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BLOCKCHAIN TECHNOLOGY FOR PREVENTING FINANCIAL FRAUD IN KAZAKHSTAN'S CONSTRUCTION SECTOR: COMPARATIVE INSIGHTS

This article examines how blockchain technology can mitigate financial fraud in Kazakhstan's construction sector and situates Kazakhstan's experience within broader digitalisation trends in Uzbekistan and Kyrgyzstan. The study uses a qualitative, comparative design based on a systematic review of recent peer-reviewed articles (2020–2025), policy reports, and authoritative news sources on blockchain-enabled public procurement, digital public finance, and construction management in Central Asia. The analysis shows that blockchain's core properties – immutability, shared traceability, and smart-contract automation – map directly onto fraud-prone stages of public construction projects, including tendering, contract execution, and material supply. Pilot projects such as Kazakhstan's "digital tenge" central bank digital currency (CBDC) and related initiatives in Uzbekistan and Kyrgyzstan suggest that distributed ledgers can improve auditability, reduce opportunities for bid-rigging and invoice fraud, and create verifiable supply-chain records, although limited legal recognition of smart contracts, governance issues in permissioned blockchains, and capacity gaps among officials and suppliers constrain impact.

Keywords: blockchain, financial fraud, construction industry, public procurement, anti-corruption.

Introduction

The construction sector in Kazakhstan is a critical engine of economic growth, but it is also highly exposed to financial fraud and corruption. Public procurement in infrastructure projects often suffers from collusion, bribery, and

falsified documentation, which translate into cost overruns, delays, and substandard outcomes. These problems echo broader governance concerns in the country's anti-corruption assessments [1]. Strengthening transparency, auditability, and traceability in construction finance is therefore a policy priority.

Globally, blockchain technology has been proposed as a way to enhance accountability by recording transactions in tamper-evident, append-only ledgers. In public procurement and project management, blockchain can support traceable bidding, immutable contracts, and automated payments via smart contracts, thereby reducing opportunities for fraud and corruption [2]; [3]. Industry analyses further suggest that blockchain-based monitoring of construction materials and payments can limit invoice fraud, material substitution, and double-billing [4]; [5].

Kazakhstan has begun to experiment with these tools. In 2023–2024, the National Bank and several ministries launched pilots of the «digital tenge» CBDC, including its use in public procurement and subsidies. In these pilots, programmable smart contracts are designed to disburse funds only to verified entities and for approved purposes, based on data from official registries [6]. One of the pilots is explicitly oriented towards construction procurement, aiming to make budget spending more transparent and efficient. Regionally, Uzbekistan is digitising construction permits and civil records to reduce opportunities for graft [7]; [8], while Kyrgyzstan has announced plans to migrate all government services to blockchain platforms by 2028 [9].

Despite these developments, rigorous academic analysis of blockchain's anti-fraud potential in Central Asia's construction sector remains scarce. This paper addresses that gap by systematically reviewing recent scholarship and practice on blockchain applications in procurement and construction, with a focus on Kazakhstan and comparative insights from Uzbekistan and Kyrgyzstan. The working hypothesis is that blockchain, when embedded in reformed procurement processes and supported by adequate legal and technical capacity, can substantially reduce fraud opportunities but cannot substitute for broader governance reforms. Our contributions are threefold: (1) an analytical framework linking blockchain functions to specific fraud risks in construction; (2) a comparative overview of digital transparency reforms in the three countries; and (3) policy recommendations tailored to Kazakhstan's legal-institutional context. The findings indicate that blockchain's main value lies in its immutable audit trail and smart-contract enforcement, but successful implementation depends on supportive legislation, digital infrastructure, and stakeholder readiness [10]; [11]; [12].

Materials and methods

Given the exploratory nature of the topic and the absence of controlled experiments, this study adopts a qualitative, comparative research design.

First, a systematic literature review was conducted on blockchain applications in public procurement and construction. Academic databases (e.g., ScienceDirect, MDPI, EAI Digital Library) and relevant institutional websites (e.g., UNDP, OSCE, Transparency International) were searched using combinations of keywords such as «blockchain», «construction», «public procurement», «corruption», and «fraud». The search focused on sources published between 2020 and 2025 and yielded more than twenty relevant documents. After screening for relevance and quality, we retained fifteen core sources, including peer-reviewed articles, reports by international organisations, and authoritative industry analyses.

