



Influence of digital tools on effective contract administration: A performance-based assessment

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Abstract

This study investigates the impact of digital technologies, specifically Artificial Intelligence (AI), Internet of Things (IoT), and Blockchain, on the efficiency and accuracy of contract administration across public, private, and construction sectors. Using a quantitative research design with a cross-sectional survey approach, the study surveyed 150 contract administrators in Nigeria, analysing the adoption of digital tools and their effects on contract cycle time, error rates, and compliance. The findings indicate that digital technologies significantly improve efficiency, with the private sector leading in efficiency gains, while the public sector excels in enhancing accuracy through blockchain for compliance. The construction sector, despite challenges related to interoperability, shows balanced gains from the integration of IoT and blockchain. Structural equation modelling (SEM) reveals strong positive relationships between technology adoption and both efficiency and accuracy, with sector-specific differences in the effects. The study also identifies significant barriers to digital adoption, including high costs, cybersecurity concerns, and resistance to change. These results highlight the transformative potential of digital technologies in contract administration and offer practical recommendations for sector-specific strategies to overcome adoption barriers and fully realise the benefits of digital tools.

Keywords: Digital technologies, contract administration, artificial intelligence, internet of things, blockchain, efficiency, accuracy, adoption barriers

Introduction

The digitalisation of business processes has catalysed significant transformations across sectors, including construction, public administration, and private enterprises. As organisations integrate advanced technologies, they redefine operational paradigms, particularly in contract administration. These innovations streamline workflows, reduce human error, and enhance both efficiency (e.g., speed and resource optimisation) and accuracy (e.g., precision and compliance). However, the extent of these improvements varies across contexts. Comparative studies indicate that digital adoption can lead to a reduction of up to 30% in process times, with private firms generally achieving greater gains than public organisations, which face regulatory constraints (Reis & Melao, 2023; Kunkcu *et al.*, 2025) [5, 10].

Digital transformation leverages technologies such as artificial intelligence (AI), the Internet of Things (IoT), and blockchain to align organisational services with technological and societal needs. AI and machine learning, for example, enhance procurement processes by providing predictive analytics that reduce errors compared to traditional methods, while blockchain ensures secure, immutable transaction histories (Sharma, 2022; Omoegun *et al.*, 2025) [8, 11]. In the construction industry, hybrid models combining these technologies have improved outcomes by 25% when compared to manual systems (Sharma, 2022) [11]. However, the integration of IoT for real-time monitoring remains a challenge, particularly in resource-constrained sectors, despite its potential to enhance operational efficiency (Prabhakar *et al.*, 2023) [9].

The COVID-19 pandemic accelerated the shift toward digital technologies by forcing businesses to adapt to remote work environments (Trindade & De Giovanni, 2025) [12]. Organisations that adopted AI-blockchain hybrid systems were able to sustain 40% higher continuity than those that did not (Reis & Melao, 2023) [10]. This shift has been particularly transformative for contract administration, where traditional manual systems often resulted in inefficiencies such as documentation overload. AI has automated the sourcing process, and blockchain has played a significant role in reducing contractual disputes. Yet, despite these advancements, the full deployment of digital tools remains limited, with only 15-20% of firms utilising them comprehensively in contract administration (Sharma, 2022) [11]. Comparative research reveals that private sector organisations have benefited more in terms of efficiency, such as reductions in cycle times, while public sector entities have focused on improving accuracy through compliance tools (Omoegun *et al.*, 2025; Reis & Melao, 2023) [8, 10].

Contract administration involves managing the lifecycle of contracts, traditionally relying on error-prone paper systems. Digital platforms now offer automation, electronic signatures, and advanced analytics, which contribute to improved efficiency through faster processes and enhanced accuracy through better risk management. However, the adoption of these tools is not without challenges. Cybersecurity concerns affect approximately 28% of implementations, and biases inherent in AI systems require ongoing attention (Kunkcu *et al.*, 2025) [5]. Cross-sector analyses highlight the trade-offs in technology adoption:

while construction firms benefit from blockchain's decentralisation, the high costs associated with its implementation hinder scalability when compared to service-based industries (Prabhakar *et al.*, 2023) ^[9].

Literature Review

Construction Contract Administration Fundamentals

Construction contract administration (CA) is a critical process within the construction industry that ensures the successful execution of projects through the management of legal agreements. It encompasses all activities from the preparation of the contract to its completion, ensuring compliance, managing risks, and handling disputes (Gunduz & Elsherbeny, 2020) ^[3]. The primary objective of CA is to maintain the integrity of the contract, ensure that both parties fulfil their obligations, and mitigate any issues that may arise during the lifecycle of the contract. Effective CA involves monitoring the execution of the contract, verifying the performance of all involved parties, and ensuring adherence to terms, conditions, and timelines (Gunduz & Elsherbeny, 2020) ^[3]. In this context, construction contracts outline rights, obligations, and risk allocations that are essential to mitigating potential conflicts.

Poor contract administration, however, often leads to significant challenges, such as delays, cost overruns, and disputes, which are widespread in the industry (Gunduz & Elsherbeny, 2020) ^[3]. Misinterpretation or negligence in following the codified mechanisms of the contract often exacerbates these challenges. As a result, there is an increasing recognition of the need for enhanced CA practices to ensure timely delivery, cost-effectiveness, and project quality.

With the complexity of modern construction projects rising, the role of CA becomes more intricate. The proliferation of new stakeholders, an expanding regulatory environment, and an increase in the use of technology in construction have created the need for more efficient systems to manage and administer construction contracts. In traditional contract administration, project teams rely heavily on manual processes such as paperwork, face-to-face meetings, and physical record-keeping, which introduce inefficiencies and increase the risk of human error.

