Transforming Construction with Off-site Methods and Technologies - TCOT 2026 Conference

August 18-20, 2026, Newcastle upon Tyne, UK

BLOCKCHAIN ADOPTION IN AI-ENABLED QUANTITY SURVEYING: TRANSFORMING CONSTRUCTION COST MANAGEMENT

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Abstract: The construction industry continues to experience persistent challenges in cost management due to fragmented information systems, manual documentation processes, and limited transparency in financial transactions. Within this context, Quantity Surveying (QS) practice remains heavily dependent on document-driven workflows such as spreadsheets, emails, and isolated cost management systems. These practices often lead to data inconsistencies, delayed valuations, disputes over measurements and variations, and reduced trust among project stakeholders. Despite the growing adoption of digital technologies such as Building Information Modelling (BIM) and cloud collaboration platforms, issues of data integrity, traceability, and secure automation remain inadequately addressed. This study aims to investigate how blockchain technology can be adopted within AI-enabled Quantity Surveying services to enhance transparency, improve cost-management efficiency, and support secure automation of financial processes in construction projects. The research adopts a systematic literature review methodology, analysing recent studies on blockchain, artificial intelligence, and digital transformation in construction cost management. The collected literature is examined through thematic analysis to identify key technological capabilities, adoption challenges, and integration mechanisms. The study proposes a conceptual adoption framework that integrates blockchain-based distributed ledgers, smart contracts, and AI-driven analytics to support transparent cost verification, automated valuation processes, and tamper-proof financial records. The findings highlight the potential of blockchain-enabled QS services to enhance trust, accountability, and efficiency across construction cost management workflows. However, challenges relating to data governance, interoperability, regulatory acceptance, and organisational readiness remain key limitations for large-scale implementation.

Keywords: Blockchain technology; Artificial intelligence; Quantity surveying; Construction cost management; Digital transformation

1 INTRODUCTION

The construction industry remains one of the most information-intensive sectors, characterised by complex financial transactions, multi-stakeholder involvement, and extensive documentation requirements. Within this context, Quantity Surveying (QS) plays a critical role in construction cost management through functions such as cost planning, preparation of bills of quantities, tender analysis, contract administration,

interim valuations, variation assessments, and final account settlement. Despite the increasing adoption of digital technologies, many QS processes continue to rely on fragmented, document-driven workflows involving spreadsheets, emails, PDFs, and isolated cost-management systems. These fragmented processes often result in duplicated data, delays in cost verification, limited traceability of financial records, and increased susceptibility to human error or manipulation. Consequently, such inefficiencies frequently lead to disputes over valuations, variations, and payment certifications, thereby reducing trust among project stakeholders. The ongoing digital transformation of the construction industry has introduced several technological innovations, including Building Information Modelling (BIM), e-tendering systems, and cloud-based collaboration platforms. While these tools have improved efficiency and data accessibility, they have not fully addressed critical challenges related to data integrity, auditability, and secure automation of cost management processes (Ebert and Duarte, 2018; Kraus et al., 2021). In many cases, digital systems remain siloed, rely on centralised databases, and still require manual verification procedures, limiting their effectiveness in ensuring transparency and trust across project stakeholders (Le Jeune et al., 2023). As a result, key QS activities such as interim valuations, variation approvals, and payment certifications remain prone to delays, inconsistencies, and subjective interpretation (Awodele et al., 2025).

Blockchain technology has emerged as a promising solution to these challenges due to its decentralised, immutable, and transparent data structure(Eze and Ameyaw, 2025). By enabling tamper-proof record-keeping and verifiable audit trails, blockchain can enhance transparency and accountability in construction financial transactions (Celik et al., 2024; Cheng et al., 2023). Furthermore, the integration of smart contracts allows for the automation of contractual processes, such as payment releases and valuation approvals, based on predefined conditions, thereby reducing administrative delays and disputes (Hewavitharana et al., 2024). In parallel, artificial intelligence (AI) technologies are increasingly being applied in the construction industry to support automated quantity take-offs, predictive cost estimation, anomaly detection, and data-driven decision-making (Egwim et al., 2024). The convergence of blockchain and AI technologies presents a significant opportunity to transform QS workflows into more intelligent, transparent, and automated systems. Blockchain provides a secure and trustworthy data infrastructure, while AI enhances analytical and predictive capabilities within cost management processes. However, despite the growing interest in digital transformation within the construction sector, the integration of blockchain within AI-enabled QS services remains underexplored. Existing studies largely focus on blockchain applications in supply chain management and payment systems, with limited attention to QS-specific cost management workflows (Xu et al., 2023; Singh, 2023). Therefore, a critical gap exists in understanding how blockchain technology can be systematically adopted within AI-enabled Quantity Surveying services to enhance transparency, improve efficiency, and enable secure automation of construction cost management processes. Addressing this gap is essential for advancing digital transformation in QS practice and improving trust, accountability, and performance across the construction project lifecycle. The relevance of blockchain and AI integration is particularly significant in off-site and industrialised construction environments, where prefabrication, distributed supply chains, modular coordination, and real-time cost verification require transparent and digitally integrated financial management systems.