Second, a contextual analysis was carried out for Kazakhstan, Uzbekistan, and Kyrgyzstan. For each country, we reviewed official strategies (e.g., Digital Kazakhstan, Digital Uzbekistan 2030), central bank publications, and press releases related to blockchain and CBDC initiatives. We also examined national corruption indicators using Corruption Perceptions Index (CPI) scores from Transparency International (2024a, 2024b, 2024c) to gauge the governance environment in which technological reforms are unfolding.

Third, insights were synthesised into an evaluative framework. Blockchain applications were grouped into three functional categories: (i) procurement transparency (e.g., tamper-proof tender bids, public dashboards); (ii) contract enforcement (smart contracts automating payments and penalties); and (iii) supply-chain integrity (material tracking and certification). Within each category, we mapped how blockchain addresses specific fraud schemes – such as bid-rigging, invoice fraud, and material substitution – based on the literature [2]; [3; [4]. Organisational prerequisites (infrastructure, skills, governance) highlighted in policy reports were also identified [5]; [7].

In operational terms, the main research question guiding these steps is how blockchain-based solutions can be designed and implemented to reduce financial fraud risks in Kazakhstan's construction sector, and what lessons can be drawn from the experiences of Uzbekistan and Kyrgyzstan. No formal statistical hypothesis is tested; instead, the study adopts an exploratory, qualitative design that aims to build an integrated analytical and conceptual framework suitable for policy-oriented analysis.

The approach is predominantly qualitative; however, quantitative indicators (e.g., CPI scores) are used to support contextual claims where data are available. Limitations of the method include reliance on published information and the lack of primary interviews or project-level transaction data. These are partially mitigated by triangulating multiple independent sources. Overall, the methodology aims to provide a coherent, evidence-based narrative and conceptual framework suitable for policy-oriented analysis.

Results and discussion

The analysis shows that blockchain's core technical features – decentralisation, immutability, and programmability – align closely with typical vulnerabilities in construction finance.

First, decentralised ledgers can replace opaque, siloed record-keeping with shared, synchronised databases. A blockchain-based procurement system would allow government agencies, contractors, auditors, and possibly citizens to view the same verified records of tender announcements, bids, contract awards, and payments. This multi-party visibility deters collusion by making it difficult to alter or conceal records after the fact. If all tender bids and awards are logged on a public or permissioned blockchain, attempts to change bid deadlines, tamper with evaluation scores, or quietly re-award contracts would be immediately evident to other nodes in the network [2]; [3].

Second, immutability ensures that once invoices, material certificates, or approvals are recorded, they cannot be erased or backdated without leaving a trace. In conventional project accounting, falsified or duplicated invoices can be introduced or substituted ex post. With blockchain, each such document is hashed and timestamped, creating a verifiable digital fingerprint that auditors can cross-check. Azobuild (2023) reports that blockchain-based tracking of construction materials allowed immediate tracing of defective batches and reduced overall material losses. This makes counterfeit or uncertified materials far more difficult to pass off as genuine.

Third, smart contracts enable automatic enforcement of contractual conditions. In construction, many payments and penalties depend on verifiable milestones, such as completion of work stages, passing of inspections, or delivery of specific quantities of materials. By encoding these rules into smart contracts, funds are released only when pre-defined on-chain evidence (e.g., verified inspection results, geo-tagged photos) is present. This reduces discretion and opportunities for unauthorised payments or delays. Khalfan et al. (2022) argue that such automatic, traceable fund transfers help build trust by making every payment event auditable and linking it explicitly to contractual performance. EY (2023) further notes that integrating blockchain with analytics can support near real-time risk monitoring in public finance.

Taken together, these features address key fraud vectors in public construction projects: manipulation of tender outcomes, invoice fraud, and material substitution. They also support continuous auditing rather than occasional, sample-based checks, which is particularly valuable in environments with limited enforcement capacity. Table 1 – summarises how core blockchain features map onto specific fraud-prone areas in construction finance and clarifies their expected anti-fraud effects.

