This study investigates artificial intelligence and blockchain technologies as part of the accounting-analytical support system in the public sector.

The problem addressed relates to the task of building an effective model of accounting-analytical support in the public sector, based on the synergy of artificial intelligence and blockchain technologies.

In the process of the study, a model of accounting-analytical support in the public sector was constructed, underlying which is the synergy of artificial intelligence and blockchain technologies. The model was built on the basis of a logical and consistent roadmap for the transition to an intelligent model of budget resource management.

An algorithm for implementing blockchain technology in the accounting-analytical support system in the public sector was developed, which takes into account technical, organizational, legal aspects, and provides a comprehensive approach to the integration of blockchain technologies.

It was substantiated that the model built would make it possible to integrate automated data collection and verification, conduct intellectual analysis, forecast, generate various forms of reporting, as well as warrant security, immutability, and information protection.

The economic effect of investments in the implementation of a model of accounting-analytical support in the public sector based on the synergy of artificial intelligence and blockchain technologies has been analyzed, which has demonstrated the economic feasibility and prospects of the project. It has been determined that after covering the initial investment of USD 644,500, it is expected to receive an additional net economic benefit of more than half a million USD in present value over 7 years of system operation.

It has been determined that the annual economic effect in the amount of 240 thousand USD would be achieved due to the complex influence of factors. In particular, it could be attained through a significant reduction in costs for the preparation and automation of reporting; reducing the number of errors; optimizing the use of budget resources; reducing costs for audit and control measures

Keywords: accounting-analytical support, information technologies, cloud technologies, artificial intelligence, blockchain, public sector

UDC 657.1:658.115
DOI: 10.15587/1729-4061.2025.340995

CONSTRUCTION OF AN ACCOUNTING-ANALYTICAL SUPPORT MODEL FOR THE PUBLIC SECTOR BASED ON THE SYNERGY BETWEEN ARTIFICIAL INTELLIGENCE AND BLOCKCHAIN TECHNOLOGIES

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Received 21.07.2025
Received in revised form 25.09.2025
Accepted 02.10.2025
Published 29.10.2025

How to Cite: *Larikova, T., Drozd, I., Lyubenko, A., Telehin, V., Novichenko, L. (2025). Construction of an accounting-analytical support model for the public sector based on the synergy between artificial intelligence and blockchain technologies. Eastern-European Journal of Enterprise Technologies, 5 (13 (137)), 50–61. https://doi.org/10.15587/1729-4061.2025.340995*

1. Introduction

Under the current conditions of digital transformation of the public sector, there is a growing need to modernize accounting-analytical support in order to increase transparency, reliability, and efficiency of management decisions. Conventional accounting and analysis systems in the public sector remain vulnerable to errors, data duplication, information processing delays, and low analytical productivity. There is an urgent need to rethink approaches to accounting-analytical support for management processes. Traditional models of accounting and reporting in public institutions mostly do not meet the requirements of transparency, reliability, and efficiency, which creates risks of inefficient use of public

funds and complicates control over the implementation of public programs.

The growth of data volumes, digitalization of public services, as well as social demand for transparency of public finances have led to an active search for innovative technological solutions. In view of the above, the combination and use of innovative technologies is of strategic importance for the construction of a reliable, secure, and analytically-oriented system of accounting-analytical support in the public sector.

Previously, accounting in the public sector was largely based exclusively on manual labor because of limited automation capabilities. Today, there is a gradual introduction of artificial intelligence technologies that transform conventional approaches and ensure the effective implementation of complex accounting-analytical procedures [1]. At the same time, due to the influence of the human factor in the accounting system, a significant number of errors were made, which reduced the quality and reliability of data. One of the most promising technological solutions is blockchain technology, which opens up opportunities for designing transparent and secure online registers, as well as maintaining reliable accounting-analytical documentation [2].

Thus, under the current conditions of digital transformation of the public sector, the search and implementation of innovative technological solutions that can provide transparency, reliability, and efficiency of accounting-analytical processes is of particular importance. The combination of artificial intelligence and blockchain technologies will open up new opportunities for modernizing the state resource management system, increasing the level of financial control and preventing inefficient use of budget funds.

Therefore, research into the construction of an accounting-analytical support model in the public sector based on the synergy of artificial intelligence and blockchain technologies is relevant and meets the modern challenges of public administration.

