International Journal of Innovations & Research Analysis (IJIRA)
ISSN :2583-0295(Online), Impact Factor: 7.662, Volume 05, No. 04(I), October- December, 2025, pp 82-88

Technological Impact on Construction Supply Chains: Computing, Digitalising, and Integrating in Industry 4.0

Pawani Reddy[1*] | Dr. A. K. Chaturvedi[2] | Dr. Sanjeev Mishra[3]

[1]Research Scholar, Rajasthan Technical University, Kota, Rajasthan, India.
[2,3]Department of Mechanical Engineering, Rajasthan Technical University, Kota, Rajasthan, India.

[*]Corresponding Author: reyya.pawani@gmail.com

Citation: Reddy, P, Chaturvedi, A.K. & Mishra, S. (2025). Technological Impact on Construction Supply Chains: Computing, Digitalising, and Integrating in Industry 4.0. International Journal of Innovations & Research Analysis, 05(04(I)), 82–88.

ABSTRACT

The construction industry is rapidly changing due to Industry 4.0, with new technologies impacting supply chain management. However, the specific effects of computing, digitalising, and integrating tools on construction supply chain performance are not yet clear. This study explores how these technologies interact using survey data from construction professionals and path analysis. The findings show that computing technologies significantly improve performance areas like cost efficiency, flexibility, and reliability. Integrating technologies, which include IoT, RFID, and machine-to-machine communication, also have positive impacts on responsiveness and coordination. In contrast, digitalising technologies, such as augmented and virtual reality, and mobile applications, show limited effects because of issues with compatibility and implementation. These results underline the need to focus on well-developed and strategically relevant technologies to see real improvements. This study contributes to both theory and practice by clarifying how Industry 4.0 tools affect performance and providing guidance for construction firms responding to digital transformation.

***Keywords**: Industry 4.0, Construction Supply Chain, Computing Technologies, Digitalising Technologies, Integrating Technologies, Supply Chain Performance.*

Introduction

The construction sector, historically marked by manual processes and disjointed coordination, is now being transformed by Industry 4.0 technologies. The use of digital tools like the Internet of Things (IoT), artificial intelligence (AI), digital twins, and blockchain allows for real-time data sharing, predictive analytics, and better material tracking. These advancements streamline procurement, improve inventory management, and enhance collaboration among stakeholders, ultimately leading to better efficiency, transparency, and project results. [1,2,3]

Despite the growing interest in these technologies, their impact on construction supply chains (CSCs) is not well understood. Most studies focus on single technologies or theoretical models, and they provide limited real-world evidence on how different types of Industry 4.0 tools affect supply chain performance. There is particularly little clarity on how computing technologies (e.g., AI, big data, cloud computing), digitalising technologies (e.g., simulation, AR and VR, smart sensors), and integrating technologies (e.g., IoT, robotics, machine-to-machine communication) interact. This gap hinders both academic research and practical decision-making regarding technology adoption in CSCs.[4,5,6]

This study addresses this gap by examining the different effects of computing, digitalising, and integrating technologies on supply chain performance in construction. Using survey data from industry professionals and path analysis, we assess their impact on key performance areas, including cost efficiency, quality, flexibility, responsiveness, and reliability.

The contribution of this paper is threefold. First, it offers systematic evidence on how various Industry 4.0 technologies influence CSC performance. Second, it differentiates between established technologies with proven advantages and newer tools that currently have limited effectiveness. Third, it provides practical advice for firms looking to align their digital transformation strategies with their supply chain goals. Together, these insights enhance theoretical understanding and offer useful guidance for the construction industry in the Industry 4.0 era.