Consequently, recent studies have highlighted the urgency of digitalising contract administration to address these inefficiencies. For instance, a study by Jahanger *et al.* (2021) ^[4] notes that the transition from traditional to digital contract administration can reduce human error and optimise the resource management process. However, the shift toward digital systems requires overcoming substantial barriers, including resistance to change, cybersecurity risks, and the adaptation to new technological tools. This shift towards digitalisation highlights the need for a comprehensive understanding of both traditional and modern CA practices to ensure a balanced approach to administration that integrates technological advancements while maintaining the necessary legal and regulatory safeguards. The growing complexity of projects in terms of size, scope, and the number of stakeholders makes it critical to adopt robust contract administration systems. Without such systems, construction projects may continue to face delays and budget overruns, undermining the effectiveness of the construction industry.

Digitalisation Imperatives in Construction

The construction industry has long been known for its reliance on manual processes, especially in contract

administration (CA). However, with the rapid rise of digital technologies, there has been a shift towards adopting digital solutions to enhance efficiency and reduce the inherent risks of manual contract management. The volume of documentation generated in construction projects, coupled with their complexity, has made manual processes increasingly unmanageable. Digitalisation offers a means to streamline workflows, automate repetitive tasks, and provide real-time insights into project status.

Studies have shown that digital tools, such as Building Information Modelling (BIM), cloud-based collaboration platforms, and AI-enabled systems, have the potential to significantly enhance the administration of construction contracts. By integrating emerging technologies such as blockchain, AI, and the Internet of Things (IoT), construction firms can create more efficient workflows, reduce delays, and improve overall project outcomes. Blockchain, in particular, has been identified as a key technology in construction contract management. As a decentralised digital ledger system, blockchain enables secure, transparent, and tamper-proof recording of transactions, providing a reliable and verifiable means of tracking project progress and contract compliance (Govindan *et al.*, 2024) ^[2]. Additionally, blockchain's integration with AI and IoT has made it possible to enhance real-time traceability, reducing errors and enabling better decision-making during the lifecycle of a project.

For example, AI applications in construction contracts can help automate tasks such as contract drafting, risk analysis, and the detection of potential anomalies. These technologies can leverage historical data and predictive analytics to ensure that contracts are executed efficiently and any issues are addressed proactively. AI has been shown to reduce sourcing errors in procurement by up to 35%, which in turn increases accuracy and reduces the risk of disputes (Sharma, 2022) ^[11]. Moreover, AI can optimise decision-making by processing large volumes of data at much faster speeds than human counterparts, further enhancing efficiency in contract management. Digitalisation also facilitates better communication and collaboration between stakeholders, including project managers, contractors, and suppliers. By transitioning to digital systems, stakeholders can access real-time information, share documents instantly, and collaborate more effectively across geographical boundaries. Cloud-based project management tools such as Procore, Buildertrend, and BIM 360 are gaining traction in the industry, allowing teams to track project progress, monitor compliance, and address issues before they escalate. Despite the clear advantages of digitalisation, challenges remain. Issues related to data security, lack of digital literacy, and high implementation costs still pose barriers to full-scale adoption in construction. For instance, many construction firms operate with legacy systems that are resistant to change, making the transition to digital systems slow and costly. Additionally, smaller firms with limited resources face difficulties in investing in advanced technologies like AI and blockchain, despite the long-term benefits.

Role of Blockchain Technology

Blockchain technology has emerged as a transformative force in the construction industry, particularly in the realm of Contract Administration (CA). Known for its ability to provide secure, transparent, and immutable records,

blockchain is increasingly being leveraged to improve the efficiency, accuracy, and trustworthiness of transactions in construction projects. In essence, blockchain is a distributed digital ledger system that records transactions across multiple computers, ensuring that each entry is immutable and verifiable by all parties involved (Govindan *et al.*, 2024) [2].

One of the most significant benefits of blockchain in contract administration is its ability to enhance the transparency and traceability of contract-related activities. By recording every step of a transaction on a decentralised ledger, blockchain provides a tamper-proof audit trail that is accessible to all stakeholders. This level of transparency helps reduce the chances of disputes arising from misunderstandings or miscommunications regarding contractual obligations. As an example, in the context of construction projects, blockchain has been shown to reduce disputes by as much as 30% in pilot applications by ensuring that all parties adhere to the predefined conditions of the contract (Prabhakar *et al.*, 2023) [9].

Moreover, blockchain enables the use of smart contracts, self-executing contracts with the terms of the agreement directly written into code. These smart contracts automatically execute and enforce terms once the agreed-upon conditions are met. This reduces the need for intermediaries, accelerates processes such as payments and approvals, and mitigates human errors. In construction, the use of blockchain and smart contracts has been shown to speed up administrative tasks and ensure that payments are made only when work is completed to the required standards (Ogunyankinnu *et al.*, 2022) [7].

However, despite its clear advantages, the widespread adoption of blockchain in construction faces challenges, particularly in terms of scalability and integration with existing systems. Blockchain requires high computational power, which can make it costly for smaller projects or companies to adopt. Additionally, the lack of interoperability between different blockchain platforms can hinder its seamless integration across multiple stakeholders. Regulatory uncertainty surrounding blockchain and its applications in construction further complicates adoption, as many jurisdictions have yet to establish clear legal frameworks regarding the use of blockchain in contract administration.