Table 1 – Blockchain features and fraud-prone areas in construction finance

Fraud-prone area in public construction finance	Typical vulnerabilities and schemes	Relevant blockchain feature(s)	Expected anti-fraud effect
Bidding and tendering	Bid-rigging, hidden amendments to tender documents, opaque pre-qualification	Shared, time-stamped ledger of tender events; transparent access for authorised actors	Makes tender publications, clarifications and submissions traceable; harder to alter or back-date documents
Contract award and signing	Favouritism in award decisions, undisclosed side agreements	Immutable record of award decisions and contract terms	Reduces ability to change contract conditions ex post without leaving a trace
Progress payments and interim certificates	Over-billing, payments for unperformed work, fake certificates of completion	Smart contracts tied to verified milestones; decentralised validation of certificates	Links payments to objective proof of completion (e.g. digital sign-off), reducing scope for fictitious progress
Materials and supply chain	Use of sub-standard or counterfeit materials, invoice fraud, circular billing	Tokenisation of materials; traceable supply-chain records on a shared ledger	Enables tracking of origin, quantities and movements of materials; makes "ghost suppliers" easier to detect
Change orders and contract variations	Inflated change orders, abuse of variations to circumvent original tender terms	Immutable history of all change orders and approvals	Ensures that changes and their justifications are logged; easier to audit unusual cost growth

Final acceptance and retention payments	Manipulated acceptance reports, premature release of retention money	Smart contracts for retention release; multi-party digital sign-off	Automates release of retention only when agreed conditions are met and signed by all required parties
Note – compiled by the authors on the basis of the sources [3]; [7]			

As Table 1 indicates, blockchain does not eliminate fraud risks uniformly across the project cycle; rather, it is most powerful where processes can be formalised as verifiable events and encoded into smart-contract logic. Areas that rely heavily on discretionary expert judgment, such as project scoping or quality assessment, still require strong governance and professional ethics.

Despite their potential, blockchain solutions face significant implementation challenges that may blunt their anti-fraud impact.

A first set of challenges concerns the legal and policy framework. Silva-Atencio et al. (2025) emphasise that, without supportive laws, blockchain's evidentiary and contractual advantages remain uncertain. In Uzbekistan, for example, UNDP has highlighted the importance of updating legislation on digital signatures, data protection, and smart contracts to underpin blockchain pilots in the civil registry [7]. In Kazakhstan, the Public Procurement Law and civil code do not yet explicitly recognise blockchain-based contracts or automated execution via smart contracts. Without legal clarity, disputes over blockchain-recorded transactions may end up being adjudicated under rules designed for paper contracts, limiting the technology's usefulness. Regulatory guidance is also needed on data governance, liability for network failures, and supervision of CBDC-based procurement.

Second, governance of permissioned blockchains is crucial. In procurement and construction, fully public, permissionless blockchains are unlikely; instead, consortia or state-run permissioned networks are expected. These require clear rules about who can join, who can validate transactions, and how access rights are managed. Silva-Atencio et al. (2025) note that technology must be accompanied by ethics training and stakeholder engagement to prevent the emergence of new power asymmetries inside the network. EY (2023) similarly warns that poor governance design can recreate centralised bottlenecks and introduce new risks. For Kazakhstan, this implies inter-agency agreements, delineation of roles for ministries, regulators, and auditors, and potentially a dedicated legal act governing blockchain-based public finance systems.

Third, technical and capacity constraints pose barriers. Blockchains must handle high transaction volumes if they are used to record all tender, contract, and payment events. Even in permissioned environments, issues such as throughput, latency, and storage costs must be addressed. Privacy is another concern: procurement data often contain commercially sensitive information that cannot be fully public, necessitating careful design of data access, anonymisation, or cryptographic techniques. Moreover, many construction firms, especially small and medium-sized contractors, may lack the digital infrastructure and skills needed to interact with blockchain-based systems. As highlighted in policy reports, grasping new technology can be daunting for stakeholders accustomed to paper-based procedures, making sustained training and support essential [5]; [7].

Finally, country-level contextual readiness varies. According to the 2024 CPI, Kazakhstan scores 40, Uzbekistan 32, and Kyrgyzstan 25, indicating significant but differing levels of perceived corruption [1]; 11]; [12]. All three countries are pursuing digital reforms, but starting from different institutional baselines. These scores suggest both the magnitude of the governance challenge and the potential gains from successful digital anti-corruption reforms.