Aim and Objectives

The aim of this study is to investigate how blockchain technology can be effectively adopted within AI-enabled Quantity Surveying (QS) services to enhance transparency, enable secure automation, and improve the efficiency of construction cost management processes. To achieve this aim, the study is guided by the following objectives: To examine the challenges and limitations associated with traditional and existing digital Quantity Surveying workflows in construction cost management, particularly in relation to data fragmentation, lack of transparency, and reliance on manual processes. To analyse the potential of blockchain and artificial intelligence technologies in enhancing transparency, trust, data integrity, and automation within QS cost management processes. To develop a conceptual framework for the adoption of blockchain technology within AI-enabled Quantity Surveying services, aimed at improving cost verification, valuation processes, and financial governance in construction projects.

2 LITERATURE REVIEW

2.1 Challenges and Limitations of Traditional and Digital QS Workflows

Quantity Surveying (QS) practice has traditionally relied on document-intensive and manually coordinated workflows for managing construction costs. These processes typically involve the use of spreadsheets, emails, PDF documents, and standalone cost-management systems, which often operate in isolation. Such fragmentation leads to duplicated data, inconsistencies in cost records, delays in verification processes, and limited traceability of financial transactions. As construction projects become increasingly complex and involve multiple stakeholders, these inefficiencies contribute significantly to disputes, reduced transparency, and diminished trust among project participants. Although the construction industry has experienced notable digital transformation through the adoption of technologies such as Building Information Modelling (BIM), cloud-based collaboration platforms, and e-tendering systems, these tools have not fully resolved core issues relating to data integrity and process automation. Existing digital systems are often built on centralised architectures, making them vulnerable to data manipulation, unauthorised modifications, and single points of failure. Furthermore, many of these systems still depend on manual validation and reconciliation processes, limiting their ability to provide real-time, verifiable, and tamper-proof cost information (Ebert and Duarte, 2018; Kraus et al., 2021). Recent studies highlight that even digitally enabled construction workflows continue to face challenges related to trust, coordination, and data security. For instance, Hewavitharana et al. (2024) emphasise that current digital systems in construction are still prone to coordination inefficiencies and lack robust mechanisms for ensuring secure and transparent data exchange. Similarly, the persistence of siloed systems and inadequate interoperability across digital platforms further constrains the effectiveness of modern QS practices (Le Jeune et al., 2023). Consequently, both traditional and digital QS workflows continue to exhibit critical limitations, including lack of transparency, limited auditability, and dependence on manual processes.

2.2 Potential of Blockchain and AI in Enhancing QS Cost Management

Blockchain technology has gained increasing attention as a transformative solution capable of addressing many of the limitations inherent in conventional QS workflows. As a decentralised and immutable distributed ledger, blockchain enables secure, transparent, and verifiable record-keeping across multiple stakeholders without the need for a central controlling authority. Key features such as immutability, traceability, and decentralisation make blockchain particularly suitable for managing construction financial transactions and contractual processes. A growing body of literature demonstrates the applicability of blockchain in construction cost management. For example, Celik et al. (2024) identify transparency, security, and traceability as core advantages of blockchain in construction applications, including contract administration, procurement, and payment systems. Similarly, Cheng et al. (2023) propose a blockchain-based framework that enhances data integrity while preserving confidentiality through encryption mechanisms, thereby enabling secure and auditable cost information management. In addition to improving data integrity, blockchain facilitates the automation of QS processes through smart contracts. These programmable contracts can execute predefined actions, such as payment releases, valuation approvals, and contract compliance checks, once specified conditions are met. This reduces reliance on manual verification, minimises delays, and mitigates disputes among stakeholders (Hewavitharana et al., 2024).

Artificial intelligence (AI) further complements blockchain by introducing advanced analytical and predictive capabilities into construction cost management. AI technologies, including machine learning, natural language processing, and computer vision, are increasingly applied across the construction lifecycle to support automated quantity take-offs, cost estimation, anomaly detection, and decision-making processes. A comprehensive review by Egwim et al. (2024) highlight the growing adoption of AI in improving efficiency, accuracy, and data-driven decision-making across construction activities. The integration of blockchain and AI represents a paradigm shift towards intelligent and secure construction management systems. While blockchain ensures the integrity and trustworthiness of data, AI enables intelligent processing and interpretation of that data. Recent research suggests that the convergence of these technologies, often alongside cloud computing, forms the foundation of secure and scalable digital ecosystems capable of transforming engineering and construction practices (Singh, 2025). This synergy has significant

implications for QS workflows, enabling automated, transparent, and data-driven cost management processes.

