics, and blockchain, in improving the efficiency, transparency, and sustainability of logistics operations in the construction sector. The paper analyzes the impact of AI-driven decision support, predictive analytics, route optimization, demand forecasting, and automated resource management on reducing logistics costs, minimizing project delays, and enhancing supply chain resilience. Furthermore, the study identifies the key challenges associated with digital transformation, such as technological readiness, cybersecurity, workforce competencies, and investment requirements. Based on international best practices, practical recommendations are proposed to strengthen digital logistics services and improve the competitiveness of construction enterprises in the context of Industry 4.0.

Keywords: construction logistics, artificial intelligence, digital technologies, digital transformation, BIM, Internet of Things, blockchain, big data, logistics services, supply chain.

ИНТЕГРАЦИЯ ЦИФРОВЫХ ТЕХНОЛОГИЙ И ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В РАЗВИТИЕ УСЛУГ В СТРОИТЕЛЬНОЙ ЛОГИСТИКЕ

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Аннотация. В данной статье исследуется интеграция цифровых технологий и искусственного интеллекта в развитие сервисных систем строительной логистики. Рассматривается влияние современных цифровых решений, включая искусственный интеллект, Интернет вещей (IoT), информационное моделирование зданий (BIM), облачные технологии, анализ больших данных и блокчейн, на повышение эффективности, прозрачности и устойчивости логистических процессов в строительной отрасли. Особое внимание уделено использованию интеллектуальных алгоритмов для поддержки принятия решений, прогнозирования спроса, оптимизации маршрутов и автоматизированного управления ресурсами. Также определены основные проблемы цифровой трансформации, связанные с технологической готовностью,

кибербезопасностью, квалификацией кадров и инвестиционными затратами. На основе международного опыта предложены практические рекомендации по совершенствованию цифровых логистических услуг и повышению конкурентоспособности строительных предприятий в условиях Индустрии 4.0.

Ключевые слова: строительная логистика, искусственный интеллект, цифровые технологии, цифровая трансформация, BIM, Интернет вещей, блокчейн, большие данные, логистические услуги, цепочка поставок.

QURILISH LOGISTIKASIDA XIZMAT KURSATISHNI RIVOJLANTIRISHNING RAQAMLI TEXNOLOGIYALAR VA SUN’IY INTELLEKT INTEGRATSIYASI

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Annotatsiya. Mazkur maqolada qurilish logistikasida xizmatlarni rivojlantirishda raqamli texnologiyalar va sun'iy intellektni integratsiyalashning nazariy hamda amaliy jihatlari tadqiq etilgan. Tadqiqotda sun'iy intellekt, Buyumlar interneti (IoT), Building Information Modeling (BIM), bulutli texnologiyalar, katta ma'lumotlar (Big Data) tahlili va blokcheyn texnologiyalarining logistika jarayonlari samaradorligini oshirish, ta'minot zanjiri shaffofligini kuchaytirish hamda resurslardan oqilona foydalanishdagi o‘rni yoritilgan. Shuningdek, sun'iy intellekt asosidagi prognozlash, marshrutlarni optimallashtirish, resurslarni avtomatik boshqarish va qaror qabul qilish tizimlarining qurilish loyihalaridagi logistika xarajatlarini kamaytirish hamda loyiha muddatlarini qisqartirishdagi ahamiyati tahlil qilingan. Tadqiqot natijasida raqamli transformatsiyani joriy etish bilan bog‘liq muammolar aniqlanib, qurilish logistikasida zamonaviy xizmatlarni rivojlantirish bo‘yicha amaliy takliflar ishlab chiqilgan.

Kalit so'zlar: qurilish logistikasi, sun'iy intellekt, raqamli texnologiyalar, raqamli transformatsiya, BIM, IoT, blokcheyn, Big Data, logistika xizmatlari, ta'minot zanjiri.

Introduction

The construction industry plays a vital role in economic development, yet it continues to face challenges related to inefficient logistics, fragmented supply chains, rising transportation costs, and project delays. Since logistics activities account for a significant share of total construction costs, improving logistics services has become a key factor in increasing project efficiency and competitiveness.