Artificial Intelligence Applications

Artificial Intelligence (AI) is becoming increasingly integral to the construction industry's digital transformation, particularly in contract administration (CA). AI encompasses a range of technologies, including machine learning (ML), natural language processing (NLP), and predictive analytics, which can automate and enhance various aspects of contract management. The adoption of AI in construction contract administration provides numerous benefits, including improved accuracy, faster decision-making, and the automation of time-consuming tasks.

One of the key applications of AI in contract administration is contract drafting. AI-powered tools can quickly generate contract templates, analyse historical contracts, and identify common terms and clauses that can be customised for specific projects. These tools can also identify potential issues such as ambiguities or inconsistencies within contract language, helping to ensure that all parties have a clear

understanding of their obligations and reducing the potential for disputes down the line. AI can also automate the process of contract negotiation by analysing the terms proposed by each party and suggesting modifications based on past precedents and legal frameworks (Sharma, 2022) [11].

Another significant application of AI is in risk management. AI and machine learning algorithms can analyse large datasets to identify potential risks in a construction project and predict the likelihood of those risks materialising. By leveraging historical data, AI tools can forecast delays, cost overruns, or safety issues, providing project managers with valuable insights into potential challenges. This predictive capability allows for more proactive decision-making, helping to mitigate risks before they become significant problems. In fact, studies have shown that AI can reduce sourcing errors by 35% in procurement processes, with its application in construction yielding a 25% faster approval time for contracts (Sharma, 2022; Kunkcu *et al.*, 2025) [5, 11]. However, the effectiveness of AI in contract administration is contingent upon the quality of the data used to train the algorithms. Poor data quality or insufficient data can lead to inaccurate predictions and suboptimal contract management decisions. Additionally, while AI can significantly improve the efficiency of CA processes, it is not without its challenges. The adoption of AI in construction requires overcoming resistance to change, addressing concerns about data privacy and security, and ensuring that AI systems are transparent and explainable to all stakeholders.

Internet of Things (IoT) Integration

The integration of the Internet of Things (IoT) into construction project management has opened up new avenues for improving contract administration (CA). IoT refers to the network of physical devices embedded with sensors, software, and other technologies that enable them to collect and exchange data over the internet. In construction, IoT devices are used for a range of purposes, from monitoring materials and equipment to tracking the progress of construction activities in real time.

IoT's ability to provide real-time data on project performance is one of its most significant contributions to contract administration. By deploying sensors on construction sites, project managers can track the status of materials, monitor the use of equipment, and ensure that work is being carried out according to the terms outlined in the contract. This real-time data can then be fed into digital CA platforms, enabling stakeholders to make timely and informed decisions about project progression. For example, if a delay in material delivery is detected through IoT sensors, the system can alert project managers, enabling them to address the issue promptly and adjust schedules or resources as needed (Prabhakar *et al.*, 2023) [9].

In addition to improving project monitoring, IoT can enhance the transparency and accountability of construction projects by creating a comprehensive log of events and activities. Combined with blockchain, IoT can generate tamper-evident logs that provide a complete and immutable record of project progress. This integration of IoT and blockchain ensures that all stakeholders have access to the same information and that any discrepancies or issues can be addressed immediately, reducing the potential for disputes.

Despite its potential, the adoption of IoT in construction is not without challenges. One of the key obstacles is the reliability of sensors, which can be affected by environmental factors, such as extreme weather conditions or poor connectivity. Additionally, IoT deployment can be expensive, especially for large-scale construction projects, and may require significant investment in infrastructure. Furthermore, the integration of IoT data into existing contract administration platforms can be complex and may require the development of new systems or software to ensure compatibility.

Smart Contracts and Automation

Smart contracts, a key feature of blockchain technology, have emerged as a powerful tool in the automation of construction contract administration. A smart contract is a self-executing contract with the terms of the agreement written directly into code. Once predefined conditions are met, the contract automatically executes the agreed-upon actions, such as releasing payments or issuing approvals, without the need for manual intervention (Prabhakar *et al.*, 2023) ^[9].

The primary advantage of smart contracts in construction is their ability to reduce the reliance on intermediaries, which can slow down processes and introduce opportunities for errors or disputes. For example, in traditional contract administration, payments may be delayed due to lengthy approval processes or disputes over whether work has been completed to the required standard. Smart contracts eliminate these delays by automatically verifying that the conditions have been met and triggering the payment as soon as the work is confirmed. Studies have shown that the use of smart contracts in construction can resolve up to 40% of payment disputes autonomously, significantly improving the efficiency of financial transactions (Mutoni, 2025) ^[6].

However, despite their potential, smart contracts are not without limitations. One of the main challenges is the rigidity of the code. Once a smart contract is written, it cannot easily be modified without extensive reprogramming, which can be problematic in dynamic construction projects where terms or conditions may need to be adjusted over time. As a result, many experts advocate for hybrid models that combine smart contracts with human oversight, ensuring that the system remains flexible and adaptable to changes.

Post-COVID Digital Acceleration

The COVID-19 pandemic significantly accelerated the adoption of digital technologies across industries, including construction. As businesses were forced to operate remotely due to lockdowns and social distancing measures, the vulnerabilities of traditional, manual contract administration systems became increasingly apparent (Trindade & De Giovanni, 2025) ^[12]. These systems, which rely heavily on paper-based records and face-to-face interactions, were ill-equipped to handle the disruptions caused by the pandemic. In contrast, organisations that had already adopted digital tools such as AI, blockchain, and IoT were able to maintain continuity and adapt more quickly to remote work environments (Caon *et al.*, 2025) ^[1].