2. Literature review and problem statement

Modern artificial intelligence (AI) and blockchain technologies are attracting significant attention from both academics and practitioners in the field of accounting-analytical support. Current research emphasizes that the integration of these technologies can significantly transform accounting-analytical processes, increase their efficiency, accuracy, transparency, and security.

Study [3] proves the potential of artificial intelligence in transforming accounting through automation and increasing data accuracy but its results need to be adapted to the specificity of the public sector, taking into account stricter regulatory requirements.

Paper [4] substantiates the feasibility of integrating artificial intelligence and modern technologies, which could ultimately transform accounting and auditing, increase the transparency and reliability of procedures. However, it is complicated by high costs and the lack of unified standards, which requires devising methodological recommendations or a model.

Bibliometric analysis proves [5] that the integration of artificial intelligence and blockchain technologies will form new trends in automation and data management, but their application in the public sector is limited by a lack of experience and high costs.

Artificial intelligence is actively being introduced into the field of accounting and auditing to promote automation and increase trust in accounting and financial information [6]. The implementation of intelligent robotic process automation and artificial intelligence in accounting and auditing is being studied [7]. However, their implementation in the public sector is hampered by the lack of unified standards, which necessitates devising specialized approaches to accounting and auditing. In addition, artificial intelligence helps increase the speed of information processing, which is especially important when working with large volumes of transactions and reporting typical of the public sector [8].

However, the issues of scaling these solutions in the public sector, where processes are more complex and more regulated, remain unresolved. At the same time, blockchain guarantees the immutability and integrity of records, which is critical for control in the public sector [9]. However, issues of large-scale implementation remain unresolved due to regulatory restrictions and the high cost of technological infrastructure. Smart contracts, which operate on the basis of blockchain technology, allow for the automation of compliance control and reporting processes, significantly reducing the need for manual management and intervention [10]. However, issues related to the legal legalization of smart contracts in different countries and technical limitations of scalability remain unresolved.

The integration of artificial intelligence and blockchain technologies could create a synergy that would ensure fast and reliable reporting due to the operational recording and processing of transactions [11]. However, the issues of dependence on cloud service providers, the risks of centralization, and the high cost of switching to new technological platforms remain unresolved.

The decentralized nature of blockchain technology will provide an increased level of security and data integrity, guaranteeing the immutability of recorded transactions [12]. However, issues related to the insufficient adaptation of educational programs to rapid changes in the labor market and the introduction of artificial intelligence and blockchain technologies into the educational process remain unresolved.

Despite a significant amount of research in the field of AI and blockchain in the accounting and analysis system, their joint application remains insufficiently studied, which indicates missed opportunities for devising more integrated and effective management strategies. Most scientific works focus on the implementation of these technologies in the business environment, while the issue of their impact on the public sector still requires detailed research. That is why the construction of an accounting-analytical support model for public institutions based on the synergy of artificial intelligence and blockchain is extremely relevant. This direction could open up opportunities for the implementation of innovative solutions that would meet the modern challenges of the digital economy and contribute to more effective management of public resources.

3. The study materials and methods

The purpose of our work is to build and implement an accounting-analytical support model in the public sector based on the synergy of artificial intelligence and blockchain technologies. This will increase the efficiency, transparency, and reliability of state resource management, automate routine

accounting processes, ensure data integrity and protection, and improve the quality of analytical support for management decisions.

To achieve this aim, the following objectives were accomplished:

– to design a mechanism for implementing artificial intelligence into the accounting-analytical support system;

– to develop an algorithm for implementing blockchain technology into the accounting-analytical support system;

– to build a structural diagram of the accounting-analytical support model in the public sector based on the synergy of artificial intelligence and blockchain technologies;

– to analyze the economic effect of implementing an accounting-analytical support model in the public sector based on the synergy between AI and blockchain technologies.

4. The study materials and methods

The object of our study is artificial intelligence and blockchain technologies in the accounting-analytical support system in the public sector.

The hypothesis of the study assumes that the implementation of an accounting-analytical support model in the public sector based on the synergy of artificial intelligence and blockchain technologies could contribute to increasing the efficiency, transparency, and reliability of state resource management.

The introduction of blockchain and artificial intelligence technologies into the accounting-analytical support system of the public sector indicates a significant transformational potential in the field of control and management of financial flows between state institutions. There are reasonable grounds to assume that the integration of these technologies will become a key factor in digitalization, which will bring the evolution of the accounting-analytical system to a qualitatively new level by increasing transparency, process automation, security, and analytical depth.