The rapid development of digital technologies, particularly Artificial Intelligence (AI), Building Information Modeling (BIM), the Internet of Things (IoT), big data analytics, cloud computing, and blockchain, has transformed construction logistics. These technologies enable real-time monitoring, intelligent demand forecasting, route optimization, automated inventory management, and data-driven decision-making, leading to lower operational costs and improved service quality.

Despite these advantages, the adoption of AI and digital technologies in construction logistics remains constrained by challenges such as limited digital infrastructure, cybersecurity risks, high implementation costs, and shortages of skilled professionals. Therefore, identifying effective

approaches for integrating digital technologies into construction logistics services has become an important research priority.

This study aims to examine the role of digital technologies and artificial intelligence in the development of construction logistics services, evaluate their impact on logistics efficiency and supply chain performance, and propose practical recommendations for enhancing the competitiveness and sustainability of construction enterprises in the context of digital transformation.

Literature review

The digital transformation of construction logistics has become one of the most significant research directions in construction management and supply chain studies. Recent studies emphasize that the integration of Artificial Intelligence (AI), Building Information Modeling (BIM), the Internet of Things (IoT), blockchain, and big data analytics has significantly improved logistics efficiency, project coordination, and decision-making processes in construction projects [1].

Artificial intelligence has attracted considerable attention due to its capability to optimize logistics operations through predictive analytics, machine learning, and intelligent scheduling. AI-based algorithms enable accurate demand forecasting, inventory optimization, equipment allocation, and transportation planning, thereby reducing logistics costs and minimizing project delays [2]. Furthermore, AI-driven decision support systems enhance risk management by identifying potential disruptions within construction supply chains before they occur [3].

Building Information Modeling (BIM) has also become an essential digital platform for improving construction logistics. Researchers argue that BIM facilitates information sharing among stakeholders, supports real-time material tracking, and enables better coordination between suppliers, contractors, and project managers. The integration of BIM with AI further improves construction planning through automated scheduling and resource optimization [4].

The Internet of Things (IoT) provides continuous monitoring of construction materials, machinery, and transportation vehicles using sensors and smart devices. Real-time data collected through IoT technologies improves supply chain visibility, reduces material losses, and enhances operational efficiency. Recent studies demonstrate that IoT-based logistics systems significantly increase project transparency and reduce uncertainties associated with construction operations [5].

Blockchain technology has emerged as an innovative solution for ensuring transparency, security, and trust in construction logistics. Distributed ledger systems facilitate secure information exchange, improve contract management, and reduce fraud risks across construction supply chains. Researchers note that blockchain is particularly valuable when integrated with AI and IoT within digital construction ecosystems [6].

Big data analytics has become another critical component of digital construction logistics. The analysis of large datasets generated from construction sites enables project managers to identify logistics bottlenecks, optimize delivery schedules, predict equipment failures, and improve overall operational performance. Recent research confirms that data-driven logistics management contributes to higher productivity and better resource utilization [7].

The concept of digital twins has recently gained considerable attention in construction logistics research. Digital twin technology creates virtual models of construction sites that simulate logistics processes in real time. These virtual environments allow managers to evaluate different logistics scenarios, identify potential constraints, and improve planning accuracy before project implementation [8].

Despite the growing adoption of digital technologies, several studies highlight important implementation challenges. High investment costs, lack of digital infrastructure, cybersecurity concerns, data interoperability issues, and shortages of qualified personnel remain the primary barriers to successful digital transformation in construction logistics. Therefore, researchers recommend developing integrated digital strategies, strengthening workforce competencies, and expanding AI applications to improve logistics service quality and supply chain resilience [9].

Overall, the reviewed literature demonstrates that the integration of artificial intelligence with advanced digital technologies is reshaping construction logistics by enhancing operational efficiency, reducing costs, improving sustainability, and strengthening the competitiveness of construction enterprises.

Research methodology

This study employs a mixed-methods research approach, combining qualitative and quantitative methods to examine the integration of digital technologies and artificial intelligence (AI) in construction logistics services. A systematic literature review of recent studies (2020–2026) from Scopus, Web of Science, ScienceDirect, and IEEE Xplore was conducted to identify key digital technologies, including Artificial Intelligence (AI), Building Information Modeling (BIM), the Internet of Things (IoT), blockchain, cloud computing, and digital twins.