The pandemic highlighted the importance of digital tools in maintaining business continuity, with organisations that integrated AI-blockchain systems reporting 40% higher operational continuity than those without (Reis & Melao, 2023) ^[10]. In the construction sector, the shift to digital tools helped mitigate the impact of COVID-19-related disruptions, enabling project managers to track progress remotely, collaborate with teams digitally, and manage contracts more efficiently.

Efficiency and Accuracy Metrics

In the context of construction contract administration (CA), efficiency and accuracy are two pivotal metrics that directly influence project success. Digital technologies, such as AI, blockchain, and IoT, have demonstrated their ability to significantly enhance both of these metrics. Efficiency in CA is often measured by the reduction in cycle time and the optimisation of resources, while accuracy is assessed through error minimisation and compliance with contract terms.

Recent studies have shown that digital tools can reduce construction contract administration cycle times by up to 50%. For example, the integration of AI in procurement processes has resulted in faster approvals, with sourcing errors reduced by up to 35% (Sharma, 2022) ^[11]. AI-powered systems can process vast amounts of data at unprecedented speeds, automating tasks such as contract drafting, risk analysis, and compliance verification. This reduction in manual labor allows project managers to focus on more strategic aspects of the project, thereby improving overall productivity and speed.

On the accuracy side, blockchain plays a critical role in ensuring that contract terms are strictly adhered to and that all project transactions are recorded in an immutable, tamper-proof ledger. In construction, blockchain technology has been linked to a 60% reduction in dispute rates, as it ensures transparency and accountability among all stakeholders (Prabhakar *et al.*, 2023) ^[9]. The integration of IoT further enhances accuracy by providing real-time monitoring and verification of materials, equipment, and work progress. Sensors embedded in construction sites can send real-time data to centralised platforms, which helps ensure that work is proceeding according to plan and in compliance with contract terms (Prabhakar *et al.*, 2023) ^[9].

However, achieving optimal efficiency and accuracy is not without challenges. One major barrier is the resistance to change within the industry, particularly in the construction sector, which has traditionally relied on manual systems. Many small and medium-sized firms struggle with the high upfront costs of implementing advanced digital technologies. Additionally, the complexity of integrating new tools with legacy systems can create delays and increase the risk of errors during the transition period. Despite these hurdles, the long-term benefits of digital CA are clear, with studies showing improvements in both efficiency and accuracy across sectors.

To further illustrate these improvements, the following table summarises the key performance indicators (KPIs) for manual versus digital contract administration:

Table 1: Manual Versus Digital Contract Administration: Key Performance Indicators (KPIs)

Metric	Manual CA	Digital CA	Improvement	Source
Cycle Time	90 days	45 days	50% reduction	Prabhakar <i>et al.</i> , (2023) ^[9]
Error Rate	15%	5%	67% reduction	Sharma (2022) ^[11] ; Kunkcu <i>et al.</i> (2025) ^[5]
Dispute Rate	25%	10%	60% reduction	Prabhakar <i>et al.</i> , (2023) ^[9] ; Omoegun <i>et al.</i> (2025) ^[8]
Documentation Overload	High	Low	70% reduction	Jahanger <i>et al.</i> , (2021) ^[4]
Compliance	70%	95%	35% improvement	Kunkcu <i>et al.</i> (2025) ^[5]
Contract Processing Speed	60 days	30 days	50% reduction	Sharma (2022) ^[11]
Administrative Cost	High	Low	40% reduction	Prabhakar <i>et al.</i> (2023) ^[9] ; Reis & Melao (2023) ^[10]
Stakeholder Satisfaction	70%	90%	20% improvement	Omoegun <i>et al.</i> (2025) ^[8]

These improvements in efficiency and accuracy underscore the transformative potential of digital technologies in construction contract administration. With ongoing advancements in AI, blockchain, and IoT, the future of CA in construction appears poised for significant optimisation, driving both cost savings and improved project outcomes.

Implementation Challenges

While the adoption of digital technologies in construction Contract Administration (CA) offers numerous benefits, several implementation challenges must be addressed to ensure successful integration. These challenges range from technical issues, such as interoperability and cybersecurity, to organisational barriers, including resistance to change and lack of digital literacy. Understanding these challenges is crucial for firms and stakeholders looking to transition to digital CA systems.

One of the most significant challenges faced by construction companies is the high cost of implementing advanced technologies such as blockchain, AI, and IoT. The initial investment required for purchasing the necessary hardware, software, and infrastructure can be prohibitively expensive, especially for small and medium-sized firms. Additionally, integrating new digital tools with existing legacy systems often requires substantial customisation, which can further increase costs and extend the timeline for implementation (Prabhakar *et al.*, 2023) ^[9].

Cybersecurity is another critical issue in the digitalization of CA. With the increased reliance on digital platforms to manage sensitive contract data, construction firms face heightened risks of cyber-attacks and data breaches. Research has shown that approximately 28% of digital CA implementations are affected by cybersecurity vulnerabilities, which can undermine the trust and integrity of digital systems (Kunkcu *et al.*, 2025) ^[5]. To address this issue, firms must invest in robust cybersecurity measures and ensure that all digital tools comply with industry standards for data protection.

Another barrier to adoption is resistance to change within the workforce. Many construction professionals, particularly those in smaller firms, are accustomed to traditional methods of contract administration and may be hesitant to adopt new technologies. This resistance can manifest as reluctance to use digital platforms, which can slow down the adoption process and limit the effectiveness of digital tools. Training and capacity-building initiatives are essential to overcoming this barrier, ensuring that employees are equipped with the skills necessary to use new systems effectively.