Literature Review

Construction supply chains reveal that the sector is marked by complexity, fragmentation, and a temporary project-based structure, distinguishing it from other industries. Recent literature systematically maps stakeholder roles and supply chain configurations, emphasising the importance of tailored coordination mechanisms and long-term collaborative relationships to improve efficiency and project outcomes. Studies highlight that while information technology, information sharing, collaboration, and performance measurement have received significant attention, there are notable research gaps in financial management, supply chain resilience, logistics, and vendor-managed inventory. These findings underscore the need for further investigation and the development of innovative frameworks to address persistent challenges and enhance the effectiveness of construction supply chain management, sparking curiosity and interest in the respondents for the potential of future research.[7,8,9]

- **Computing Technologies**

Computing technologies in construction supply chains demonstrate that tools such as cloud computing (CC), big data analytics (BDA), artificial intelligence (AI), business intelligence (BI), and enterprise resource planning (ERP) systems are pivotal in enhancing integration, efficiency, and decision-making across the sector. Cloud computing enables real-time data access and collaboration among geographically dispersed stakeholders, while big data analytics and AI facilitate predictive insights, risk assessment, and optimisation of project delivery. Business intelligence tools support the visualisation and interpretation of complex supply chain data, aiding strategic planning, and ERP systems integrate diverse business functions, improving resource allocation and operational transparency. However, implementing these technologies is often challenged by fragmented project structures, interoperability issues, and the need for substantial IT infrastructure investment. Despite these barriers, evidence suggests that when effectively adopted, these computing technologies significantly improve coordination, productivity, and overall supply chain performance in construction [10,11.12].

- **Digitalising Technologies**

Digitalising technologies in construction supply chains demonstrate that innovations such as simulation technology, 3d printing, virtual reality (VR), augmented reality (AR), smart sensors, and radio frequency identification (RFID) are reshaping how physical processes and data are converted into digital form and how stakeholders interact with digital environments. These technologies collectively enhance traceability, real-time information flow, and process efficiency, addressing long-standing industry challenges like fragmentation and lack of transparency. For instance, simulation and VR/AR facilitate advanced planning, visualisation, and stakeholder collaboration, while smart sensors and RFID improve material tracking and supply chain visibility. Despite their transformative potential, the literature notes a gap between theoretical frameworks, practical implementation, and persistent barriers such as integration complexity and insufficient digital infrastructure. Nonetheless, adopting these digitalising technologies is pivotal for advancing Supply Chain 4.0 in construction, driving greater flexibility, productivity, and cost reduction across the sector [13,14,15].

- **Integrating Technologies**

Integrating technologies in construction supply chains highlights the transformative role of Internet of Things (Iot), machine-to-machine (M2M) communication, robotics technology, blockchain, and autonomous vehicles in enabling connectivity, interoperability, and automated communication across systems and platforms. Iot strategies, for example, are increasingly incorporated to enhance real-time monitoring, traceability, and efficiency in construction supply chain networks, facilitating data-driven decision-making and process automation. Integrated supply chain platforms—often leveraging these

technologies—significantly impact project management by improving stakeholder coordination and real-time project tracking, particularly in risk, time, and cost management. Adopting such technologies not only streamlines procurement and logistics but also addresses traditional challenges like fragmentation and lack of transparency, ultimately supporting the digital transformation and resilience of construction supply chains.[16]

The prevailing literature on construction supply chains (CSCs) has mainly focused on traditional management practices, with a limited emphasis on the transformative potential of Industry 4.0 technologies. While recent studies have begun to explore the impact of digitalisation on CSC performance, a significant research gap remains in understanding the triadic interplay between computing, digitalisation, and integrating tools in Industry 4.0. Specifically, there is a paucity of research examining how the convergence of advanced computing capabilities, digital technologies (e.g., Building Information Modelling, BIM), and integrative platforms (e.g., Internet of Things, Iot) can enhance CSC performance. Furthermore, the current body of knowledge lacks a comprehensive framework for assessing the technological impact on CSCs, neglecting the interdependencies between technological, organisational, and environmental factors. This study aims to address this research gap by investigating the technological impact on CSC performance through a triadic perspective of computing, digitalising, and integrating tools in Industry 4.0, thereby providing a nuanced understanding of the complex relationships between technology, CSCs, and Industry 4.0. The proposed research model is presented in Figure 1.

