



Finance, Banking, Insurance, and Stock Market

UDC 004.8:004.75:336.71

DOI <https://doi.org/10.5281/zenodo.17642066>

Synergy of artificial intelligence and blockchain in optimizing financial transactions and real-time auditing

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Accepted: 27.10.2025 | Published: 18.11.2025

Abstract. Traditional centralised financial and auditing mechanisms are increasingly proving ineffective in addressing challenges such as fraud risks, data manipulation, and delays in transaction verification. Against this backdrop, the synergy of artificial intelligence (AI) and blockchain has become a key driver of innovation, ushering in a paradigm shift toward intelligent and decentralised financial ecosystems. The **purpose of this study** is to analyse how the integration of artificial intelligence algorithms and blockchain infrastructure can enhance the efficiency, transparency, and accountability of financial operations and auditing practices in real-time. **Methods:** analysis of scientific literature – to study the current state of research on the problem; generalisation and systematisation – to present the research results. The **study's** results demonstrate that the convergence of AI and blockchain technologies enables a transition from traditional post-event auditing and transaction verification to continuous, predictive, and self-regulating processes. AI



contributes through machine learning, neural networks, and predictive analytics, supporting real-time anomaly detection, liquidity and risk forecasting, and autonomous transaction management. Blockchain complements these functions by ensuring data immutability, traceability, and decentralised validation, eliminating the need for intermediaries and guaranteeing the integrity of recorded information. The integration of AI-based analytics with blockchain-based smart contracts enables the automation of financial operations, where transactions are executed and verified simultaneously according to predefined algorithms. In the field of auditing, this integration supports continuous monitoring, rapid detection of irregularities, and complete transparency of operations, significantly increasing trust and compliance with regulatory standards. The **conclusions** emphasise that the integration of AI and blockchain not only improves the efficiency of financial systems but also transforms the very nature of financial management. It provides a technological foundation for real-time auditing, adaptive risk management, and autonomous financial decision-making. At the same time, implementing such systems requires addressing legal, ethical, and cybersecurity challenges to ensure a balanced integration of blockchain and AI into the global financial system.

Keywords: decentralized systems, smart contracts, machine learning, data transparency, automated auditing, risk management.

**Синергія штучного інтелекту та блокчейну в оптимізації фінансових
транзакцій і аудиту в режимі реального часу**

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Анотація. Традиційні централізовані фінансові та аудиторські механізми все частіше виявляються недостатньо ефективними у вирішенні таких проблем, як ризики шахрайства, маніпуляції з даними та затримки у перевірці транзакцій. На цьому фоні синергія штучного інтелекту (ШІ) та блокчейну стає ключовим рушієм інновацій, що пропонує зміну парадигми в бік інтелектуальних та децентралізованих фінансових екосистем. **Мета дослідження** – проаналізувати, як інтеграція алгоритмів штучного інтелекту та інфраструктури блокчейну може підвищити ефективність, прозорість та підзвітність фінансових операцій та аудиторської практики в режимі реального часу. Використані **методи:** аналізу наукової літератури – для дослідження поточного стану вивчення проблеми дослідження; узагальнення та систематизації – для представлення результатів дослідження. **Результати дослідження** показують, що зближення технологій штучного інтелекту та блокчейну дає змогу перейти від традиційного аудиту та верифікації транзакцій після завершення подій до безперервних, прогнозованих та саморегульованих процесів. Штучний інтелект сприяє цьому завдяки машинному навчанню, нейронним мережам і прогнозній аналітиці, які підтримують виявлення аномалій у режимі реального часу, прогнозування ліквідності та ризиків, а також автономне управління транзакціями. Блокчейн доповнює ці функції, забезпечуючи незмінність даних, відстежуваність і децентралізовану валідацію, усуваючи потребу в посередниках і гарантуючи цілісність записаної інформації. Інтеграція аналітики на основі штучного інтелекту зі смарт-контрактами на базі блокчейну забезпечує автоматизацію фінансових операцій, коли транзакції виконуються і перевіряються одночасно відповідно до заздалегідь визначених алгоритмів. У сфері аудиту ця синергія підтримує безперервний моніторинг, швидке виявлення порушень і повну прозорість операцій, значно підвищуючи рівень довіри та дотримання нормативно-правових норм. **У висновках** наголошується, що поєднання штучного інтелекту та блокчейну не лише підвищує ефективність фінансових