2.3 Towards a Framework for Blockchain Adoption in AI-Enabled QS

Despite the recognised potential of blockchain and AI technologies, their integration into QS workflows remains at an early stage of development. Existing studies largely focus on isolated applications of blockchain in construction supply chains or payment systems, with limited emphasis on QS-specific cost management processes. This highlights the need for a structured approach to guide the adoption of these technologies within QS practice. The literature identifies several critical components required for an effective blockchain-based QS framework. First, a secure data architecture is essential, typically involving permissioned blockchain systems that enable controlled access to sensitive financial data while maintaining transparency and traceability (Cheng et al., 2023). Second, smart contract mechanisms are necessary to automate core QS processes such as valuations, variation approvals, and payment certifications, thereby reducing manual intervention and improving efficiency. Third, the integration of AI tools is crucial for enabling intelligent cost management functions, including automated quantity extraction, predictive cost estimation, and anomaly detection. The ability of AI to process large datasets and generate actionable insights enhances decision-making and risk management within construction projects (Egwim et al., 2024).

Furthermore, interoperability between blockchain platforms, AI systems, and existing construction technologies such as BIM is essential for seamless data exchange and system integration. This requires the use of standardised data protocols and application programming interfaces (APIs) to ensure consistency and compatibility across platforms. Finally, governance mechanisms, including access control, data ownership, and dispute resolution protocols, are critical for ensuring trust and accountability among stakeholders (Xu et al., 2023; Zhou, 2024). However, several challenges must be considered in developing such frameworks. These include issues related to data quality, interoperability, regulatory uncertainty, and organisational resistance to technological change. Additionally, the legal recognition of blockchain-based records and smart contracts remains an evolving area in many jurisdictions, posing potential barriers to widespread adoption.

3. RESEARCH METHODOLOGY

This study adopts a qualitative research approach based on a systematic literature review (SLR) to investigate the adoption of blockchain technology within AI-enabled Quantity Surveying (QS) services for construction cost management. The choice of a systematic review is appropriate given the emerging nature of blockchain and artificial intelligence applications in construction, where existing knowledge is dispersed across multiple domains and requires structured synthesis. The systematic literature review was conducted following a transparent and replicable process involving literature identification, screening, selection, and synthesis. Relevant academic publications were sourced from major scholarly databases, including Scopus, Web of Science, ScienceDirect, and Google Scholar, to ensure comprehensive coverage of peer-reviewed research. The search strategy focused on combinations of keywords such as “blockchain in construction,” “artificial intelligence in construction,” “quantity surveying digital transformation,” “construction cost management,” and “smart contracts in construction.” To ensure the quality and relevance of the reviewed studies, specific inclusion and exclusion criteria were applied. Only peer-reviewed journal articles, conference papers, and high-quality review studies were considered. Publications were selected based on their relevance to blockchain applications, AI integration, and construction cost management processes. Studies that did not directly contribute to understanding digital transformation in QS practice or lacked methodological rigor were excluded. Figure 1 presents the simplified PRISMA-based literature screening and selection process adopted for the review.