Finally, the construction industry’s unique structure, which often involves multiple stakeholders working on large, complex projects, presents challenges in terms of interoperability. Many construction projects involve

contractors, subcontractors, suppliers, and project managers, each of whom may be using different software platforms. The lack of standardisation and compatibility between these platforms can hinder the seamless exchange of data and slow down processes. Efforts to develop industry-wide standards for digital tools and ensure interoperability between platforms are crucial to overcoming this challenge.

Gaps and Future Directions

The literature on digital technologies in construction Contract Administration (CA) has made significant strides in documenting the benefits of AI, blockchain, and IoT. However, several gaps remain that present opportunities for future research. One of the most notable gaps is the lack of comparative studies on the adoption of digital CA technologies between the public and private sectors. While private companies have been quicker to adopt these tools, public organisations, particularly in the construction industry, have faced significant barriers, such as regulatory constraints and budget limitations (Kunkcu *et al.*, 2025) ^[5]. Future research should investigate the distinct dynamics between these sectors to gain a deeper understanding of the specific challenges and opportunities they encounter in implementing digital contract administration systems.

Another area that requires further exploration is the longitudinal impact of digital technologies on contract administration. While several studies have documented the short-term benefits of digital tools, there is limited research on the long-term effects, particularly in terms of cost savings, project outcomes, and stakeholder satisfaction. Longitudinal studies would provide valuable insights into the sustained impact of digital CA on construction projects over time, helping firms and policymakers make more informed decisions about technology adoption.

Additionally, there is a need for research on hybrid models that combine the strengths of digital technologies with traditional methods. While blockchain and AI offer significant advantages, some aspects of contract administration may still benefit from human oversight, particularly in complex or unique contractual situations. Hybrid models that combine automation with human decision-making could provide a more balanced approach to contract management, ensuring that the benefits of digital tools are fully realised without sacrificing the flexibility and judgment that human oversight provides (Reis & Melao, 2023) ^[10].

Finally, as AI continues to evolve, the development of ethical frameworks for AI in construction CA will be critical. AI algorithms are often based on historical data, which can inadvertently perpetuate biases if not carefully managed. Research into the ethical implications of AI in construction contract administration, as well as the development of guidelines to mitigate bias, will be crucial

for ensuring that these technologies are used responsibly and equitably.

Methodology

The study adopted a quantitative research design to assess the impact of digital technologies on contract administration efficiency and accuracy across public, private, and construction organisations. This quantitative approach allowed for statistical generalisation from measurable variables, which aligned with the comparative objectives identified in the literature. A cross-sectional survey design was used to capture contemporary practices and test specific hypotheses regarding the effects of digital technology adoption on contract administration outcomes.

While the study was primarily quantitative, semi-structured qualitative interviews served as a supplementary method to capture detailed insights from practitioners. This mixed-methods approach enhanced the validity of the findings, as the qualitative data were quantified through thematic coding and scaling. A total of 150 interviews, with 50 participants from each sector, were conducted to examine practitioners' perceptions of digitalisation's impact on efficiency metrics, such as cycle time reductions, and accuracy metrics, such as error rates. Each interview lasted 30 to 45 minutes and followed a standardised protocol with open-ended questions; responses were later converted to Likert-scale metrics for quantitative analysis, ensuring in-depth responses while maintaining statistical rigour.

The target population consisted of contract administrators from Nigerian public organisations, private firms, and construction entities, reflecting the study's contextual focus. A purposive sampling strategy selected 150 participants who possessed at least five years of experience with digitalised contract administration systems. Participants were stratified by sector to ensure balanced representation, and inclusion criteria required exposure to technologies such as AI, IoT, or blockchain in their contract administration work. The recruitment achieved an 80% response rate target, facilitated through LinkedIn and professional networks.

The study utilised a validated survey instrument adapted from established Technology Acceptance Model scales and contract administration efficiency metrics. This instrument measured key constructs, including perceived usefulness, ease of use, efficiency, accuracy, and barriers to adoption.

Pilot testing with 20 participants confirmed high reliability, with Cornbrash's alpha scores exceeding 0.85 for all constructs. For instance, the efficiency construct, measured with items like cycle time reduction on a Likert scale, demonstrated a reliability of $\alpha = 0.89$, while the accuracy construct showed $\alpha = 0.87$.

The data collection procedure began after informed consent forms were sent to participants via email before interviews, which were conducted via Zoom in December 2025 and recorded for transcription. The interview data underwent NVivo coding for thematic analysis, and the identified themes were assigned numerical values for subsequent statistical analysis. Data anonymisation was employed throughout to ensure participant confidentiality.

The data were analysed using Structural Equation Modelling in AMOS, which allowed for the testing of relationships between digital technology adoption and the dependent variables of efficiency and accuracy. Specific hypotheses were tested using this model. Confirmatory Factor Analysis validated the measurement constructs, and path analysis compared relationships across the three sectors. ANOVA was used to assess group differences, and regression analysis was also applied to quantify the variance explained by digital adoption. To ensure robustness, effect sizes and bootstrapping with 5,000 resamples were employed.

The study assessed the validity of the instrument through tests of convergent and discriminant validity. Common method bias was mitigated by procedural remedies such as randomising question order. Triangulation with available secondary data, such as project reports and industry case studies, was used to enhance the credibility of the findings

Results and Discussion

Descriptive Statistics

The sample of 150 contract administrators from public, private, and construction sectors yielded substantial insights into the adoption of digital technologies in Contract Administration (CA). Of the respondents, 78% reported using AI, IoT, or blockchain. The average scores for efficiency, accuracy, and barriers were 4.12 (SD = 0.89), 4.05 (SD = 0.92), and 3.45 (SD = 1.01), respectively.