Kazakhstan. Kazakhstan's blockchain ecosystem is nascent but dynamic. The launch of the digital tenge CBDC reflects openness to distributed ledger innovation in monetary and fiscal operations. By March 2024, key ministries had endorsed a roadmap to use the digital tenge in selected public procurement and subsidy programmes, including pilots in construction services [6]. The CBDC design involves smart contracts interfacing with government databases and maintaining white and black lists of legal entities, ensuring that only vetted companies can receive state funds. This programmability enables spending controls that can prevent diversion of funds and simplify ex post audits. Parallel to CBDC experiments, Kazakhstan has been upgrading its e-procurement platform and training regulators and prosecutors in blockchain analytics [5]; [10]. These developments suggest growing institutional capacity, even though comprehensive blockchain integration into construction procurement is still at an early stage.

Uzbekistan. Uzbekistan offers an instructive example of stepwise digitalisation. With a CPI score of 32, it faces severe governance challenges but has pursued ambitious e-governance reforms. The Transparent Construction platform in Tashkent functions as a one-stop portal for building permits, reducing personal contact and opportunities for bribery [8]. UNDP-supported pilots have introduced blockchain in the civil registry to secure vital records against tampering [7]. The government's Digital Uzbekistan 2030 strategy explicitly mentions blockchain as a tool for strengthening public trust in state data. While construction-specific blockchain pilots are still limited, the existence of digital permitting pipelines

and broader legal reforms create a favourable foundation for future integration of blockchain into construction procurement.

Kyrgyzstan. With the lowest CPI score (25) among the three countries, Kyrgyzstan faces a particularly challenging environment. Yet its leadership has articulated the most far-reaching blockchain vision, pledging to move all government services to blockchain by 2028 and to create a state crypto reserve and a gold-backed stablecoin (USDKG) [9]. If realised, such reforms could eventually encompass land registries, cadastral maps, and public procurement systems. For construction, this could mean that land allocation, permitting, contract awards, and payments are all recorded on a single distributed ledger. The ambition of this plan underscores the role of political will in driving digital anti-corruption reforms but also raises concerns about implementation capacity and the risk of over-promising.

The comparison suggests that Kazakhstan is experimenting cautiously through targeted pilots; Uzbekistan is building enabling digital infrastructure and legal reforms; and Kyrgyzstan is pursuing a bold, system-wide blockchain agenda. Kazakhstan can learn from both the incremental approach in Uzbekistan and the strategic signalling in Kyrgyzstan when designing its own roadmap for construction procurement.

To illustrate the potential financial impact of blockchain, consider a hypothetical public construction project in Kazakhstan with a budget of 10 billion KZT (approximately USD 22 million). Empirical estimates from international organisations suggest that corruption-related leakage in public investment projects can reach 5–10 % in high-risk environments. If blockchain-based procurement, invoicing, and payment systems reduce this leakage even by half, savings would be in the order of 250–500 million KZT per project.

In addition, blockchain can support new financial mechanisms such as integrity retention funds. For example, a smart contract could hold back 5 % of project funds in escrow until an independent audit confirms completion without major irregularities. This creates financial incentives for contractors to comply with rules and avoid fraud. While a full cost–benefit analysis requires detailed pilot data, existing case studies indicate that efficiency gains, reduced dispute resolution costs, and lower audit expenses can offset the initial investment in blockchain infrastructure [2]; [5].

The analysis underscores that the novelty of applying blockchain in Kazakhstan's construction sector lies in incorporating technology, law, and institutional capacity into a single framework.

From a policy perspective, the main message is that blockchain should be seen as an enabler within a broader anti-corruption strategy rather than a stand-alone solution. UNDP and OSCE experiences in Central Asia highlight that user capacity,

ethics training, and regulatory compliance are as important as technical design [7]; [10]. For Kazakhstan, reforms could include amendments to procurement and civil law to recognise electronic and smart contracts, guidelines on storing and auditing blockchain records, and integration with existing e-procurement and financial management systems.

From a comparative standpoint, Uzbekistan's gradual approach – first digitising records and services, then piloting blockchain – suggests that building intermediate digital infrastructure is prudent. Kazakhstan could prioritise full electronic procurement and high-quality data before layering blockchain for verification. Kyrgyzstan's comprehensive vision, in turn, illustrates the value of strong political signalling, though it also warns about the risks of over-extension. Kazakhstan's relatively higher institutional capacity gives it an opportunity to balance ambition with realism.

