



PLANNING MALAYSIA:

Journal of the Malaysian Institute of Planners

VOLUME 23 ISSUE 4 (2025), Page 629 – 643

EXPLORING THE CHALLENGES IN IMPLEMENTING BLOCKCHAIN TECHNOLOGY IN CONTRACT MANAGEMENT FOR QUANTITY SURVEYING PROFESSION IN MALAYSIAN CONSTRUCTION INDUSTRY

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Abstract

The increasing complexity of construction projects in Malaysia has amplified the need for transparent, efficient, and secure contract management systems, particularly within the quantity surveying profession. Blockchain technology, with its decentralised ledger and smart contract capabilities, presents a potential solution to long-standing issues such as data manipulation, inefficiencies, and a lack of accountability in contract administration. This study explores the challenges associated with implementing blockchain technology in construction contract management and propose effective strategies for its integration into quantity surveying. A quantitative research method was employed through the distribution of 600 questionnaires to registered quantity surveyors. Data collected from the survey of 142 respondents were analysed using descriptive statistical techniques. The results of this study reveal the ranking of key barriers to blockchain adoption by the quantity surveying profession, including the immaturity of the technology, high implementation costs, privacy concerns, resistance to change, and security risks. This paper provides recommendations for addressing these challenges to facilitate the digital transformation of contract management in the industry. This study concludes that while blockchain holds significant potential to contract management efficiency, strategic efforts in education, policy, and industry collaboration are essential to support its successful adoption by the Malaysian quantity surveying profession.

Keywords: blockchain technology, construction, contract management, quantity surveying, challenges, adoption

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INTRODUCTION

The increasing demand for transparency, efficiency, and accountability in the Malaysian construction industry has further encouraged the exploration of emerging technologies such as blockchain. One profession that plays a vital role in cost control and contract administration is quantity surveying. Despite the industry's significant contribution to the national economy, employing 1.2 million individuals and accounting for 9.5% of the total workforce (Aziz & Hamid, 2020), it continues to face persistent challenges such as low productivity, slow technological adoption, and vulnerability to unethical practices. These challenges are exacerbated by the limited use of digital innovations, particularly in contract management practices.

Several studies have argued and concluded that the construction industry's slow integration of advanced digital technologies, including blockchain, artificial intelligence, and big data, has hindered improvements in project performance and ethical standards (Jasimin et al, 2023; Ghaffarpasand et al., 2020; Li et al., 2020). The lack of awareness, understanding, and readiness among construction professionals, especially quantity surveyors, has contributed to the limited implementation of such transformative technologies (Farid et al., 2019). Blockchain, known for its decentralised, transparent, and tamper-proof nature, has been identified as a promising solution to these issues. Through its smart contract features and secure data-sharing capabilities, blockchain technology offers potential benefits such as improved traceability, automated compliance, enhanced data integrity, and reduced transaction costs in contract management (Muneeb et al., 2022).

The objective of this paper is to explore the challenges faced by quantity surveying professionals when adopting blockchain technology for contract management in the Malaysian construction industry. The outcome of this study will identify the key barriers to blockchain implementation within the local quantity surveying profession, specifically in its transition towards digital transformation in contract management through blockchain adoption.

LITERATURE REVIEW

Construction Contract Management

Construction contract management is a crucial aspect of ensuring the effectiveness and efficiency of construction projects. This involves various activities, including the administration of contracts, risk management, compliance oversight and, the continuous evaluation of performance to meet the goals outlined in the contracts. Okereke et al., (2023) asserted that the expertise of a quantity surveyor is crucial throughout the construction process, particularly in managing claims and ensuring adherence to contract terms. This comprehensive involvement equips QSs to address complexities and potentially

mitigate risks associated with contract execution, which is vital for maintaining project performance.

One significant challenge in construction contract management is the reliance on traditional legal frameworks and documentation practices, which are often cumbersome and difficult to navigate. Gurgun and Koc (2021) emphasize that participants in construction projects express concerns about the legal processes tied to traditional contract management, which often leads to operational and enforcement difficulties. The adoption of smart contracts has emerged as a potential solution, although it introduces additional challenges, such as the need for legal professionals to acquire programming skills to manage and develop these contracts effectively (Gurgun & Koc, 2021). However, Mwaiseje et al., (2024) indicated that the lack of an adequate dispute resolution mechanism remains a prominent risk in these new frameworks, underscoring the complexities faced by construction managers in navigating concurrent legal obligations and technological innovations.