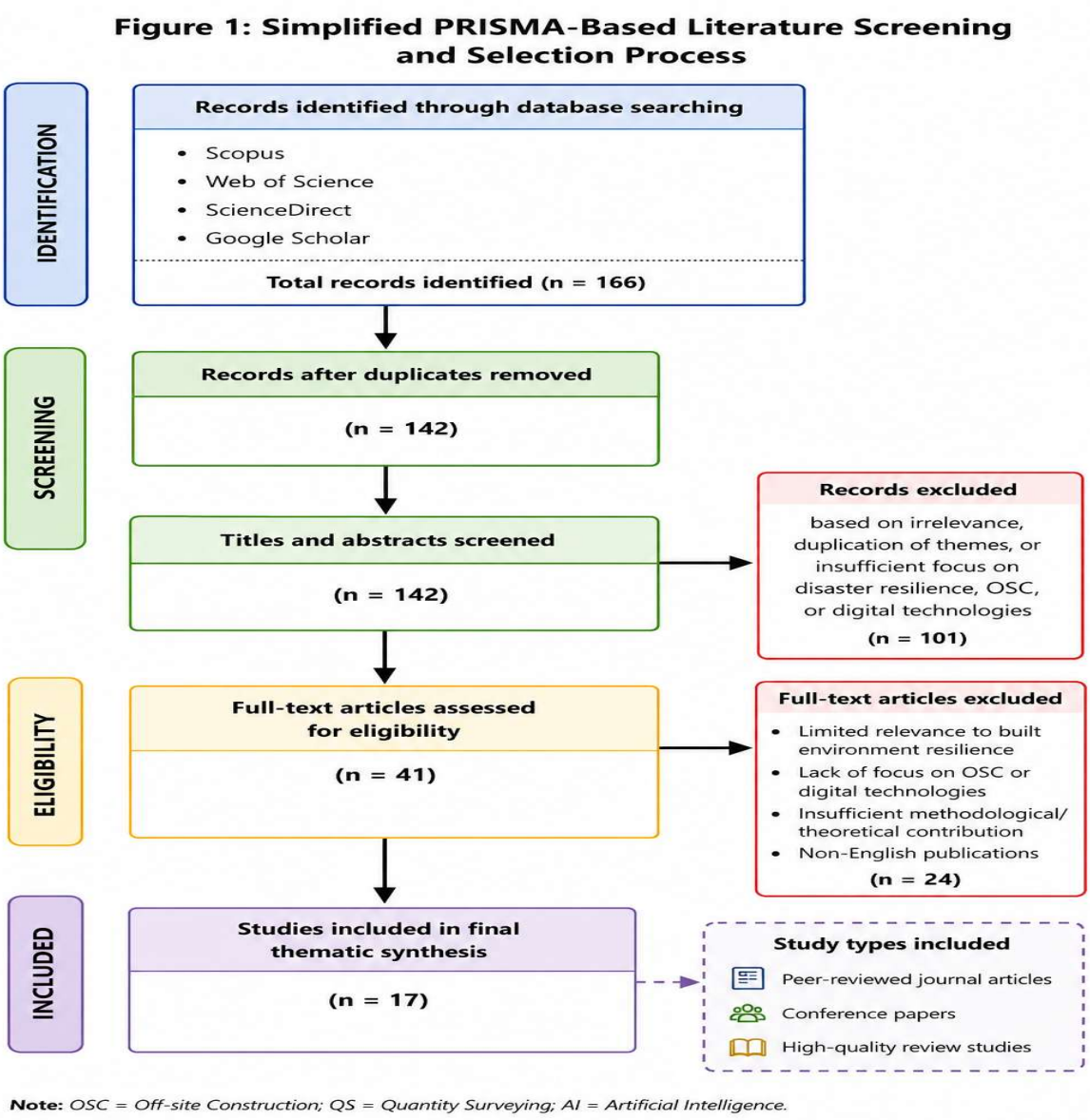

Figure 1 presents the simplified PRISMA-based literature screening and selection process adopted for the review.

Following the selection process, the identified literature was analysed using thematic analysis, which enabled the identification of recurring patterns, concepts, and relationships across the studies. The analysis focused on four key thematic areas aligned with the research objectives: Limitations of existing QS workflows, including issues related to data fragmentation, lack of transparency, and reliance on manual processes. Capabilities of blockchain technology, particularly decentralisation, immutability, traceability, and smart contract automation. Applications of artificial intelligence in construction, including automated quantity take-offs, predictive cost estimation, anomaly detection, and decision-support systems. Integration mechanisms for blockchain and AI, focusing on how these technologies can be combined within construction information systems to improve cost management processes. The insights derived from this thematic analysis formed the basis for developing a conceptual framework for blockchain adoption in AI-enabled QS services. This approach enables the study to provide a structured and evidence-based

understanding of how emerging technologies can be integrated to enhance transparency, efficiency, and automation in construction cost management.

4. FINDINGS AND THEMATIC ANALYSIS

The thematic analysis of the reviewed literature revealed four major themes that explain both the limitations of current Quantity Surveying (QS) practices and the transformative potential of blockchain and artificial intelligence (AI) technologies in construction cost management.

4.1 Limitations of Existing QS Workflows

The analysis confirms that both traditional and digitally enhanced QS workflows remain constrained by fragmentation, lack of transparency, and reliance on manual processes. Construction cost management systems are often distributed across multiple platforms, including spreadsheets, emails, and standalone software, resulting in inconsistent data records and duplication of information. These fragmented systems limit real-time access to reliable cost data and complicate verification processes. Even with the adoption of digital technologies such as BIM and cloud-based collaboration tools, many QS processes continue to depend on centralised databases and manual validation procedures. This creates vulnerabilities related to data manipulation, limited auditability, and delayed decision-making (Ebert and Duarte, 2018; Kraus et al., 2021). Furthermore, the absence of integrated and tamper-proof systems contributes to persistent disputes over valuations, variations, and payment certifications. Recent studies emphasise that issues of trust, coordination, and data security remain unresolved in current construction workflows. For example, Hewavitharana et al. (2024) Application of blockchain in procurement and management of building services highlight that existing systems lack robust mechanisms for ensuring secure and transparent data exchange among stakeholders. These limitations demonstrate the need for more reliable and integrated technological solutions in QS practice.

4.2 Capabilities of Blockchain Technology in QS Cost Management

The findings indicate that blockchain technology offers significant capabilities for improving transparency, security, and traceability in construction cost management. As a decentralised and immutable ledger, blockchain enables all authorised stakeholders to access a shared and verifiable record of financial transactions, thereby reducing information asymmetry and enhancing trust. A key advantage of blockchain lies in its ability to create tamper-proof audit trails for cost-related activities, including tender submissions, valuation records, variation orders, and payment certifications. This enhances accountability and reduces opportunities for data manipulation. Celik et al. (2024) identify transparency, immutability, and traceability as core features that make blockchain particularly suitable for construction applications. Moreover, blockchain supports the use of smart contracts, which enable the automation of contractual processes. These contracts execute predefined actions when specified conditions are met, such as releasing payments upon verification of completed work. This reduces administrative delays, minimises disputes, and ensures compliance with contractual agreements (Hewavitharana et al., 2024). In addition, advanced frameworks incorporating encryption techniques allow blockchain systems to balance transparency with data confidentiality, ensuring secure sharing of sensitive cost information (Cheng et al., 2023).