To highlight similarities and differences across the three contexts, Table 2 provides a comparative snapshot of blockchain-related reforms and their relevance for construction and public procurement.

Table 2 – Blockchain-related reforms and readiness in Kazakhstan, Uzbekistan and Kyrgyzstan

Country	Stance on blockchain	Blockchain / CBDC initiatives	Use cases relevant to construction	Key factors	Main risks
Kazakhstan	Positions itself as a regional digital hub; strong policy focus on fintech and e-gov	Pilot of the "digital tenge" (CBDC); experiments with blockchain in public finance and tax administration	Early pilots in public procurement and potential integration into construction tenders	Relatively advanced digital infrastructure; experience with e-gov portals; strong political interest in fintech	Legal framework for smart contracts is incomplete; governance of permissioned networks not fully defined; skills gaps among procurers and contractors
Uzbekistan	Gradual, state-led digitalisation of public services; emphasis on reducing bureaucracy	Blockchain pilots for land registries and selected public services; exploration of digital identity solutions	Potential application to permitting, land use and municipal construction projects	Centralised reform drive; visible anti-corruption agenda; support from international partners	Fragmented legacy systems; limited interoperability; capacity constraints at local authority level; cautious regulatory stance on new technologies
Kyrgyzstan	Ambitious rhetoric around moving many public services to blockchain platforms by 2028	Strategic plans to digitise state services using blockchain; early regulatory discussions	Prospective use cases in public procurement and infrastructure projects rather than large-scale pilots to date	Strong political signalling; openness to innovation; opportunity to leapfrog via new systems	Fiscal and institutional capacity are constrained; risk that announcements outpace implementation; need for clear standards and donor coordination
Note - compiled by the authors on the basis of the sources [1; 11; 12]					

The comparison in Table 2 shows that Kazakhstan starts from a stronger digital and institutional baseline than its neighbours, but also faces more complex legacy systems. Uzbekistan's and Kyrgyzstan's experiences underline that ambitious blockchain plans must be matched with realistic implementation capacity, otherwise expectations around anti-corruption impact are likely to be disappointed.

From a theoretical and methodological viewpoint (JEL O33, D73, K42, L74, C81), blockchain in construction sits at the intersection of innovation diffusion, public administration reform, legal adaptation, and sector-specific governance. Our qualitative comparative method provides a way to assess such policy innovations even when experimental or project-level data are limited. Future work could complement this analysis with quantitative evaluations of specific pilots, using fraud indices or audit findings before and after blockchain implementation.

Conclusions

This study has explored how blockchain technology can help prevent financial fraud in Kazakhstan's construction sector, drawing on comparative insights from Uzbekistan and Kyrgyzstan. The literature and policy evidence reviewed indicate that blockchain's key properties – immutability, decentralised traceability, and smart-contract automation –provide powerful tools for enhancing transparency and accountability in procurement and project management. Kazakhstan has already initiated promising measures, such as pilots of the digital tenge CBDC in public procurement and training of regulators in blockchain analytics.

However, realising blockchain's full potential requires parallel reforms. Legal frameworks must be updated to recognise blockchain-based contracts and records; governance structures for permissioned networks must be carefully designed; and public officials, auditors, and suppliers need new skills to use and trust the system. Experiences from Uzbekistan and Kyrgyzstan show that blockchain is not a cure-all: the technology's effectiveness depends heavily on pre-existing governance quality and the consistency of broader institutional reforms.

For Kazakhstan, a phased approach appears most appropriate. In the short term, authorities could (i) expand high-quality e-procurement and digital record-keeping, (ii) pilot blockchain in large, high-risk construction projects, and (iii) develop regulatory guidelines for CBDC-based procurement. In the medium term, results from these pilots should inform legislative amendments and the design of sector-wide blockchain platforms. International organisations such as UNDP and OSCE can continue to play a useful role by funding pilots and providing technical assistance.

Ultimately, the success of blockchain as an anti-fraud instrument in construction will be measured not by the number of nodes or lines of code, but

by tangible reductions in corruption, better quality infrastructure, and higher public trust in state spending (JEL G38, K42). The framework and comparative perspective proposed in this paper provide a basis for future empirical evaluations and for policy dialogue in Kazakhstan and similar emerging economies that seek to harness blockchain for integrity in public construction.