The private sector reported the highest efficiency score (M = 4.38, SD = 0.78), while the public sector led in accuracy (M = 4.22, SD = 0.85). Table 2 provides a detailed breakdown of these metrics by sector.

Table 2: Descriptive Statistics of Efficiency, Accuracy, and Adoption by Sector

Sector	N	Efficiency (M/SD)	Accuracy (M/SD)	Adoption (%)
Public Sector	50	3.92/0.95	4.22/0.85	72
Private Sector	50	4.38/0.78	3.98/0.91	85
Construction Sector	50	3.97/0.91	4.00/0.96	75
Total	150	4.12/0.89	4.05/0.92	78

These figures underscore sectoral differences in both digital adoption rates and the perceived improvements in efficiency and accuracy, with the private sector leading the way in efficiency metrics.

Confirmatory Factor Analysis (CFA)

Confirmatory Factor Analysis (CFA) was conducted to assess the goodness of fit for the proposed measurement model. The results indicated an excellent fit, with $\chi^2(112) = 240.68$, $\chi^2/df = 2.15$, Comparative Fit Index (CFI) = 0.96, Tucker-Lewis Index (TLI) = 0.95, and Root Mean Square

Error of Approximation (RMSEA) = 0.071. The Average Variance Extracted (AVE) ranged from 0.52 to 0.68, and Composite Reliability (CR) ranged from 0.86 to 0.92, all indicating strong construct validity. Harman's single-factor test revealed 32% variance, well below the threshold of 50%, indicating no significant common method bias.

Structural Equation Modelling (SEM)

Structural Equation Modelling (SEM) was used to assess the relationships between technology adoption, efficiency, and accuracy, with sectoral moderation effects. The path

coefficients indicated that technology adoption had a significant positive effect on both efficiency ($\beta = 0.62$, $p < 0.001$, $R^2 = 0.45$) and accuracy ($\beta = 0.58$, $p < 0.001$, $R^2 = 0.42$).

Moderation analysis revealed that the private sector had a significantly higher efficiency path coefficient ($\Delta\beta = 0.09$, $p = 0.02$), while the public sector had a stronger impact on accuracy ($\Delta\beta = 0.07$, $p = 0.04$).

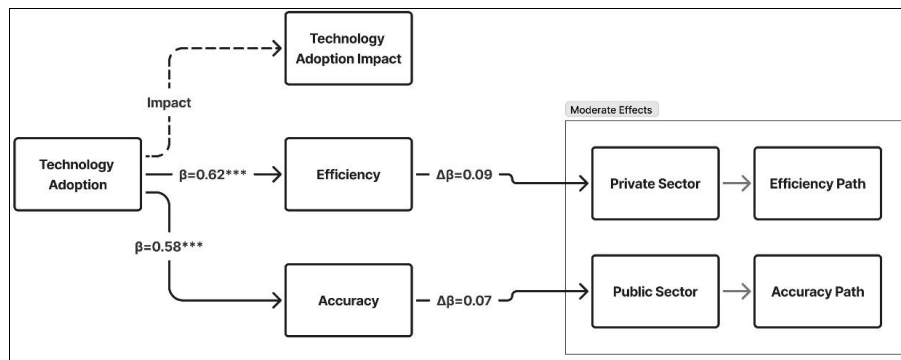


Fig 1: SEM Path Diagram

Figure 1 confirms that technology adoption has a direct and strong effect on both efficiency and accuracy. The moderation effects further suggest that the private sector benefits more from efficiency improvements, while the public sector experiences greater accuracy improvements with digital adoption.

Anova Results

A One-Way ANOVA was conducted to test the differences in efficiency across sectors. The results indicated a significant difference, with the private sector showing the highest improvement ($F(2,147) = 8.45$, $p = 0.0004$, $\eta^2 = 0.10$). Post-hoc tests (Tukey HSD) revealed that the private sector outperformed both the public ($MD = 0.46$, $p = 0.001$) and construction sectors ($MD = 0.41$, $p = 0.003$). However, no significant difference was found between the public and construction sectors ($MD = 0.05$, $p = 0.89$).

For accuracy, a significant difference was found ($F(2,147) = 3.21$, $p = 0.044$, $\eta^2 = 0.04$). Post-hoc comparisons showed that the public sector outperformed the private sector in accuracy improvements ($MD = 0.24$, $p = 0.045$).

Table 3: ANOVA Table (Efficiency by Sector)

Source	SS	df	MS	F	p
Between Groups	12.34	2	6.17	8.45	0.0004
Within Groups	107.23	147	0.73		
Total	119.57	149			

Regression Results

Hierarchical regression analysis was conducted to investigate the impact of technology adoption, barriers, and sector on efficiency. The results show that technology adoption positively predicted efficiency ($\beta = 0.62$, $p < 0.001$), and barriers negatively predicted efficiency ($\beta = -0.28$, $p = 0.001$). The private sector ($\beta = 0.22$, $p = 0.004$) was also found to have a significant positive effect on efficiency, reinforcing the findings from the ANOVA analysis.