4.3 Role of Artificial Intelligence in Enhancing QS Processes

Artificial intelligence (AI) plays a complementary role in enhancing the analytical and decision-making capabilities of QS services. The findings show that AI technologies are increasingly applied across construction processes to automate complex tasks and improve efficiency. AI-driven tools can perform automated quantity take-offs from BIM models, generate accurate cost estimates, and support predictive cost forecasting. Machine learning algorithms can analyse historical project data to identify cost patterns, optimise resource allocation, and improve budgeting accuracy. Additionally, AI-based anomaly detection systems can identify irregularities in financial claims, helping to reduce fraud and errors in cost reporting. A comprehensive review by Egwim et al. (2024) demonstrate that AI enhances efficiency, accuracy, and

decision-making across the construction value chain. These capabilities are particularly valuable in QS practice, where large volumes of data must be processed to support cost planning and control.

4.4 Integration of Blockchain and AI for Intelligent QS Workflows

The analysis highlights that the integration of blockchain and AI technologies creates a powerful synergy capable of transforming QS workflows into intelligent, transparent, and automated systems. While blockchain provides a secure and immutable data infrastructure, AI enables advanced data processing, analysis, and decision-making. This integration allows AI systems to operate on verified and trustworthy datasets stored on blockchain platforms, thereby improving the reliability of cost estimation, forecasting, and anomaly detection processes. At the same time, blockchain ensures that all financial transactions and decisions are securely recorded and auditable. Emerging research suggests that the convergence of blockchain, AI, and digital construction technologies forms the foundation of next-generation construction management systems (Singh, 2025). Such systems enable automated cost verification, real-time financial monitoring, and transparent stakeholder collaboration. However, the findings also indicate that integrating these technologies requires careful consideration of interoperability, data governance, and system architecture. Challenges such as data standardisation, integration with existing construction tools, and regulatory acceptance must be addressed to enable effective implementation (Xu et al., 2023; Zhou, 2024).

Overall, the reviewed literature demonstrates a growing consensus regarding the potential of blockchain and AI technologies to improve transparency, automation, and decision-making within construction cost management. However, the analysis also reveals important gaps and tensions within existing studies. While blockchain is widely recognised for enhancing data integrity and traceability, empirical implementation within QS-specific workflows remains limited. Similarly, although AI applications in construction are expanding rapidly, most studies focus on isolated predictive functions rather than integrated financial governance systems. Furthermore, challenges relating to interoperability, regulatory uncertainty, organisational readiness, and standardisation continue to constrain practical adoption. These gaps highlight the need for integrated conceptual frameworks capable of supporting secure, intelligent, and interoperable QS processes within digitally transforming construction environments.

5. CONCEPTUAL FRAMEWORK FOR BLOCKCHAIN ADOPTION IN AI-ENABLED QUANTITY SURVEYING

Based on the thematic analysis of the literature, this study proposes a conceptual framework for the adoption of blockchain technology within AI-enabled Quantity Surveying (QS) services. The framework is designed to address the identified limitations of existing QS workflows by enhancing transparency, enabling secure automation, and improving efficiency in construction cost management processes. The proposed framework integrates blockchain, artificial intelligence (AI), and digital construction systems into a unified architecture that supports intelligent and trustworthy QS operations. It consists of five interrelated layers, each representing a critical component required for the effective implementation of blockchain-enabled QS services.

5.1 Distributed Ledger and Data Layer

At the foundation of the framework is the distributed ledger and data layer, which utilises a permissioned blockchain to record and manage construction cost information. This layer captures key financial data, including tender submissions, bills of quantities, interim valuations, variation orders, and payment certifications. The decentralised nature of blockchain ensures that all authorised stakeholders have access to a shared, consistent, and tamper-resistant record of transactions. This enhances data transparency and reduces information asymmetry among project participants. To address confidentiality concerns, sensitive cost data can be stored off-chain, with encrypted references recorded on the blockchain. This approach balances transparency with data privacy while maintaining data integrity (Cheng et al., 2023).

5.2 Smart Contract Layer

The smart contract layer enables the automation of contractual and cost management processes within QS workflows. Smart contracts are self-executing digital agreements programmed to perform predefined actions when specific conditions are met. In the context of QS services, smart contracts can automate processes such as interim valuations, payment certifications, variation approvals, and compliance verification. For example, payments can be automatically triggered upon verification of completed work or approval of valuation records. This reduces reliance on manual verification, minimises administrative delays, and enhances accountability among stakeholders (Hewavitharana et al., 2024). For example, within an interim valuation cycle, site progress data and valuation records can be securely recorded on the blockchain platform, while smart contracts automatically trigger payment certification upon verification of predefined contractual conditions. AI tools can simultaneously analyse historical cost and progress data to identify anomalies, forecast potential cost deviations, and support decision-making during valuation assessments.