систем, а й трансформує саму суть фінансового управління. Вона забезпечує технологічну основу для аудиту в режимі реального часу, адаптивного управління ризиками та автономного прийняття фінансових рішень. Водночас, впровадження таких систем вимагає вирішення правових, етичних та кібербезпекових викликів для забезпечення збалансованої інтеграції блокчейну та ШІ у світову фінансову систему.

Ключові слова: децентралізовані системи, смарт-контракти, машинне навчання, прозорість даних, автоматичний аудит, управління ризиками.

Problem statement. The acceleration of the digital transformation of the global financial system has led to an increase in demand for technologies that can ensure both efficiency and reliability of financial transactions. Traditional transaction management and audit mechanisms, while effective in earlier stages of technology development, are increasingly unable to cope with the scale, complexity and speed of modern financial data flows. Centralised architectures create vulnerabilities related to data manipulation, single points of failure and delays in verification processes, while manual audit methods remain resource-intensive and responsive. These limitations have highlighted an urgent need for systems that can provide automated and transparent financial supervision in real-time. In this context, a promising direction of technological innovation is the convergence of artificial intelligence (AI) and blockchain. AI enables rapid data processing, pattern recognition, and predictive analysis, while blockchain provides immutability, decentralisation, and the ability to verify transaction records. Together, they create the foundation for building intelligent, self-regulating financial systems capable of continuous optimisation and monitoring, without dependence on intermediaries.

The relevance of studying the synergy of AI and blockchain lies in the fact that it can fundamentally change the foundations of financial management and auditing. The integration of these technologies will enable the creation of adaptive infrastructures where each transaction is verified, analysed, and recorded in real-



time, thereby eliminating the time and information barriers characteristic of traditional systems. In financial transactions, such a combination increases speed, accuracy and trust, and in auditing, ensures accuracy and proactive risk detection. Technological convergence contributes to compliance with regulatory requirements, fraud prevention, and operational transparency – key elements in maintaining trust in global financial markets. As institutions worldwide transition to decentralised finance and automated governance, understanding the mechanisms and implications of the interaction between AI and blockchain is becoming increasingly crucial for the development of resilient and secure financial ecosystems. Accordingly, studying this collaborative interaction is not only a response to technological evolution but also a strategic imperative to ensure the integrity, accountability, and resilience of financial systems in the era of real-time digital finance.

Analysis of recent research and publications. Several works by domestic scientists are devoted to addressing research issues. In particular, the work of M. Zhytar [1] considers digitalisation as a multidimensional factor that changes internal business processes, information infrastructure and external communications of financial institutions. The author focuses on the role of digital platform integration in enhancing the efficiency of financial accounting and data availability for analytics, emphasising the need to align management practices with technological innovations to maintain enterprise competitiveness.

Authors M. I. Sinkovskiy and O. D. Borzenkova [2] explore the potential of digital platforms to enhance budget transparency and the effectiveness of expenditure control, highlighting technological and organisational barriers to implementation and the necessity of e-government policies that facilitate the integration of new tools into government processes.

Scientists N. Ivanova, L. Milman, and A. Sakun [3] examine specific scenarios for the use of registries to ensure the integrity of accounting data, outline the functional limitations of current solutions, and suggest directions for adapting



professional standards to technological changes, providing practical examples and technical comments on this integration.