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ҚАЗАҚСТАННЫҢ ҚҰРЫЛЫС САЛАСЫНДА ҚАРЖЫЛЫҚ АЛАЯҚТЫҚТЫ БОЛДЫРМАУ ҮШІН БЛОКЧЕЙН ТЕХНОЛОГИЯСЫ: САЛЫСТЫРМАЛЫ ТАЛДАУ

Бұл мақала Қазақстандағы құрылыс саласындағы қаржылық алаяқтықты блокчейн технологиясының көмегімен қалай азайтуға болатынын қарастырады және Қазақстандағы тәжірибені Өзбекстан мен Қырғызстандағы кең ауқымды цифрландыру үрдістері аясында орналастырады. Зерттеу Орталық Азияда блокчейн негізіндегі мемлекеттік сатып алу, цифрлық мемлекеттік қаржы және құрылыс басқару салаларындағы соңғы рецензияланған мақалаларды (2020–2025 жж.), саясаттық есептер мен беделді ақпарат көздерін жүйелі шолуға негізделген сапалық, салыстырмалы дизайнды пайдаланады. Талдау блокчейннің негізгі қасиеттері – өзгеріссіздік, ортақ іздеу мүмкіндігі және смарт-келісімшарт автоматтандыруы – мемлекеттік құрылыс жобаларының тендер өткізу, келісімшартты орындау және материалдармен жабдықтау

сияқты алаяқтыққа бейім кезеңдеріне тікелей сәйкес келетінін көрсетеді. Қазақстанның «сандық теңге» орталық банктің сандық валютасы (CBDC) сияқты пилоттық жобалар мен Өзбекстан мен Қырғызстандағы ұқсас бастамалар таратылған регистрлердің аудиттілікті жақсарта алатынын, тендерде манипуляция жасау мен шот-фактура алаяқтығын азайта алатынын және тексерілетін жабдықтау тізбегі жазбаларын жасай алатынын көрсетеді, дегенмен смарт-келісімшарттардың заңдық мойындалуының шектеулі болуы, рұқсат етілген блокчейндердегі басқару мәселелері және шенеуніктер мен жеткізушілер арасындағы әлеуеттің жетіспеушілігі әсерін шектейді.

Кілтті сөздер: блокчейн, қаржылық алаяқтық, құрылыс индустриясы, мемлекеттік сатып алу, сыбайлас жемқорлыққа қарсы.

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ТЕХНОЛОГИЯ БЛОКЧЕЙН ДЛЯ ПРЕДОТВРАЩЕНИЯ ФИНАНСОВОГО МОШЕННИЧЕСТВА В СТРОИТЕЛЬНОМ СЕКТОРЕ КАЗАХСТАНА: СРАВНИТЕЛЬНЫЙ АНАЛИЗ

В данной статье рассматривается, как технология блокчейн может снизить уровень финансового мошенничества в строительном секторе Казахстана, а также анализируется опыт Казахстана в контексте более широких тенденций цифровизации в Узбекистане и Кыргызстане. В исследовании используется качественный сравнительный подход, основанный на систематическом обзоре недавних рецензируемых статей (2020–2025), отчетов о политике и авторитетных новостных источников по темам государственных закупок с использованием блокчейна, цифровых государственных финансов и управления строительством в Центральной Азии. Анализ показывает, что основные свойства блокчейна — неизменность, общая прослеживаемость и автоматизация смарт-контрактов — напрямую соотносятся с этапами государственных строительных проектов, на которых часто происходят мошенничества, включая

тендеры, исполнение контрактов и поставку материалов. Пилотные проекты, такие как «цифровой тенге» — цифровая валюта центрального банка Казахстана (CBDC) — и связанные с ним инициативы в Узбекистане и Кыргызстане, показывают, что распределенные реестры могут улучшить возможность аудита, сократить возможности для сговора на торгах и мошенничества с счетами-фактурами, а также создать поддающиеся проверке записи о цепочке поставок, хотя ограниченное юридическое признание смарт-контрактов, проблемы управления в разрешенных блокчейнах и разрыв в потенциале между чиновниками и поставщиками сдерживают их влияние.

Ключевые слова: блокчейн, финансовое мошенничество, строительная отрасль, государственные закупки, борьба с коррупцией.

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