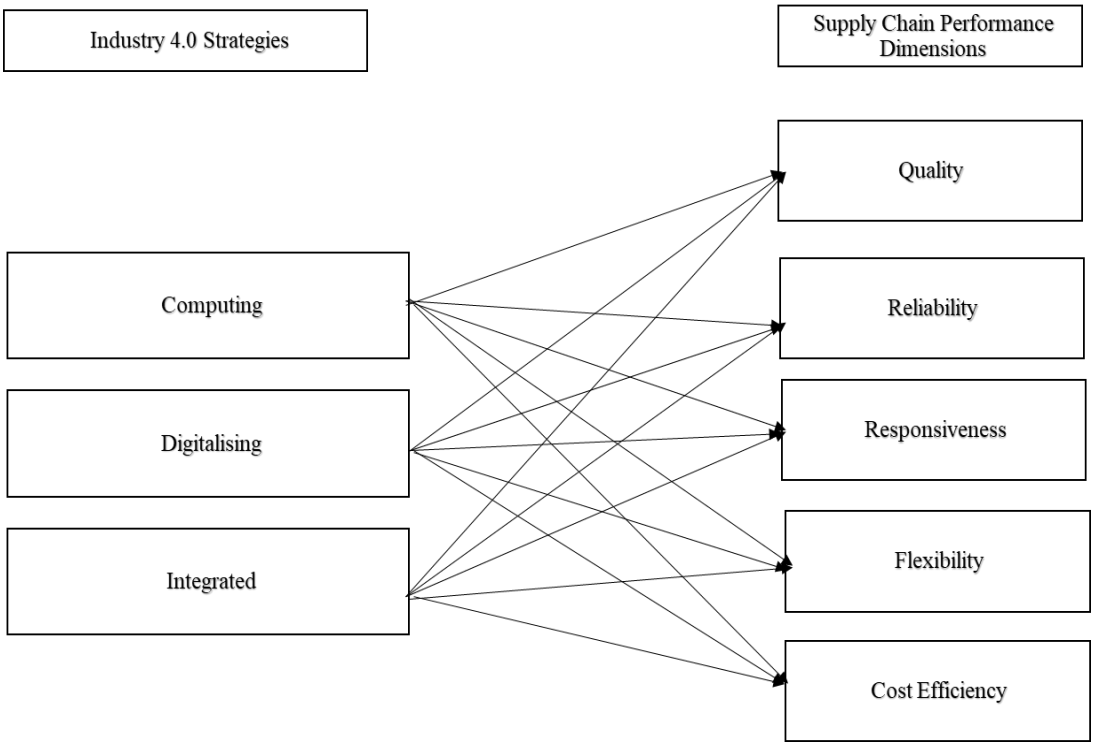

Figure 1: The proposed research model.

Methodology

To explore how different Industry 4.0 technologies influence construction supply chain performance (SCP), this study adopted a quantitative research approach supported by path analysis. A structured questionnaire was designed and distributed to professionals working in the construction sector. Out of 150 responses received, 89 were found to be complete and valid after careful data cleaning. The performance-related variables used to assess SCP were adapted from two previous studies—one focusing on agribusiness supply chain practices in Australia [17], and another examining the impact of electronic banking on supply chain management among small and medium enterprises [18].

For the Industry 4.0 component, three core technological constructs—computing, integrating, and digitalising—were drawn from the framework proposed by Huang et al. (2023)[19], which links these technologies to supply chain capabilities and resilience. The collected data was analysed using Jamovi, an open-source statistical software platform, which enabled the examination of the relationships between technological adoption and key supply chain performance outcomes. This method provided clear insights into which technology categories are currently making the most measurable impact on construction supply chains and highlighted areas where adoption remains limited.

Results and Discussion

- **Demographic Profile**

The majority profile of the respondents in this study reveals important characteristics that shape the overall perspective on the adoption of digital technologies in the construction supply chain. A dominant share of the participants (60.7%) falls within the age group of 31 to 50 years, indicating that mid-career professionals represent the core of the sample. This age group typically combines experience with an active role in operational and strategic decision-making. Their presence suggests that the study reflects views from individuals who are knowledgeable about traditional supply chain practices and responsible for integrating modern technologies into existing systems. This group will likely face the challenges of adapting to new technological environments and can offer insights into practical implementation and organisational readiness. In terms of education, the majority of respondents (55.1%) hold a master's degree. This level of academic attainment indicates a workforce that is generally well-informed and capable of understanding and managing the complexities associated with Industry 4.0 technologies. Higher education can contribute to better decision-making, openness to innovation, and a greater ability to evaluate the strategic benefits of digital transformation initiatives. Regarding income, a significant portion (40.9%) of the respondents earn more than ₹50,000 per month, suggesting that many participants will likely be in mid to senior-level positions within their organisations. These roles often come with the authority to influence or make investment decisions, particularly concerning adopting new technologies. Higher income levels may also correlate with higher expectations regarding technology performance and return on investment, providing a more critical lens through which digital transformation is assessed.