Blockchain in Construction Contract Management

Blockchain technology is increasingly recognised as a transformative force in the construction industry, particularly in contract management. The application of blockchain and smart contracts has shown significant potential to streamline various processes, enhance transparency, and improve trust among stakeholders involved in construction projects. By facilitating automated compliance with contractual conditions, blockchain can mitigate common issues, such as payment delays, disputes, and inefficiencies (Celik et al., 2024; Muneeb, 2022).

One of the primary benefits of blockchain technology in contract management is its ability to create secure and transparent layers of information that can be accessed by all stakeholders involved in a construction project. This capacity serves to enhance accountability and reduce disputes arising from ambiguities in contract terms. Celik et al., (2024) asserted that blockchain can significantly improve various construction processes, including contract management, by ensuring that every change or transaction is accurately documented and traceable. Their review emphasizes the technology's role in increasing efficiency and effectiveness across the construction supply chain. Similarly, Muneeb et al., (2022) highlighted how blockchain-based smart contracts can automate and streamline business processes, thereby significantly optimising workflows in multiparty arrangements, which is especially pertinent to quantity surveying projects involving several stakeholders.

Moreover, the use of smart contract that utilises automated scripts running on blockchain that execute predefined condition offers the potential to transform how quantity surveying manages contracts. Yigit and Dag (2024) emphasize that implementing smart contracts on blockchain platforms can foster

transparency and accountability, leading to increased contract execution processing speeds and improved construction resources management. This is critical in quantity surveying, where tracking and verifying compliance with contract specifications is paramount. Additionally, Pan et al., (2023) explored a framework for integrating smart contracts with Building Information Modelling (BIM), asserting that this combination can enhance the material supply chain management aspect of construction projects, reducing risks associated with traditional contract execution.

Considering the broader implications of integrating blockchain for supply chain management, Malik et al., (2021) detailed how blockchain technology can address critical issues related to transparency and traceability in global supply chains, a significant aspect of construction contract management that quantity surveyors must navigate. Their findings resonate with those of Syamsuddin et al., (2023), who argued that this technology promises to increase operational efficiency and significantly reduce costs related to contract management across various sectors, including construction.

The implications for project risk management are also substantial. Jasimin et al., (2023) and Demirkesen et al., (2024) note that blockchain's unique properties enable improved data management practices, which can significantly enhance project risk management strategies in construction. By employing a structural equation model, this study demonstrated how blockchain ensures more reliable risk management frameworks, enhancing trust among parties involved in contract agreements through transparent data-sharing mechanisms.

In short, the potential integration of blockchain technology and smart contracts into contract management within the quantity surveying profession represents a noteworthy advancement towards improving efficiency, reducing disputes, and fostering accountability in construction processes. Collective insights from the discussed literature affirm that blockchain not only facilitates better contractual arrangements but also enhances overall project effectiveness within the construction sector.

Challenges in Implementing Blockchain in Construction Professional Practice

The integration of blockchain technology into construction contract management has substantial potential, particularly in the field of quantity surveying. However, several key challenges continue to hinder its adoption, ranging from organisational barriers to technological and regulatory limitations. Among the key challenges that can be identified from existing the literatures are, but not limited to the following:

Lack of Management Support and Technical Knowledge

One of the most pressing barriers to blockchain adoption in construction is the lack of internal management support and technical expertise. Blockchain is viewed as a highly disruptive and complex innovation that requires advanced technological competence and domain-specific integration (Ghaffarpasand et al., 2020; Celik et al., 2024). Without sufficient internal knowledge, firms struggle to initiate, scale, or sustain blockchain-related initiatives (Li et al., 2020; Mahmood et al., 2020). As Hernandez and Miller (2021) emphasised, senior management commitment is pivotal for successful digital transformation, and its absence remains a critical limiting factor. In quantity surveying, this issue is amplified by fragmented workflows and limited experience with large-scale digital projects (Chan & Lim, 2020; CIDB, 2024).