Researchers B. Yu. Kyshakevych, A. O. Luchakivskyi, B. Ya. Zvarych and S. Yu. Sledz [4] analyse the integration of blockchain and AI technologies in reducing operational and fraud risks. The authors demonstrate how combined analytics and distributed ledger techniques can enhance the resilience of supply chains and mitigate transaction risks in real-time, and provide practical recommendations for establishing a risk management architecture in foreign economic activity.

O. V. Diak [5] conducts an empirical analysis of blockchain analytics tools, oversized data processing methods, and the potential applications of machine learning to verify transaction authenticity. His work illustrates practical approaches to continuous monitoring of financial activities, highlights key technical challenges in auditing digital assets, and emphasises the need for innovative audit methodologies in digital market environments. A. P. Shot, V. M. Andrusiak, and M. V. Yatsko [6] consider both the advantages and practical limitations of blockchain in accounting and propose steps for the phased integration of the technology into corporate practice.

Authors O. Yaroshchuk and I. Belova [7] systematise key concepts, historical vectors of development, and current examples of the application of blockchain technology in auditing and accounting. The authors emphasise the educational and regulatory need to adapt professional audit standards, outline the general technical principles of blockchain technologies in accounting activities, and provide recommendations for training specialists to work with distributed data registries.

Researchers P. Mykytiuk and V. Mykytiuk [8] substantiate the role of financial technologies in increasing the efficiency of cash flow management, investments, and financial services through the automation of analytical processes and increasing the transparency of decisions. M. Poliak-Sverhun [9] considers the potential of integrating blockchain technologies and AI in fiscal administration, which contributes to minimising corruption risks and optimising tax data collection.



M. I. Koliadka and O. V. Feier [10] analyse the trends in the digitalisation of the economy and outline the prospects for implementing innovative financial instruments based on blockchain and AI solutions.

In his study, V. Zaghariy [11] considers blockchain as a key tool for increasing the transparency of international financial transactions and reducing transaction costs in the global capital circulation. At the same time, L. Kaptosv [12] investigates the optimisation of highly loaded digital systems using Redis caching, emphasising the importance of effective data management for financial platforms.

The team of authors A. O. Yakovenko, T. M. Gnatieva, and I. E. Vroniuk [13] investigate innovative approaches to modernising accounting and auditing through the integration of digital tools, machine learning, and data analytics. K. Yankovska [14] highlights the impact of digital technologies on the transformation of audit procedures and the training of specialists to work with automated verification systems. V. M. Andrusiak, I. O. Khoroshilova, and N. V. Smirnova [15] emphasise the significant impact of digitalisation on the development of the accounting and auditing system in Ukraine, and prove the need for standardisation of technological practices in the financial sector.

Highlighting previously unresolved parts of the general problem. Despite significant scientific interest, unresolved issues remain regarding the integration of algorithmic transparency and accountability in the combination of AI solutions with decentralised data registries.

In particular, the aspects of harmonising algorithmic solutions with the principles of legal liability and evidentiary power of records in different jurisdictions have not been sufficiently studied, as well as methods for standardising interfaces between machine learning systems and blockchain networks. At the same time, there is a lack of consensus on practical methods for assessing cybersecurity risks when using AI pipelines and smart contracts simultaneously, and economic models for scaling such systems in the real economy have not been sufficiently studied. The proposed research aims to address these tasks.



Formulation of the article objectives (task statement). The purpose of this research is to analyse the integration of AI algorithms and blockchain infrastructure, and their role in enhancing the efficiency, transparency, and accountability of financial transactions and auditing practices in real-time.

In accordance with the goal, we were set the following tasks: to analyse the theoretical foundations and principles of interaction between AI and blockchain in the financial sector; to identify mechanisms of their synergy in optimising financial transactions and audit systems in real time; to assess the benefits, risks and prospects of implementing integrated technologies into modern financial infrastructure; to provide recommendations on the directions of further development of intellectually decentralised financial systems.