Work experience also shows a concentration at the early to mid-career level, with 60.7% of respondents having five or fewer years of professional experience. This could reflect a workforce that is still adapting to the demands of an evolving industry, balancing traditional methods with the need to embrace digital tools. While they may not have decades of experience, their exposure to digital platforms from their careers might make them more open to learning and adapting, which is vital for successful technology integration. Functionally, most respondents belong to the supply chain (33.7%) and operations (20.2%) departments. These two areas are at the heart of technological transformation in construction, as they directly involve material flow, logistics, scheduling, and real-time decision-making. Their strong representation ensures that the findings are highly relevant to core functions where Industry 4.0 tools such as Iot, automation, and data analytics are most applicable. Lastly, the employment sector of the majority of respondents, 82%, is the private sector. This suggests that the data reflects perspectives from organisations that are typically more dynamic, competitive, and faster in adopting new technologies than their public sector counterparts. Private sector organisations often prioritise efficiency, cost-effectiveness, and innovation to maintain a competitive edge, making them more receptive to digital solutions. Most characteristics indicate a professionally active, well-educated, and strategically positioned sample to provide meaningful insights into adopting and integrating digital technologies in the construction supply chain.

- **.Impact of Technologies on Construction Supply Chain Performance**

The Goodness-of-Fit Index (GFI) is one of the earliest and most commonly reported fit indices in structural equation modelling. Conceptually, GFI reflects the proportion of variance and covariance in the observed data jointly explained by the model. It is analogous to R^2 in regression and ranges from 0 to 1, with higher values indicating better model fit.In this study, the GFI value is 0.978, which exceeds the commonly accepted threshold of 0.90 for adequate fit and even approaches 0.95, considered an indicator of excellent fit [20]. This suggests that the model adequately reproduces the observed covariance matrix, which captures many relationships among the variables under study.

Table 2: Parameter Estimates and Confidence Intervals for the Impact of Technologies on Construction Supply Chain Performance

Path			b	SE	LL	UL	β	p	Results
Computing	→	Quality	0.612	0.226	0.170	1.055	0.351	0.007	S
Computing	→	Reliability	0.729	0.224	0.290	1.168	0.420	0.001	S
Computing	→	Responsiveness	0.787	0.214	0.368	1.205	0.458	<.001	S
Computing	→	Flexibility	0.719	0.216	0.296	1.142	0.441	<.001	S
Computing	→	Cost Efficiency	0.836	0.221	0.402	1.269	0.486	<.001	S
Digitalising	→	Quality	-0.141	0.192	-0.518	0.236	-0.123	0.462	NS
Digitalising	→	Reliability	-0.180	0.191	-0.555	0.194	-0.159	0.345	NS
Digitalising	→	Responsiveness	-0.344	0.182	-0.701	0.012	-0.306	0.058	M
Digitalising	→	Flexibility	-0.189	0.184	-0.550	0.171	-0.177	0.303	NS
Digitalising	→	Cost Efficiency	-0.236	0.188	-0.605	0.134	-0.209	0.211	NS
Integrated	→	Quality	0.451	0.159	0.139	0.763	0.373	0.005	S
Integrated	→	Reliability	0.472	0.158	0.163	0.782	0.393	0.003	S
Integrated	→	Responsiveness	0.551	0.151	0.255	0.846	0.463	<.001	S
Integrated	→	Flexibility	0.418	0.152	0.120	0.717	0.371	0.006	S
Integrated	→	Cost Efficiency	0.467	0.156	0.161	0.772	0.392	0.003	S

b - unstandardised, β- standardised, Confidence Level- LowerLevel, Upper Level, p- significance value, S- supported, NS- not supported, M -marginal,