Regulatory Uncertainty and Legal Ambiguity

Blockchain implementation is further hindered by legal and regulatory ambiguities. A lack of comprehensive frameworks surrounding blockchain usage in contract documentation and project management limits its enforceability and compliance (Rahman et al., 2020; Gurgun & Koc, 2021). Smart contracts, written in code rather than legal language, pose additional challenges regarding their alignment with existing legal standards (Pan et al., 2023). Zarour and Haron (2021) argued that construction stakeholders are hesitant to embrace blockchain without clear legal validation and standardisation. Moreover, Al-Bassam et al., (2021) highlighted that inconsistent policies and enforcement mechanisms increase adoption risk, particularly in transnational or large-scale projects.

Limited Collaboration Among Stakeholders

Successful blockchain integration in construction projects requires coordinated collaboration among all stakeholders, including the client, consultant, contractor, and regulatory bodies. However, this sector is characterised by siloed operations, adversarial relationships, and poor data-sharing practices (Demirkesen et al., 2024; Hasan et al., 2022). These challenges create barriers to the development of shared digital platforms and hinder the creation of trustworthy, real-time information systems (Malik et al., 2021; Celik et al., 2024). Aziz and Hamid (2020) further pointed out that divergent interests often lead to duplicated efforts and inefficiencies, limiting the collaborative potential of blockchain in delivering a unified source of truth across projects.

Potential for Misuse and Unethical Applications

Despite its promise to enhance transparency, blockchain is not immune to ethical risks. When misused, blockchain systems may enable unregulated or illicit activities, such as data tampering and money laundering (Zarour & Haron, 2021;

Muneeb et al., 2022). The decentralised and anonymous nature of certain blockchain configurations, especially public networks, increases the risk of manipulation by malicious actors. As Hasan et al., (2022) warned that the lack of strong governance structures can lead to ethical breaches, especially in jurisdictions without robust regulatory frameworks. These concerns underscore the importance of robust compliance and audit mechanisms in blockchain platforms.

Privacy Concerns in Data Sharing

While blockchain's transparency facilitates traceability and accountability, it simultaneously raises serious privacy concerns, particularly in contract administration and financial transactions. Gurgun and Koc (2021) discussed the reluctance of construction professionals to share sensitive data on public or semi-public ledgers due to fears of corporate espionage or breaches of confidentiality. Lim et al., (2021) found that organisations prefer private blockchain because such networks may reduce the overall benefits of openness and interoperability. Additionally, Malik et al., (2021) argued that the trade-off between transparency and privacy must be carefully managed, especially when dealing with proprietary or competitive data.

High Implementation Cost

The financial burden of blockchain implementation ranging from system development to training and maintenance remains a key obstacle for small and medium-sized construction firms. According to Celik et al., (2024), high upfront costs are often disproportionate to perceived benefits, especially when return on investment is unclear. Demirkesen et al., (2024) noted that resource-constrained organisations often abandon blockchain adoption due to limited capital and uncertainty about long-term viability. Mahmood et al., (2020) similarly emphasised that funding challenges and the absence of scalable models hinder adoption across developing economies.

Integration Difficulties with Legacy Systems

Integrating blockchain solutions into existing construction IT systems is technically demanding. Most legacy platforms lack interoperability with distributed ledgers, leading to data silos and operational friction (Park et al., 2019; Hasan et al., 2022). Li et al., (2020) observed that aligning blockchain with enterprise resource planning (ERP) systems requires substantial investment and staff retraining. Furthermore, the absence of common technical standards and protocols across the industry makes seamless integration a challenge, delaying the full realisation of blockchain's potential in construction workflows (Pan et al., 2023; Chan & Lim, 2020).

Resistance to Change and Digital Transformation

Cultural resistance remains a deeply rooted issue in the construction industry's slow digital transformation. Traditional work methods, hierarchical decision-making, and scepticism towards emerging technologies contribute to a reluctance to change (Mustafa et al., 2024; Rahman & Ismail, 2019). In quantity surveying, blockchain is often perceived as overhyped and lacking proven value, which discourages firms from investing in pilot initiatives or workforce development (Mahmood et al., 2020; Aziz & Hamid, 2020). Lim et al., (2021) highlight that organisational inertia, especially in long-established firms, continues to be a non-technical yet powerful barrier to digital adoption.

Immaturity of Blockchain Technology

Despite rapid advancements, blockchain technology has remained in its early stages in the construction sector. As pointed out by Celik et al., (2024), the lack of industry-specific case studies and success stories contributes to uncertainty about blockchain's practical utility. Hasan et al., (2022) argued that the technology diffusion has been slow by limited empirical validation and pilot project outcomes. Similarly, Ghaffarpasand et al., (2020) caution that blockchain's operational limitations such as transaction speed, scalability, and data governance. These developmental issues create hesitation among decision-makers and investors alike.