Presentation of the main research material. The development of financial technologies, from early automation to the emergence of intelligent systems, reflects a profound transformation of the global financial sphere. It should be noted that initially, automation in finance was aimed at mechanising repetitive operations, such as data entry, accounting, and transaction processing, to reduce the number of human errors and operational costs. Such early systems, although effective, operated within centralised architectures, which limited their transparency, traceability, and adaptability. The emergence of AI and blockchain technologies has marked a new stage in this evolution, enabling financial ecosystems to become not only automated but also intelligent, adaptive, and decentralised.

AI is a branch of computer science that aims to mimic human reasoning and decision-making, enabling financial systems to analyse large volumes of data, identify complex patterns, and make predictions with high accuracy. In parallel, blockchain, based on distributed ledger technology, ensures the integrity, immutability, and transparency of data across multiple network nodes, thereby eliminating the need for intermediaries and strengthening trust in digital financial interactions across various sectors of the economy.



The fundamental complementarity of AI and blockchain lies in their ability to interact with each other, which increases the reliability and intelligence of financial systems [8, p. 74]. The mechanisms of their interaction are based on decentralised data storage combined with machine learning and distributed data analytics. Blockchain structures provide AI algorithms with verified, tamper-proof data sets that are necessary for creating objective models and ensuring the traceability of algorithmic solutions. At the same time, AI contributes to the optimisation of the blockchain by improving reconciliation mechanisms, detecting fraudulent actions and predicting network anomalies. The integration of AI-based analytics into distributed ledger environments enables real-time auditing, automates smart contracts, and predicts financial management, thereby creating an ecosystem of self-regulating financial transactions.

The complementarity of AI and blockchain offers several key advantages, including reliability, transparency, speed, and security in financial transactions [9, p. 15–16]. Thus, transparency arises from the immutability and public verification of records in the blockchain, which enables financial market participants to track each transaction throughout its lifecycle. The level of reliability is increased through data verification and reconciliation protocols that minimise the risks of manipulation and fraud. Additionally, AI continuously monitors the system and detects any violations. The speed of transactions increases due to automated smart contracts and intelligent data processing, which eliminate the need for manual verification or centralised clearing. Security is enhanced due to the cryptographic basis of the blockchain and the anomaly detection capabilities of AI systems, which together create multi-layered architectures of protection against cyber threats. The convergence of these technologies is transforming financial systems into dynamic, self-learning, and secure environments that can operate autonomously and adapt to complex market conditions. This shift from traditional automation to intelligent, decentralised finance marks not only a technological evolution but also a paradigm shift in understanding transparency, accountability, and value creation in the global



financial system. The combination of AI and blockchain technologies has become the foundation for optimising financial transactions, transforming the efficiency, reliability, and adaptability of digital financial ecosystems. Financial transaction systems are increasingly requiring real-time data validation, proactive forecasting, and autonomous transaction flow management – all areas where AI offers significant advantages over traditional analytical tools. Through algorithms based on deep learning, natural language processing, and predictive modelling, AI enables the continuous assessment of transaction authenticity, the detection of fraud, and the prediction of liquidity or volatility risks [10, p. 31–32]. For example, neural network models can analyse historical transaction data to predict anomalies in financial systems, and reinforcement learning systems can optimise decision-making processes in high-frequency trading environments. Such capabilities enable proactive rather than reactive management of financial flows, thereby reducing systemic risks and increasing capital mobility.

Blockchain technology extends these functions by providing an immutable, verifiable, and decentralised basis for recording and controlling transactions, including international financial transactions. Each transaction is stored in a cryptographically protected block that is distributed across multiple nodes in the network, ensuring transparency and preventing data manipulation [11, p. 343–344]. The decentralised nature of blockchain eliminates dependence on centralised clearing houses and reduces operational barriers. Thus, the immutability of records ensures the integrity of financial histories, and traceability mechanisms enable auditors and regulators to verify the source, authenticity, and sequence of transactions in real-time.