Computing technologies are all significantly positive with a consistent statistical impact on all dimensions of the construction supply chain performance, with the highest being on quality (β = 0.351, p < 0.001). 007), and reliability (β = 0.420, p = . 001), efficiency (β = 0..xrTableCell14, p <. 001), flexibility (β = 0.441, p <. 001), and cost-effectiveness (β = 0.486, p <. 001). These results indicate that digital transformation has positive performance implications, facilitating data-driven decision-making, communication, and operational accuracy. Similarly, **integrating technologies** such as IoT, RFID, and M2M communication were also showed a significant positive effect on all performance metrics: quality (β = 0.373, *p* = .005), reliability (β = 0.393, *p* = .003), responsiveness (β = 0.463, *p*< .001), flexibility (β = 0.371, *p* = .006), and cost efficiency (β = 0.392, *p* = .003). These technologies encourage synchronisation and prominence across supply chain processes.

Conversely, **digitalising technologies**—such as augmented reality, virtual reality, mobile applications, and wearable devices—did not exhibit significant positive effects. The paths to quality (β = –0.123, *p* = .462), reliability (β = –0.159, *p* = .345), flexibility (β = –0.177, *p* = .303), and cost efficiency (β = –0.209, *p* = .211) were not statistically significant, and even the path to responsiveness was only marginally significant (β = –0.306, *p* = .058). These results suggest that although digitalising technologies offer novel interfaces and visualisation capabilities, their practical integration into the supply chain may still be limited due to technical complexity, implementation costs, or a lack of interoperability with core systems. As such, while digitalising technologies hold promise, their current influence appears limited compared to the more mature computing and integrating technologies. These insights highlight the importance of adopting new tools and ensuring strategic integration and organisational readiness to fully realise their potential in enhancing supply chain performance in Industry 4.0.

Conclusion

This study underscores the critical role of computing and integrating technologies in enhancing the overall performance of construction supply chains within the context of Industry 4.0. Computing technologies demonstrated the highest impact on key dimensions such as cost-effectiveness, flexibility, and reliability, while integrating technologies like Iot, RFID, and M2M communication also yielded significantly positive results across performance metrics. Conversely, despite their innovative interfaces and immersive potential, digitalising technologies did not show statistically significant impacts, pointing to limitations in practical integration. These findings emphasise the necessity of aligning technological adoption with strategic goals and organisational capabilities to maximise value creation.

The results offer valuable insights for construction industry stakeholders seeking to enhance supply chain performance through digital transformation. Practitioners should prioritise investment in computing and integrating technologies that directly support data-driven operations, real-time communication, and supply chain synchronisation. In contrast, while digitalising technologies may offer

long-term benefits, their current deployment should be approached cautiously, ensuring proper alignment with organisational needs and infrastructure readiness. A phased implementation strategy, accompanied by training and change management, may improve the integration of such tools in the future.

Future research should explore the contextual and organisational factors influencing the successful adoption of digitalising technologies in construction supply chains. Longitudinal studies could assess the evolving impact of these tools over time as they mature and become more interoperable. Moreover, mixed-method studies incorporating qualitative insights could shed light on the barriers to adoption and the specific use cases where digitalising technologies may offer the greatest value. Comparative studies across regions or construction sectors could also enrich understanding of digital transformation dynamics in diverse settings.