Security Vulnerabilities

Although blockchain technology is generally considered a secure digital infrastructure, vulnerabilities remain, particularly in public blockchain environments. Lim et al., (2021) explain that while decentralised architectures protect against single-point failures, they are not immune to coordinated cyberattacks, such as the infamous 51% attack. Gurgun and Koc (2021) also highlighted concerns about data integrity, especially when sensitive project information is stored across distributed networks. Furthermore, Park et al., (2019) stressed the need for robust security frameworks and contingency protocols, especially for smart contract execution, to ensure that blockchain can be reliably used in high-stakes construction applications.

RESEARCH METHODOLOGY

This study adopted a quantitative research approach, using questionnaire surveys to explore the challenges faced by quantity surveyors in adopting blockchain technology for contract management. A survey was developed based on insights from the literature, and respondents were asked to rate each challenge on a 5-point Likert scale, where 1 represented "Not significant" and 5 represented "Extremely significant." The questionnaire was distributed via email and

LinkedIn between April 15 and May 5, 2024. Using purposive sampling, about 600 questionnaires were distributed and 142 completed responses were received, resulting a response rate of 23.67%. According to Baruch (1999), a survey-based research response rate of 100% is rarely attainable, and Laguilles et al., (2011) noted that typical online survey response rates average around 20%. Therefore, the response rate achieved in this study can be considered both acceptable and sufficient for meaningful analysis.

Data collected from the survey were analysed using descriptive statistical techniques. Analytical tools such as Microsoft Excel and SPSS were employed to interpret the findings through measures of central tendency, frequency distributions, and dispersion, where Mean Rank Analysis was also used. The results were presented using visual aids to enhance clarity and comprehension. This methodological approach enabled the identification of key patterns and themes concerning the challenges faced by quantity surveyors, ultimately supporting the development of evidence-based challenges in utilising blockchain technology within the Malaysian quantity surveying profession.

To ensure validity, the questionnaire was developed based on an extensive literature review and subsequently reviewed by academic and industry experts for content accuracy. A pilot test involving 15 registered quantity surveyors refined its clarity and relevance. Reliability was confirmed through Cronbach's Alpha (values > 0.70), and mean rank analysis identified the relative significance of the identified challenges. Finally, the results were compared with findings from previous studies to establish external validity.

FINDINGS AND DISCUSSION

Key Challenges to Implementing Blockchain in Contract Management in the Malaysian Quantity Surveying Profession

In interpreting the findings, this paper established a benchmark mean value of 3.00 on the 5-point Likert scale as the threshold for acceptance. Consequently, challenges with mean values exceeding 3.00 were identified as significant barriers to blockchain adoption in the Malaysian quantity surveying profession.

Table 1: Mean Rank Analysis of Key Challenges in Blockchain Adoption

Challenges in the implementation of blockchain technology	Mean	Standard deviation	Ranking
Immaturity of Technology	4.49	0.769	1
Cost of Investment	4.46	0.603	2
Risk to Privacy	4.45	0.896	3
Unwillingness to Adapt	4.39	0.617	4
Threats to Security	4.35	0.755	5
Usage in Illegal Activities	4.15	0.982	6

Challenges in the implementation of blockchain technology	Mean	Standard deviation	Ranking
Absence of Management Support and Knowledge	4.11	0.923	7
Absence of Regulation Support	4.04	0.551	8
Absence of coordination, cooperation, and collaboration	3.82	0.718	9
Difficulties in Integrating Existing System	3.66	0.743	10

The survey results reveal that the immaturity of blockchain technology poses the most critical challenge (Mean = 4.49, SD = 0.769). Respondents expressed concerns about scalability, usability, and interoperability, which limit blockchain's capacity to support complex construction contracts. This finding corroborates prior studies by Celik et al. (2024) and Mahmood et al. (2020), who similarly noted that blockchain systems struggle to process large volumes of data and maintain efficiency. The limited availability of construction-specific platforms, as observed by Park et al. (2019) and Hasan et al. (2022), further reinforces these concerns. Thus, this study enhances existing literature by providing empirical evidence that technological immaturity remains the foremost barrier to adoption in the Malaysian context.