A crucial technological embodiment of this synergy is the intelligent smart contract. This self-sufficient digital agreement runs on blockchain infrastructure and is governed by logic driven by AI. Unlike conventional smart contracts, which perform predefined operations, AI-enhanced versions can dynamically adapt to changing market conditions or user behaviour. For example, in the insurance sector,



AI-enabled smart contracts can automatically adjust premium levels based on real-time risk assessments derived from predictive models. In payment systems, such contracts can optimise transaction fees by estimating network congestion or exchange rates in milliseconds. Integrating AI into blockchain smart contracts transforms financial transactions from static, rule-based exchanges into adaptive, context-aware processes that are capable of autonomous optimisation (table 1).

Table 1

AI and blockchain in various financial sectors

Scope of application	AI functionality	Role of blockchain	Outcome
Banking sector	Fraud detection, risk assessment, and customer behaviour analysis	Secure data exchange between institutions	Fraud reduction, improved creditworthiness assessment
Payment systems	Dynamic transaction routing, cost optimisation	Decentralised settlements and clearing	Fast, low-cost, verified payments
Cryptofinance	Market forecasting, asset management automation	Tokenisation, immutable trade records	Transparent algorithmic trading and management
Insurance	Predictive claims scoring, customer profiling	Ensuring policy enforcement based on smart contracts	Real-time claims settlement and reduction of human bias

Source: systematised by the author according to [9–12]

These examples demonstrate how the combination of AI and blockchain is fundamentally reimagining the infrastructure of financial transactions. In banking, AI-powered analytics enhances the accuracy of creditworthiness assessments, while blockchain ensures data integrity and customer privacy through the secure exchange of encrypted records. Payment systems benefit from AI-powered routing algorithms that minimise delays and costs, as well as blockchain's decentralised verification, which eliminates intermediaries. In cryptofinance, machine learning algorithms predict asset price fluctuations, while blockchain secures trading histories and ownership records in the form of tokens. In insurance, AI's predictive capabilities



simplify insurance claim verification, and blockchain-based smart contracts automatically perform calculations, ensuring fairness and speed.

The potential for AI and blockchain to interact in real-time audit systems represents a paradigm shift in how financial integrity, accountability, and transparency are achieved in the digital economy. Traditional auditing, which has long relied on retrospective analysis of static datasets and manual verification, suffers from inherent challenges, including time lags, human error, data manipulation, and limited transaction traceability. The emergence of decentralised technologies and intelligent data analytics is transforming this space into one characterised by continuous assurance, prediction, and immutable verification. Blockchain technology provides the structural foundation for this transformation by decentralising audit trails, ensuring that every transaction and system event is permanently recorded in a tamper-proof ledger accessible to authorised participants. At the same time, AI is introducing cognitive and analytical capabilities that enable real-time detection of irregularities, risk prediction, and adaptive decision-making.

Integrating AI into auditing enables the automated monitoring and detection of anomalies across large streams of financial and operational data. Advanced AI models, particularly those based on deep learning and unsupervised clustering, can detect subtle deviations from expected behavioural patterns that human auditors may miss. For example, reinforcement learning systems can self-improve detection accuracy over time by analysing feedback on validated audit results. Natural language processing further expands the capabilities of auditing by enabling automatic interpretation of unstructured financial documents, contracts, and communications. These AI-driven mechanisms not only accelerate the audit process but also enhance its accuracy and adaptability, enabling auditors to transition from manual data review to strategic oversight and informed decision-making. By continuously analysing streaming data, AI supports real-time audit models that detect deviations, signs of fraud, or regulatory violations and flag them instantly, significantly reducing response time and financial risks [14, p. 71–72]. At the same



time, blockchain technology complements these capabilities by ensuring the authenticity and immutability of the data on which AI models operate. A distributed ledger system creates a shared, cryptographically protected record of all transactions and actions relevant to the audit. Each block in the ledger contains verified, time-stamped information that can be independently verified by all nodes in the network, ensuring complete transparency and trust. Such a decentralised architecture eliminates single points of failure and manipulation, thereby increasing trust in audit results. Innovative contract mechanisms allow for the automation of compliance checks by triggering alerts or reports when AI systems detect violations (table 2). Through this symbiotic integration, AI provides interpretive intelligence and blockchain provides trust in data integrity – a balance that enables fully automated, real-time audit environments.