References

1. Fletcher, C. (2024). Technology trends in construction supply chain management: 2024 innovations. Building Radar. https://www.buildingradar.com/construction-blog/technology-trends-in-construction-supply-chain-management-2024-innovations.
2. Jabban, B. (2024). The digital supply chain in construction: Why it matters. Construct360. https://www.construct360.net/blog/how-the-digital-supply-chain-can-transform-construction
3. Supply Chain IT. (2024). How emerging technologies are improving construction supply chains. Supply Chain IT. https://www.supplychainit.com/how-emerging-technologies-are-improving-construction-supply-chains/
4. Patrucco, A., Ciccullo, F., & Pero, M. (2020). Industry 4.0 and supply chain process re-engineering: A coproduction study of materials management in construction. Business Process Management Journal, 26(5), 1093-1119. https://doi.org/10.1108/BPMJ-04-2019-0147
5. Rad, F. F., Oghazi, P., Palmié, M., Chirumalla, K., Pashkevich, N., Patel, P. C., & Sattari, S. (2022). Industry 4.0 and supply chain performance: A systematic literature review of the benefits, challenges, and critical success factors of 11 core technologies. *Industrial Marketing Management*, *105*, 268-293.
6. Lv, Y., & Shang, Y. (2023). Investigation of Industry 4.0 technologies mediating effect on the supply chain performance and management practices. *Environmental Science and Pollution Research*, *30*(48), 106129–106144.
7. Singh, N., Ashish, D.K. & Dixit, A. (2024). "Construction supply chain: a systematic literature review with bibliometric analysis", Journal of Global Operations and Strategic Sourcing, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/JGOSS-04-2023-0032
8. Studer, W. P., & De Brito Mello, L. C. B. (2021). Core elements underlying supply chain management in the construction industry: A systematic literature review. Buildings, 11(12), 569. https://doi.org/10.3390/buildings11120569
9. Politesi. (2023). The construction supply chain: a systematic literature review on configuration, coordination and collaboration. Politecnico di Milano. https://www.politesi.polimi.it/handle/10589/208963
10. Deraman, R., Salleh, H., Beksin, A. M., Alashwal, A. M., Abdullahi, B. C., & Abdullah, A. A. (2011). The roles of information and communication technology (ICT) systems in construction supply chain management and barriers to their implementation. African Journal of Business Management, 5(15), 2402-2412. http://www.academicjournals.org/AJBM
11. Vignesh, S., & Prabakaran, P. A. (2024). Optimising supply chain management operations in construction: A systematic review of SCM trends, challenges, and innovations. International Journal of Research Publication and Reviews, 5(2), 2892-2897. https://ijrpr.com/uploads/V5ISSUE2/IJRPR22893.pdf
12. Al-Talib, M., Al-Saad, W., Alzoubi, A. and Anosike, A.I. (2024). A systematic review of the literature on the use of information technologies in supply chain management. International Journal of Industrial Engineering and Operations Management, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/IJIEOM-09-2023-0073

13. Gharaibeh, L., Eriksson, K. M., Lantz, B., Matarneh, S., &Elghaish, F. (2024). Toward digital construction supply chain-based Industry 4.0 solutions: scientometric-thematic analysis. Smart and Sustainable Built Environment, 13(1), 42-62. https://doi.org/10.1108/SASBE-12-2021-0224

14. Zenezini, G., Mangano, G., & Castelblanco, G. (2024). Impact of Integrated Supply Chain Platforms on Construction Project Management. Proceedings of ISARC 2024. https://www.iaarc.org/publications/fulltext/049_ISARC_2024_Paper_331.pdf

15. Kwok, T. W., & Chang, S. (2024). Comprehensive evaluation of digital technology's effects on the supply chain of prefabricated construction. *Engineering, Construction and Architectural Management*.

16. Mohammed, L. A. O. (2024). Improving the Supply Chain of Building Materials. Politecnico di Torino. https://webthesis.biblio.polito.it/30702/1/tesi.pdf

17. Peterson, H. C., Wysocki, A. F., & Harsh, S. B. (2010). Linking supply chain practices to competitive advantage: An example from Australian agribusiness. *British Food Journal, 112*(2), 107–123. https://doi.org/10.1108/BFJ-10-2010-0181

18. Hamidianpour, F., Esmaeilpour, M., &Daryanavard, A. (2016). The effect of electronic banking on the supply chain management performance of small and medium businesses. *Modern Applied Science, 10*(11), 19–29. https://doi.org/10.5539/mas.v10n11p19

19. Huang, K., Wang, K., Lee, P. K. C., & Yeung, A. C. L. (2023). The impact of Industry 4.0 on supply chain capability and supply chain resilience: A dynamic resource-based view. *International Journal of Production Economics, 259*, 108913. https://doi.org/10.1016/j.ijpe.2023.108913

20. Daire Hooper, Joseph Coughlan, and Michael R. Mullen(2008). Structural Equation Modelling: Guidelines for Determining Model Fit. Academic Conferences International Limited, Vol. 6 No. 1.

❑❑❑