The second-ranked challenge is the cost of investment (Mean = 4.46, SD = 0.603). Survey responses indicate a strong consensus that high costs associated with infrastructure, training, and maintenance costs deter adoption, particularly among SMEs. This aligns with findings by Demirkesen et al. (2024) and Al Amri et al. (2019), who reported that the financial burden of blockchain often outweighs its perceived benefits in resource-constrained industries. However, this study builds upon earlier findings by illustrating that Malaysian quantity surveyors also regard investment as a long-term risk due to uncertain returns and the lack of industry incentives. This suggests that financial barriers are not merely immediate but also strategic, influencing organizations' willingness to commit resources.

Privacy concerns emerged as the third key challenge (Mean = 4.45, SD = 0.896). While blockchain is often praised for its transparency, respondents expressed reservations about exposing sensitive contractual and financial data. This concern echoes the findings of Gurgun and Koc (2021) and Lim et al. (2021), who reported that professionals are hesitant to share proprietary information on distributed ledgers. Simultaneously, this viewpoint contradicts overly optimistic perspectives such as those presented by Muneeb et al. (2022), which emphasize blockchain's role in enhancing trust. Within the Malaysian QS profession,

transparency is viewed as a double-edged sword; it is essential for accountability yet can potentially undermine confidentiality without robust governance mechanisms.

The fourth-ranked barrier is unwillingness to adapt (Mean = 4.39, SD = 0.617). Respondents' hesitation to adopt blockchain reflects entrenched resistance to digital transformation within the construction industry. This result aligns with findings by Aziz and Hamid (2020) and Mahmood et al. (2020), who identified scepticism and organisational inertia as significant inhibitors. In contrast to international findings, the Malaysian context reveals that resistance is not only cultural but also closely linked to limited exposure and a lack of demonstrable case studies, which render blockchain adoption seem risky and unproven.

Finally, security threats (Mean = 4.35, SD = 0.755) were also perceived as a significant challenge. Despite blockchain's reputation for cryptographic security, respondents remain apprehensive about cyberattacks and vulnerabilities associated with smart contract execution. Lim et al. (2021) and Gurgun and Koc (2021) reported similar concerns, particularly regarding 51% attacks and data integrity. These findings confirm that while blockchain offers relative security compared to traditional systems, its risks are heightened in high-stakes sectors such as construction. Consequently, the results suggest that stakeholder trust in blockchain hinges on the establishment of robust security frameworks and regulatory safeguards.

Lower-ranked challenges such as illegal usage (Mean = 4.15), lack of management support and knowledge (Mean = 4.11), regulatory uncertainty (Mean = 4.04), as well as coordination and integration difficulties (Means = 3.82 and 3.66, respectively) are still relevant but are viewed as secondary. Interestingly, this contrasts with studies by Hasan et al. (2022) and Park et al. (2019), who identified coordination and integration as central barriers. This divergence implies that, in Malaysia, technological immaturity, costs, and privacy risks represent more immediate concerns, whereas systemic issues may only gain prominence after foundational barriers are addressed.

Recommendations for Overcoming Challenges in the Digital Transformation of Quantity Surveying Contract Management

Since the survey identified the immaturity of blockchain technology as the foremost challenge (Mean = 4.49), consistent with findings by Celik et al. (2024) and Ghaffarpasand et al. (2020), developing flexible regulatory frameworks has become imperative. Respondents' concerns regarding scalability and reliability echo findings that the immaturity of blockchain technology hampers contract modifications and large-scale adoption. Consequently, this issue responds to the calls by Rahman et al. (2020) and Zarour and Haron (2021) for adaptable legal

structures that maintain the integrity of blockchain records while enabling contractual flexibility. Establishing such frameworks would alleviate uncertainty about the irreversible nature of blockchain transactions and help reduce legal ambiguity (Gurgun & Koc, 2021).

Given that the cost of investment was ranked as the second major challenge (Mean = 4.46), consistent with Demirkesen et al. (2024) and Al Amri et al. (2019), it is critical to mitigate financial burdens that hinder adoption. Respondents highlighted that cost is not only an upfront barrier but also poses a strategic risk due to unclear returns, echoing Lim et al. (2021) and Hasan et al. (2022), who found that the lack of incentives discourages experimentation. Consequently, governments and industry bodies should provide targeted financial support through subsidies, tax relief, and grants, alongside pilot programs for SMEs. These measures would lower entry barriers and encourage organizations to trial blockchain solutions without committing to full-scale investment.