Table 2

Modernising auditing with AI and blockchain

Modernization aspect	AI impact	Blockchain impact	Synergistic effect
Data verification	Automated cross-checking and anomaly detection	Time-stamped immutable ledgers	Continuous data authentication
Fraud detection	Predictive modeling and behavioral analysis	Transparent accounting of all transactions	Early fraud detection and tracking
Regulatory compliance	Algorithmic verification of legal standards	Smart contracts to ensure compliance	Verifiable autonomous compliance audit
Reporting and accountability	Real-time audit conclusion generation	Publicly verified data origin	Increase trust and reduce reporting latency

Source: formed by the author based on [14 - 16]

As we can see, the combination of AI and blockchain in auditing not only modernises data verification but also strengthens the principles of accountability and transparency at every stage of the audit lifecycle. AI expands the interpretive capabilities of auditors, transforming data into useful information, while blockchain preserves the provenance and integrity of this data in decentralised systems. This



synergy facilitates the development of real-time audit panels, predictive compliance systems, and autonomous audit bots that operate with minimal human intervention.

However, the implementation of these technologies is associated with significant challenges. From an ethical perspective, relying on AI for decision-making raises concerns about algorithmic bias, data privacy, and the potential loss of human oversight. From a legal perspective, the regulatory framework is still adapting to the complexities of decentralised audit infrastructures, especially regarding jurisdiction, data ownership, and cross-border data sharing. From a cybersecurity perspective, although blockchain enhances protection through cryptographic mechanisms, cybersecurity vulnerabilities may still arise in the logic of smart contracts, API integration, or AI data pipelines. In these circumstances, addressing financial and personal data security issues requires an interdisciplinary approach that combines legal harmonisation, ethical governance, and robust technical safeguards. Legal harmonisation involves harmonising national and international norms to create a single, secure legal space in the digital space. Ethical governance is responsible for developing and enforcing principles of accountability, transparency, and fairness in the use of AI and blockchain technologies. Robust technical safeguards include the use of modern encryption methods, multi-level access controls, and continuous system auditing to prevent cyber threats.

Conclusions. The analysis has shown that the combination of AI and blockchain forms a new paradigm for the development of financial systems, in which efficiency, transparency and accountability are achieved through the combination of intelligent analytical mechanisms and decentralised infrastructures. AI provides flexibility and adaptability in financial processes by predicting risks, automating transaction processing, and detecting anomalies in real-time. At the same time, blockchain establishes a technological foundation for the immutability and reliability of data, mitigates the risks of manipulation, and enhances trust among participants in financial systems. The joint application of these technologies contributes to the transition from traditional centralised models to self-regulated



financial ecosystems, in which audit and control processes are carried out automatically, and the human factor is minimised. The results obtained confirm that the integration of AI and blockchain creates the prerequisites for the formation of innovative mechanisms for managing financial flows, increasing the resilience of systems to fraud and optimising audit procedures.

The practical implementation of such approaches opens up opportunities for building fully transparent, secure and self-learning financial platforms capable of adapting to changes in the external environment. At the same time, the implementation of such technologies requires further regulation of ethical, legal and cybersecurity aspects, which determines the need for interdisciplinary research in this area. The prospects for further scientific research lie in the development of models for standardisation, regulation and scaling of the synergy of AI and blockchain in the global financial architecture.

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