5.3 Artificial Intelligence and Analytics Layer

The AI and analytics layer introduces intelligent data processing and decision-support capabilities into QS operations. AI tools can analyse large datasets derived from BIM models, project documentation, and financial records to support key cost management functions. These include automated quantity take-offs, predictive cost estimation, anomaly detection in financial transactions, and risk assessment. By leveraging machine learning and data analytics, this layer enhances the accuracy and efficiency of QS processes while enabling proactive decision-making. The integration of AI aligns with the increasing adoption of data-driven approaches in construction management (Egwim et al., 2024).

5.4 Integration and Interoperability Layer

The integration and interoperability layer ensures seamless communication between blockchain systems, AI modules, and existing construction technologies such as BIM platforms and enterprise cost-management software. This layer facilitates data exchange through application programming interfaces (APIs) and standardised data protocols. Effective interoperability is essential for maintaining data consistency and enabling real-time information flow across project stakeholders. Without this layer, the benefits of blockchain and AI integration would be limited by system fragmentation and compatibility issues. Existing research emphasises that interoperability remains a critical challenge in digital construction environments and must be addressed for successful technology adoption (Xu et al., 2023).

5.5 Governance and Access Control Layer

The final layer focuses on governance and access control, which are essential for ensuring trust, accountability, and regulatory compliance within blockchain-enabled QS systems. This layer defines stakeholder roles, data access permissions, validation protocols, and dispute resolution mechanisms. Role-based access control ensures that only authorised participants can view, modify, or approve specific transactions, thereby maintaining system integrity. Additionally, governance structures help manage issues related to data ownership, confidentiality, and compliance with legal and contractual requirements. As highlighted in the literature, effective governance is critical for overcoming barriers related to trust, coordination, and adoption in blockchain-based construction systems (Zhou, 2024).

5.6 Framework Synthesis and Implications

Collectively, these five layers form a holistic and integrated framework that addresses the key challenges identified in QS workflows. The framework demonstrates how blockchain provides a secure and transparent data infrastructure, while AI enhances analytical and predictive capabilities. The integration and governance layers ensure that these technologies function cohesively within the broader construction ecosystem. By combining these components, the proposed framework enables: Transparent and tamper-proof financial records. Automated cost verification and payment processes. Improved accuracy in cost estimation and forecasting and enhanced trust and collaboration among stakeholders. This framework contributes to the

advancement of digital transformation in construction by providing a structured pathway for integrating blockchain and AI technologies into QS practice. It also serves as a foundation for future empirical validation and practical implementation in real-world construction projects. Unlike existing blockchain-focused construction frameworks that primarily emphasise procurement or supply-chain applications, the proposed framework specifically integrates blockchain and AI functionalities within Quantity Surveying cost management workflows, including valuation verification, automated payment processes, predictive cost analysis, and financial governance functions. To illustrate the proposed conceptual framework and its layered architecture, **Figure 2** presents a visual representation of how blockchain and artificial intelligence technologies integrate to support secure, transparent, and automated Quantity Surveying workflows.