A set of general scientific methods of cognition was used to conduct the study. When analyzing the theoretical foundations and current state of blockchain technology, as well as its practical application in the public sector, methods of theoretical analysis, comparison, generalization, and synthesis were applied.

The synergy of artificial intelligence and blockchain technologies in the accounting-analytical support system will open up opportunities, in particular automatic analysis of large data sets; identification of potential risks; forecasting financial indicators; support for making management decisions. AI will make it possible to improve the quality and speed of information processing, minimize the human factor, and ensure the system's adaptability to changes in the regulatory and economic environment.

5. Results of investigating the construction of an accounting-analytical support model based on the synergy of artificial intelligence and blockchain

5. 1. Mechanism of introducing artificial intelligence into the accounting-analytical support system

Artificial intelligence (AI) is a modern technological tool that in the public sector will help automate the processing of large amounts of accounting, financial and analytical information, increase data transparency.

The introduction of AI technologies into the accounting-analytical support system has great advantages, including the ability to process large amounts of data; perform routine operations automatically; provide constant monitoring; analyze complex financial transactions; provide recommendations for making management decisions [13].

Therefore, the introduction of AI into the accounting-analytical support system will make it possible to automate routine processes, increase the accuracy and efficiency of financial information processing, reduce the risks of human errors, provide a deep analytical overview, and contribute to more informed management decision-making. In addition, owing to the ability to learn and adapt to changing conditions, AI will help to respond quickly to new challenges, increase the effectiveness of resource use control, and devise transparent reporting mechanisms for public sector institutions.

However, in addition to the advantages, there are disadvantages when implementing AI into the accounting-analytical support system in the public sector. Table 1 summarizes the key advantages and disadvantages of implementing AI into the accounting-analytical support system in the public sector.

Table 1

Advantages and disadvantages of implementing AI in the accounting-analytical support system in the public sector

Advantages	Disadvantages
Automation of routine operations: – AI makes it possible to automatically perform repetitive and standard tasks (document processing, data entry), which significantly reduces the workload on employees and reduces execution time; – increasing accuracy and reducing errors: machine learning and analysis algorithms help minimize human errors when processing financial information. Processing large volumes of data: – AI is able to quickly analyze large data sets, which is critically important for government agencies with numerous reports and budget flows. Forecasting and analytics: – AI helps forecast financial indicators, identify trends, assess risks and the effectiveness of budget programs; – detection of anomalies and fraud: automated monitoring systems using AI effectively detect atypical operations that may indicate violations or abuse. Support for managerial decision-making, based on complex data analysis: – AI provides recommendations that improve the quality and validity of decisions. Improving transparency and accountability: – owing to automatic reporting and monitoring, it increases openness and control over the use of budget funds	High initial costs: – the implementation of AI systems requires significant investments in software, equipment, infrastructure and staff training. Complexity of integration: – technical difficulties when combining AI with existing outdated information systems can slow down the implementation process. Dependence on data quality: – incorrect, incomplete, or outdated data can lead to erroneous conclusions and recommendations of AI. Insufficient level of staff qualifications: – effective use of AI requires specialists with relevant knowledge, which are often lacking in government institutions. Security and privacy risks: – the use of AI in working with sensitive information increases the threat of cyberattacks and data leakage. Possible resistance to change: – the organizational culture of government institutions can be conservative, which creates barriers to the implementation of innovations. Ethical and legal issues: – uncertainty regarding responsibility for decisions made by automated systems, as well as problems with the transparency of algorithms

Source: summarized by an author based on data from [13].

One can see that the introduction of AI into the system of accounting-analytical support in the public sector opens up new horizons for increasing the efficiency, transparency, and quality of public finance management. Automation of routine and labor-intensive processes, the ability to process large amounts of information with minimal errors, as well as the possibility of in-depth analysis and forecasting of financial indicators make AI an indispensable tool in today's complex budget administration. However, the introduction of AI technologies in the public sector is associated with certain disadvantages, in particular the need for significant financial investments, integration with existing systems, training of qualified personnel, and ensuring information security. No less important are organizational and ethical issues, in particular resistance to change and regulation of responsibility for automated decisions.

Fig. 1 shows a mechanism for introducing AI into the system of accounting-analytical support in the public sector.