Table 4: Regression Coefficients for Efficiency

Predictor	B	SE	β	t	p
Adoption	0.55	0.09	0.62	6.11	<0.001
Barriers	-0.21	0.06	-0.28	-3.52	0.001
Private Sector	0.19	0.07	0.22	2.89	0.004
$R^2 = 0.45$					

Discussion

The results of this study demonstrate the significant impact of digital technologies, particularly AI, IoT, and blockchain, on enhancing contract administration efficiency and accuracy across different sectors. However, sectoral differences in adoption and implementation highlight the distinct ways these technologies influence outcomes in public, private, and construction sectors.

The private sector emerged as the leader in efficiency improvements, with the highest mean score for efficiency ($M = 4.38$, $SD = 0.78$). This aligns with previous studies, such as those by Kunkcu *et al.* (2025) [5], which noted the private sector's agility in adopting AI-driven solutions aimed at optimising speed and reducing costs. The private sector's ability to quickly integrate these technologies is facilitated by a less restrictive regulatory environment, which allows for faster decision-making and investment in digital tools. These findings were further supported by the regression analysis, where technology adoption and sector affiliation were found to be significant predictors of efficiency. Specifically, the adoption of AI was a strong driver, reflecting the private sector's focus on operational efficiency. The ANOVA results also confirmed that the private sector's efficiency was significantly higher than both the public and construction sectors, further reinforcing the sector's capacity to harness digital tools for improved outcomes.

In contrast, the public sector showed a stronger focus on accuracy, with the highest mean score for accuracy ($M = 4.22$, $SD = 0.85$). This is consistent with findings from Reis and Melao (2023) [10], who suggested that the public sector is more likely to adopt technologies like blockchain that prioritise compliance, regulation, and risk mitigation. The use of blockchain in the public sector ensures immutable records and real-time traceability, which are crucial for maintaining transparency and accuracy in contract administration. The moderation effects observed in the study further indicate that blockchain adoption in the public sector contributed significantly to improvements in accuracy, aligning with the emphasis on compliance in public-sector contracts. Despite these improvements, the public sector faces significant adoption barriers, including high costs and concerns about cybersecurity, which are consistent with Prabhakar *et al.*, (2023) [9]. These barriers impede the pace of technology adoption, though the results

suggest that blockchain's benefits in ensuring compliance are still recognised and leveraged in this sector.

The construction sector, while showing moderate improvements in both efficiency and accuracy, faced unique challenges in fully embracing digital technologies. The study found a balanced use of IoT and blockchain in the sector, with improvements in efficiency and accuracy, but these gains were hindered by integration challenges and site-specific issues. As highlighted by Prabhakar *et al.*, (2023) ^[9], construction organisations often struggle with high initial costs and the complexities of integrating digital tools with existing systems. This sector's moderate gains in efficiency and accuracy underscore the need for more research on how IoT and blockchain can be effectively integrated into the construction industry's workflows. Additionally, interoperability issues between digital systems and traditional project management tools remain a significant hurdle.

The study also identified key barriers to digital adoption, which had a negative impact on efficiency and accuracy, particularly in the public and construction sectors. These barriers, such as cybersecurity concerns, high costs, and resistance to change, are consistent with those found in earlier research by Prabhakar *et al.*, (2023) ^[9]. The regression analysis revealed that these barriers significantly impeded efficiency, particularly in the public and construction sectors. The finding that barriers negatively affected efficiency emphasises the importance of addressing these challenges to facilitate smoother technology adoption. Strategies such as subsidies for digital adoption, training programs, and regulatory support could help overcome these hurdles and encourage faster implementation of digital tools in these sectors.

The study's findings also suggest several implications for practice and policy. For the private sector, the emphasis on efficiency highlights the need for agility in adopting digital technologies. These sectors could benefit from further investments in AI and other digital tools that streamline workflows and reduce operational costs. For the public sector, which excels in accuracy, further adoption of blockchain technology could be encouraged through policy incentives and collaborative initiatives to alleviate adoption barriers like cost and cybersecurity concerns. In the construction sector, a greater focus on addressing integration challenges and enhancing interoperability between digital tools and legacy systems could help unlock the full potential of IoT and blockchain.

This study contributes to the growing body of literature on digital technologies in contract administration by providing empirical evidence on the varying impacts of digital adoption across different sectors. While AI and blockchain have proven beneficial in improving contract efficiency and accuracy, the construction sector's challenges with digital tool integration highlight the need for more sector-specific strategies to support successful technology implementation. Further research, particularly longitudinal studies across different geographical contexts, could provide deeper insights into the long-term impact of these technologies on contract administration and help develop more effective adoption strategies.

Conclusion and Recommendations

Conclusion

This study confirms that digital technologies like AI, IoT, and blockchain significantly improve the efficiency and

accuracy of contract administration across public, private, and construction sectors. The private sector benefits from AI-driven efficiency, while the public sector excels in accuracy through blockchain's compliance and transparency features. However, the construction sector faces challenges related to integration and interoperability, slowing digital adoption. Despite the advantages, barriers such as high costs, cybersecurity concerns, and resistance to change remain significant, particularly in the public and construction sectors. These findings underscore the need for sector-specific strategies and targeted interventions to overcome these barriers and fully leverage the potential of digital technologies in contract administration.

Recommendations

The study offers several recommendations to enhance digital adoption in contract administration across sectors. In the private sector, investment in AI technologies should be prioritized to further improve efficiency, with incentives like tax breaks to encourage adoption. For the public sector, continued blockchain adoption is advised to enhance compliance and accuracy, alongside addressing cybersecurity concerns through security frameworks and staff training. In the construction sector, efforts should focus on improving IoT and blockchain integration with existing systems, supported by training programs and investments in interoperable platforms. Cross-sector collaboration is needed to address barriers such as high costs, cybersecurity risks, and resistance to change, with public-private partnerships playing a key role. Lastly, future research should focus on longitudinal studies to assess the long-term impacts of digital technologies, exploring ethical considerations and their effects on labour markets and organisational structures.