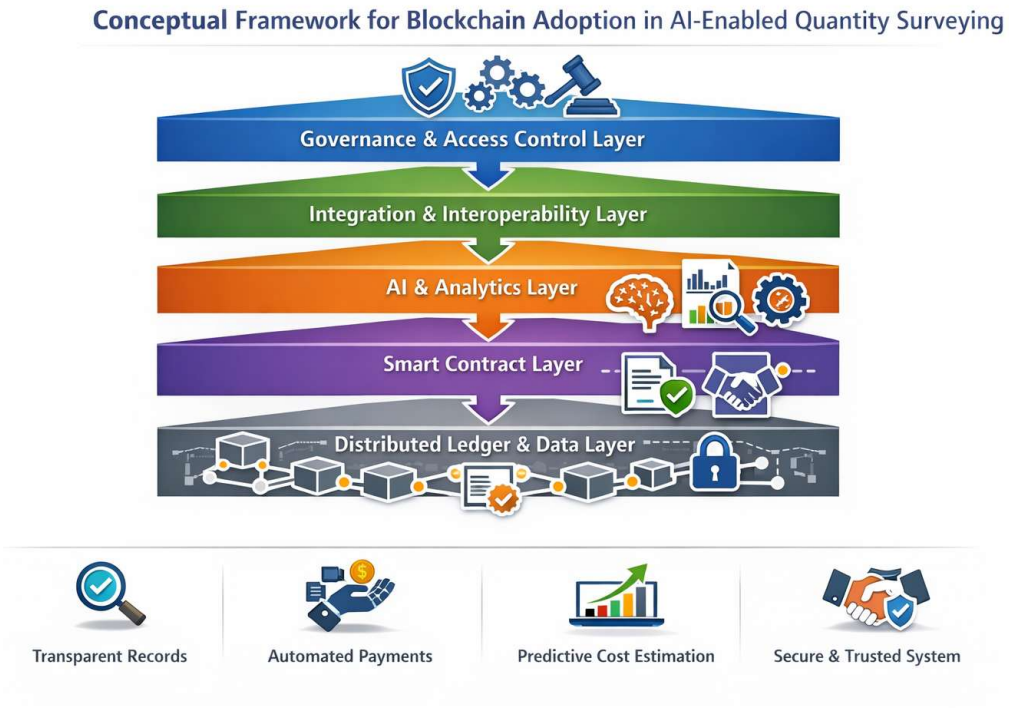

Figure 2: Conceptual Framework for Blockchain Adoption in AI-Enabled Quantity Surveying

Figure 2 demonstrates the interaction between the five core layers of the framework, highlighting how data flows from the distributed ledger layer through smart contracts and AI analytics, while being supported by integration and governance mechanisms. The diagram also illustrates the key outcomes of the framework, including enhanced transparency, automated financial processes, improved predictive cost capabilities, and strengthened trust among construction stakeholders.

6. DISCUSSION

The findings of this study reinforce the growing importance of digital transformation in construction cost management and highlight the limitations of existing Quantity Surveying (QS) workflows. Despite the adoption of digital tools such as BIM and cloud-based systems, QS practices remain constrained by fragmented data environments, reliance on manual verification, and limited transparency in financial transactions. These challenges continue to contribute to inefficiencies, delays, and disputes within construction projects. The integration of blockchain technology offers a transformative solution to these limitations by introducing decentralised, immutable, and transparent data management systems. Unlike

traditional centralised databases, blockchain enables multiple stakeholders to access and verify shared records without relying on a single controlling authority. This significantly reduces the risk of data manipulation and enhances trust across project participants. The findings align with existing studies that emphasise blockchain's ability to improve transparency, traceability, and accountability in construction processes (Celik et al., 2024; Cheng et al., 2023). Furthermore, the incorporation of smart contracts into QS workflows provides a mechanism for automating key cost management processes, including interim valuations, payment certifications, and variation approvals. By reducing the need for manual intervention, smart contracts can minimise delays, improve efficiency, and ensure compliance with contractual conditions. This supports previous research highlighting the potential of blockchain-based automation in reducing disputes and improving financial governance (Hewavitharana et al., 2024).

Artificial intelligence (AI) further enhances the capabilities of blockchain-enabled QS systems by enabling advanced data analytics and decision support. AI-driven tools can process large volumes of construction data to generate accurate cost estimates, detect anomalies in financial transactions, and support predictive forecasting. These capabilities enable QS professionals to shift from reactive cost control to proactive and data-driven decision-making. As highlighted in the literature, AI plays a critical role in improving efficiency and accuracy across construction processes (Egwim et al., 2024). Importantly, the discussion highlights that the true value lies in the integration of blockchain and AI rather than their isolated application. Blockchain ensures data integrity and trust, while AI enables intelligent analysis and automation. Together, these technologies create a synergistic system capable of transforming QS workflows into secure, transparent, and intelligent processes. This aligns with emerging research on the convergence of blockchain, AI, and digital systems in engineering and construction contexts (Singh, 2025). However, the implementation of such integrated systems is not without challenges. Key barriers identified in the literature include interoperability issues between digital construction tools, lack of standardised data protocols, regulatory uncertainties, and concerns regarding data governance and privacy (Xu et al., 2023; Zhou, 2024). Additionally, organisational resistance to change, lack of technical expertise, and the need for stakeholder alignment may hinder adoption. Therefore, while the proposed framework demonstrates significant potential to improve QS practice, its successful implementation will depend on addressing these technological, organisational, and regulatory challenges. This underscores the need for phased adoption strategies, pilot implementations, and the development of industry-wide standards to support the integration of blockchain and AI in construction cost management.

7. CONCLUSION

This study investigated the adoption of blockchain technology within AI-enabled Quantity Surveying (QS) services as a transformative approach to improving construction cost management. The research identified persistent limitations in traditional and existing digital QS workflows, including fragmented data systems, limited transparency, and reliance on manual processes that contribute to inefficiencies, delays, and disputes among project stakeholders. Through a systematic literature review and thematic analysis, the study examined the capabilities of blockchain and artificial intelligence (AI) technologies in addressing these challenges. The findings demonstrate that blockchain technology, with its decentralised and immutable ledger, can enhance transparency, traceability, and accountability in construction financial transactions. In addition, the use of smart contracts enables the automation of key QS processes such as interim valuations, payment certifications, and variation approvals, thereby reducing administrative delays and improving process efficiency.