As the findings indicate, the unwillingness to adapt and lack of management support were reported as significant barriers (Mean = 4.39 and 4.11), aligning with Aziz and Hamid (2020) and Farid et al. (2019). Survey respondents echoed the literature claims that resistance is driven by limited awareness and a lack of demonstrable benefits (Chan & Lim, 2020; Othman & Chong, 2020). Consequently, tailored training for both technical staff and decision-makers can foster organizational readiness and reduce cultural inertia. Such initiatives would strengthen internal support for blockchain adoption and ensure the profession develops the necessary digital competencies (Li et al., 2020).

Considering that privacy risks ranked third (Mean = 4.45), in line with findings by Gurgun and Koc (2021) and Lim et al., (2021), enhancing data protection mechanisms is vital. Respondents' concerns echo Malik et al., (2021), who emphasised the transparency–privacy trade-off in blockchain systems. Consequently, investment should be directed toward privacy-enhancing solutions, such as permissioned blockchains and advanced encryption methods. These approaches can safeguard sensitive contract data while maintaining blockchain's strengths in transparency and accountability (Hasan et al., 2022; Zarour & Haron, 2021).

In light of the results that highlight coordination difficulties and system integration issues, albeit ranked lower (Means = 3.82 and 3.66), they still parallel the literature that identifies fragmentation and interoperability as persistent barriers (Celik et al., 2024; Park et al., 2019). Respondents' perceptions suggest that these challenges may become more pressing once technological and financial concerns are resolved. Consequently, industry-wide platforms for collaboration and hybrid solutions that ensure interoperability should be prioritized. This aligns

with Al-Bassam et al. (2021) and Mustafa et al. (2024), who argue that collective action and knowledge sharing can reduce adoption friction.

As revealed by this study, security vulnerabilities were recognised as a significant challenge (Mean = 4.35), confirming the concerns raised by Lim et al., (2021) and Muneeb et al., (2022). Respondents' apprehensions about smart contract manipulation and cyberattacks reinforce the need for robust safeguards. Consequently, stakeholders should prioritise investments in cybersecurity, including multi-signature verification, advanced encryption, and regular audits, as suggested by Gurgun and Koc (2021). Enhancing security frameworks will reinforce stakeholder trust and promote broader blockchain adoption.

By addressing these key challenges through a combination of regulatory reform, financial incentives, education and training, privacy innovation, industry collaboration, and cybersecurity measures, the quantity surveying profession can successfully integrate blockchain into contract management. This approach will support a more transparent, secure, and efficient process; ultimately contributing to the digital transformation of the construction industry.

CONCLUSION

This research set out to explore the challenges associated with implementing blockchain technology in contract management within the Malaysian construction industry, focusing specifically on the quantity surveying profession. Through a structured quantitative research approach and supported by statistical analysis of 142 responses from registered quantity surveyors, the study identified key hindrances, including data integration issues, cybersecurity vulnerabilities, regulatory ambiguities, and the need for significant capacity building.

The literature review provided a robust theoretical foundation that was empirically reinforced by the survey results and validations. The findings underscore that while there is widespread recognition of blockchain's potential to enhance transparency and operational efficiency, its dual-edged nature with regard to technological complexity and regulatory shortcomings demands a strategic, phased implementation approach. This study recommends the development of proactive regulatory reforms, comprehensive training initiatives, financial incentives, and industrial collaborations as integral components of successful blockchain integration strategies.

Furthermore, the adoption of blockchain technology necessitates a fundamental rethinking of traditional contractual workflows and professional roles in quantity surveying. The strategic recommendations aim not only to mitigate the identified challenges but also to pave the way for sustainable digital transformation in contract management. The study ultimately contributes to both academic literature and industry practice by offering evidence-based insights that

can guide policymakers, industry leaders, and practitioners in leveraging blockchain technology to foster a more transparent, secure, and efficient contractual environment.

In conclusion, while the path to blockchain integration in the Malaysian construction industry is beset with challenges, the combination of strategic planning, regulatory support, and capacity building can drive successful adoption. By addressing these critical issues, the industry can harness blockchain's transformative potential, thereby ensuring improved contract management processes, enhanced stakeholder trust, and a more robust foundation for future construction projects.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Universiti Malaya for funding this research under the Early Career Research Grant (BKP082-2024-ECRG).

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Received: 2nd May 2025. Accepted: 10th September 2025