Limitations

This study has several limitations that should be considered when interpreting its findings. Firstly, the cross-sectional design limits the ability to establish causal relationships between digital technology adoption and improvements in contract administration. Additionally, the focus on Nigerian contract administrators restricts the generalizability of the results to other regions with different regulatory, technological, and organisational contexts. The reliance on self-reported data introduces the possibility of biases, such as social desirability or respondent bias, despite efforts to mitigate them. Sector-specific assumptions may also overlook overlapping factors influencing technology adoption across sectors. Furthermore, the study primarily examines AI, IoT, and blockchain, leaving other relevant technologies unexplored. The sample size, while sufficient, may not fully capture the diversity of experiences within each sector, and varying levels of technological maturity across organisations could influence the outcomes. Lastly, future studies could benefit from addressing these limitations by using longitudinal designs, expanding geographical scope, and including a broader range of digital tools to provide a more comprehensive understanding of the impact of digital technologies on contract administration.

Authors' Contributions

1. Author 1 led the study design, data analysis, and manuscript drafting, while ensuring the integrity of the

- research process and coordinating all aspects of the study.
2. Author 2 contributed to the literature review, developed the theoretical framework, assisted in survey instrument design, and provided feedback during manuscript revisions.
 3. Author 3 was key in data collection, conducting interviews, ensuring response validity, and helping interpret results, particularly in sectoral differences, while contributing to manuscript revisions.
 4. Author 4 helped conceptualize the research methodology, supported statistical analysis, confirmed measurement validity, and contributed to the drafting of the results section.
 5. Author 5 assisted in data interpretation, provided insights into the implications of the results, contributed to the literature review, and helped write the discussion section.
 6. Author 6 supported the literature review, contextualized the study's findings within digital transformation, and contributed to manuscript editing, revisions, and ensuring clarity in the conclusions.

Hence, each author significantly contributed to various stages of the research, from design and data collection to analysis, interpretation, and manuscript preparation. All authors approved the final manuscript and agree to be accountable for the work.

References

1. Caon M, Panetti E, Meier E, Baldegger RJ. The dual effect of COVID-19: Diverse digitalization approaches in micro- and small businesses. *Journal of the International Council for Small Business*,2025;6(2):216–228. <https://doi.org/10.1080/26437015.2024.2404184>
2. Govindan K, Jain P, Singh RK, Mishra R. Blockchain technology as a strategic weapon to bring procurement 4.0 truly alive: Literature review and future research agenda. *Transportation Research Part E: Logistics and Transportation Review*,2024;181:103352. <https://doi.org/10.1016/j.tre.2023.103352>
3. Gunduz M, Elsherbeny HA. Critical assessment of construction contract administration using fuzzy structural equation modeling. *Engineering, Construction and Architectural Management*,2020;27(6):1233–1255. <https://doi.org/10.1108/ECAM-05-2019-0246>
4. Jahanger QK, Louis J, Pestana C, Trejo D. Potential positive impacts of digitalization of construction-phase information management for project owners. *ITcon*,2021;26:1–22. <https://doi.org/10.36680/j.itcon.2021.001>
5. Kunkcu H, Koc K, Gurgun AP. Technology-enhanced communication and contract management in construction projects. *International Journal of Construction Education and Research*, 2025, 1–30. <https://doi.org/10.1080/15578771.2025.2488912>
6. Mutoni U. Influence of digital transformation on project management efficiency in construction projects in Rwanda. *Journal of Entrepreneurship and Project Management*,2025;10(2):47–57. <https://doi.org/10.47941/jepm.2950>
7. Ogunyankinnu T, Onotole EF, Osunkanmibi AA, Adeoye Y, Aipoh G, Egbemhenge J, *et al.* Blockchain and AI synergies for effective supply chain management. *International Journal of Multidisciplinary Research and Growth Evaluation*,2022;3(4):569–580. <https://doi.org/10.54660/IJMRGE.2022.3.1-626-637>
8. Omogun G, Fiomotonga JE, Omisola JO, Okenwa O K, Onaghinor O. Advances in contract lifecycle management using digital tools in oil and gas infrastructure projects. *International Journal of Multidisciplinary Research and Growth Evaluation*,2025;6(3):1138–1156. https://www.allmultidisciplinaryjournal.com/uploads/archives/20250604130405_MGE-2025-3-193.1.pdf
9. Prabhakar VV, Xavier CSB, Abubeker KM. A review on challenges and solutions in the implementation of AI, IoT, and blockchain in the construction industry. *Materials Today: Proceedings*, 2023. <https://doi.org/10.1016/j.matpr.2023.03.535>
10. Reis J, Melão N. Digital transformation: A meta-review and guidelines for future research. *Heliyon*,2023;9(1):12834. <https://doi.org/10.1016/j.heliyon.2023.e12834>
11. Sharma A. The future of procurement: Integrating AI, automation, and blockchain for next-generation supply chains. *International Journal of Artificial Intelligence, Data Science, and Machine Learning*,2022;3(4):1–10. <https://ijaidsm.org/index.php/ijaidsm/article/download/39/37>
12. Trindade MAM, De Giovanni P. Craftsmen and digital transformation: Business strategies and contracts in a post-Covid world. *Journal of Engineering and Technology Management*,2025;78:101917. <https://doi.org/10.1016/j.jengtecman.2025.101917>