The study further established that AI technologies complement blockchain by providing advanced analytical capabilities, including automated quantity take-offs, predictive cost estimation, anomaly detection, and data-driven decision-making. The integration of blockchain and AI creates a synergistic system in which secure data infrastructure and intelligent analytics work together to improve the reliability, efficiency, and transparency of QS workflows. A key contribution of this research is the development of a conceptual framework that integrates distributed ledger systems, smart contracts, AI analytics, interoperability mechanisms, and governance structures to support blockchain adoption in AI-enabled QS services. The framework provides a structured pathway for transforming construction cost management into a more transparent, automated, and intelligent process. Despite these contributions, the study acknowledges that

the proposed framework remains conceptual and has not yet been validated through empirical application. Challenges related to interoperability, data governance, regulatory frameworks, and organisational readiness may affect the practical implementation of blockchain-enabled QS systems. Therefore, future research should focus on empirical validation through case studies, pilot projects, and real-world implementations to assess the feasibility and effectiveness of the proposed framework. In conclusion, the integration of blockchain and artificial intelligence presents a significant opportunity to modernise Quantity Surveying practice and enhance construction cost management. By improving transparency, enabling secure automation, and supporting data-driven decision-making, these technologies have the potential to significantly support the digital transformation of Quantity Surveying practice and improve transparency, automation, and data-driven decision-making within construction cost management.

ACKNOWLEDGEMENTS

Under the Harnessing Talent (HANT) Postdoctoral Fellowship (PDF) Grant, this research is sponsored by the Directorate for Research and Postgraduate Support at Durban University of Technology, P.O. Box 1334, Durban 4000, South Africa.

REFERENCES

Awodele, I.A., Eze, E.C., Gento Municio, A.M., Ramabodu, M.S., and Olatunde, N.A. 2025. Advancing circular economy transition in the Nigeria construction industry through digital twin technology adoption. *Green Technologies and Sustainability*, 3: 100201.

Celik, B.G., Abraham, Y.S., and Attaran, M. 2024. Unlocking blockchain in construction: A systematic review of applications and barriers. *Buildings*, 14(6): 1600. https://doi.org/10.3390/buildings14061600

Cheng, J.C.P., Liu, H., Gan, V.J.L., Das, M., Tao, X., and Zhou, S. 2023. Construction cost management using blockchain and encryption. *Automation in Construction*, 152: 104841. https://doi.org/10.1016/j.autcon.2023.104841

Ebert, C., and Duarte, C.H.C. 2018. Digital transformation. *IEEE Software*, 35(4): 16–21. https://doi.org/10.1109/MS.2018.2801537

Egwim, C.N., Alaka, H., Demir, E., Balogun, H., Olu-Ajayi, R., Sulaimon, I., Wusu, G., Yusuf, W., and Muideen, A.A. 2024. Artificial intelligence in the construction industry: A systematic review of the entire construction value-chain lifecycle. *Energies*, 17(1): 182. https://doi.org/10.3390/en17010182

Eze, E.C., and Ameyaw, E.E. 2025. A strategic framework for bolstering the adoption of blockchain-enabled smart contracts in infrastructure public–private partnerships projects. *Construction Innovation*. https://doi.org/10.1108/CI-04-2025-0180

Hewavitharana, S., Perera, S., Jin, X., Seneviratne, K., and Bamdad, K. 2024. Application of blockchain in procurement and management of building services: A critical and systematic review. *Journal of Information Technology in Construction (ITcon)*, 29: 635–661. https://doi.org/10.36680/j.itcon.2024.029

Kraus, S., Jones, P., Kailer, N., Weinmann, A., Chaparro-Banegas, N., and Roig-Tierno, N. 2021. Digital transformation: An overview of the current state of the art of research. *SAGE Open*, 11(3): 21582440211047576. https://doi.org/10.1177/21582440211047576

Le Jeune, K., Ontong, K., and Moghayedi, A. 2023. Promoting the digital transformation of the South African quantity surveying profession through the implementation of change management theories. *Journal of Construction Project Management and Innovation*, 13(2): 75–92.

Singh, A.K. 2023. Investigating barriers to the adoption of blockchain technology in construction supply-chain management. *Technological Forecasting and Social Change*, 193: 122620. https://doi.org/10.1016/j.techfore.2023.122620

Singh, J. 2025. A systematic review of blockchain, AI and cloud integration for secure digital ecosystems. *International Journal of Networked and Distributed Computing*. https://doi.org/10.1007/s44227-025-00072-1

Xu, Y., Chong, H.Y., and Chi, M. 2023. Modelling the blockchain adoption barriers in the AEC industry. *Engineering, Construction and Architectural Management*, 30(1): 125–153. https://doi.org/10.1108/ECAM-04-2021-0335

Zhou, R. 2024. Blockchain technology adoption by critical stakeholders in construction: Drivers, barriers and strategies. *Buildings*, 14(9): 3034. https://doi.org/10.3390/buildings14093034.