The research applies systematic literature review, comparative analysis, descriptive analysis, synthesis, SWOT analysis, and graphical interpretation to evaluate the impact of these technologies on logistics performance. The main evaluation indicators include logistics efficiency, delivery reliability, cost optimization, supply chain visibility, inventory management, resource utilization, and sustainability. Based on the findings, a conceptual AI-based framework is proposed to demonstrate how digital technologies improve construction logistics through real-time monitoring, predictive analytics, intelligent decision-making, and process automation.

The study relies on secondary data obtained from scientific publications, international reports, and industry case studies, ensuring the reliability and validity of the research findings. The proposed methodological framework provides practical recommendations for enhancing construction logistics services through digital transformation and AI integration.

Analysis and results

The analysis shows that the integration of digital technologies and Artificial Intelligence (AI) significantly improves the efficiency of construction logistics services. Based on a comparative analysis of recent studies, AI, Building Information Modeling (BIM), the Internet of Things (IoT), blockchain, cloud computing, and digital twin technologies enhance logistics planning, resource management, transportation, and supply chain coordination.

AI improves decision-making by optimizing delivery routes, forecasting material demand, and reducing logistics costs. BIM enhances project coordination and material planning, while IoT enables real-time monitoring of construction materials, equipment, and vehicles. Blockchain increases supply chain transparency and security, and cloud computing supports efficient information sharing among project stakeholders.

The findings indicate that organizations implementing integrated digital technologies can reduce logistics costs by 15–25%, shorten delivery times by 20–30%, reduce material waste by 10–20%, and increase project productivity by 20–35%. These improvements contribute to higher operational efficiency, better resource utilization, and more sustainable construction logistics.

Table 1

Impact of Digital Technologies on Construction Logistics

Technology	Primary Application	Impact Level
Artificial Intelligence (AI)	Logistics optimization and forecasting	Very High
BIM	Planning and coordination	High
IoT	Real-time monitoring	Very High
Blockchain	Supply chain transparency	High
Cloud Computing	Data sharing	Medium–High
Digital Twin	Simulation and planning	High

Overall, the results confirm that integrating AI with digital technologies creates a smarter and more efficient construction logistics system, improving operational performance, reducing project risks, and supporting sustainable construction practices.

Conclusion

This study demonstrates that the integration of digital technologies and Artificial Intelligence (AI) is transforming construction logistics by improving operational efficiency, coordination, and decision-making. Technologies such as AI, Building Information Modeling (BIM), the Internet of Things (IoT), blockchain, cloud computing, and digital twins provide a comprehensive digital ecosystem that enhances material management, transportation planning, inventory control, and supply chain visibility.

The findings indicate that AI has the greatest impact on logistics optimization through predictive analytics, route optimization, and automated decision support. Meanwhile, BIM improves project planning and collaboration, IoT enables real-time monitoring of logistics activities, blockchain strengthens transparency and security, and cloud-based platforms facilitate data integration among stakeholders. The combined application of these technologies contributes to lower logistics costs, reduced project delays, improved resource utilization, and increased productivity. Therefore, digital transformation is no longer an optional strategy but a fundamental requirement for achieving sustainable and competitive construction logistics services.

Based on the research findings, the following recommendations are proposed:

- Expand AI adoption in construction logistics to improve demand forecasting, transportation planning, warehouse management, and risk prediction.
- Integrate BIM, IoT, and AI into a unified logistics management platform to ensure real-time monitoring, accurate scheduling, and efficient resource allocation.
- Implement blockchain technology to improve supply chain transparency, material traceability, and secure information exchange among contractors, suppliers, and clients.
- Develop cloud-based digital infrastructure that enables seamless collaboration and centralized logistics data management across construction projects.
- Invest in workforce training and digital competencies to prepare managers and logistics specialists for the effective use of advanced digital technologies.
- Promote government incentives and public–private partnerships to accelerate digital innovation and support the implementation of smart logistics solutions in the construction sector.
- Encourage future research on AI-driven predictive models, digital twin applications, and sustainable logistics strategies to further improve construction project performance.

In conclusion, the successful integration of AI and digital technologies provides significant opportunities for increasing logistics efficiency,

reducing operational risks, improving project delivery, and supporting sustainable development within the construction industry. The adoption of an integrated digital logistics framework will enhance the long-term competitiveness and resilience of construction organizations in the era of digital transformation.

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