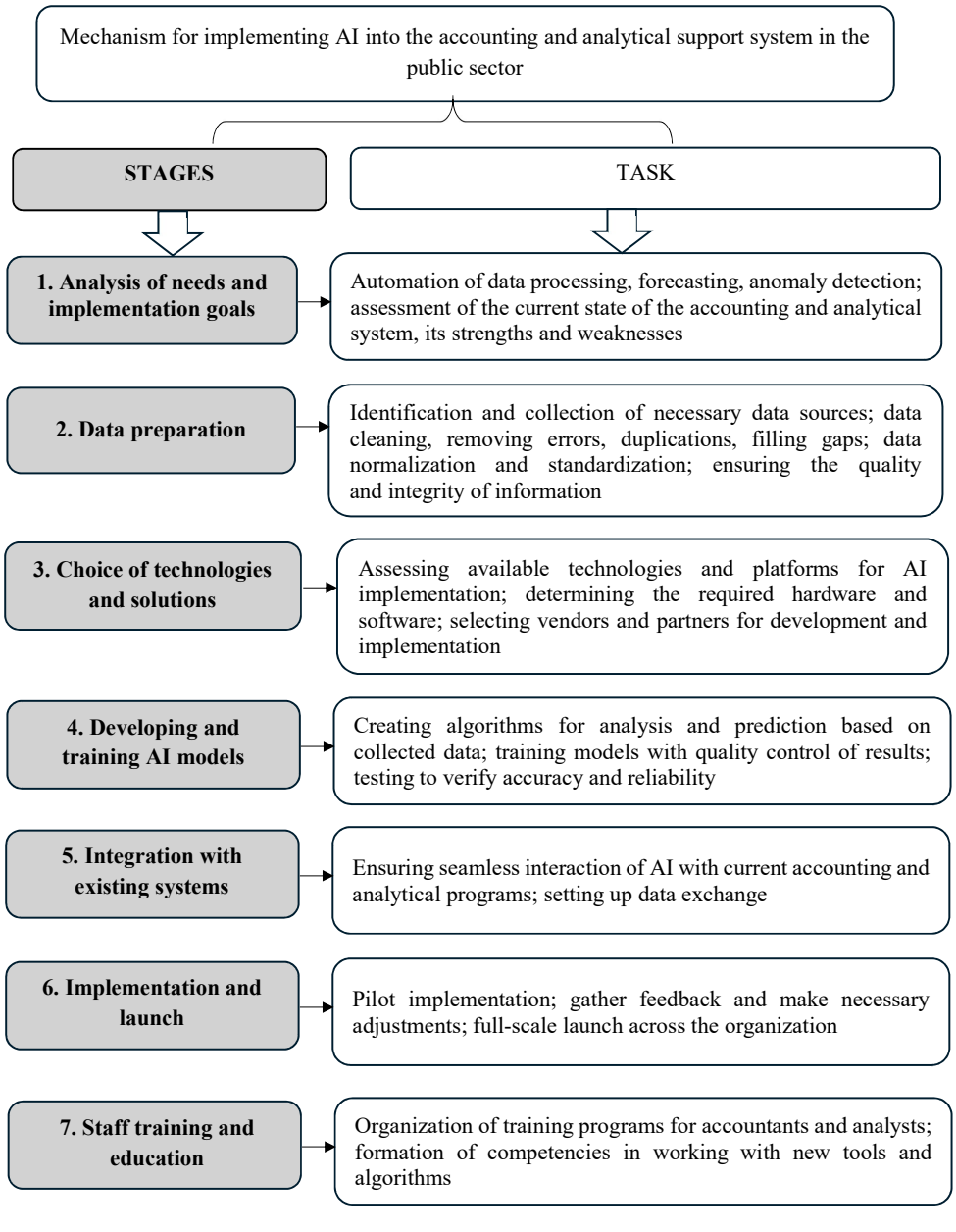

Fig. 1. Mechanism for implementing AI into the accounting-analytical support system in the public sector

Source: summarized by an author based on data from [11, 17]

Thus, the implementation of AI in the accounting-analytical support system is a phased and complex process that requires careful planning, ensuring data quality, choosing appropriate technologies, training personnel, and constant monitoring of results. Such an approach will allow for the most effective integration of innovative technologies, improving the quality of the accounting, reporting, and analytics system, and optimizing management decisions at public sector institutions.

5. 2. Algorithm for implementing blockchain technology into the accounting-analytical support system

The introduction of blockchain technology into the accounting-analytical support system in the public sector will increase the transparency of the use of public funds, the traceability of public payments between public sector entities, and their intended purpose. Blockchain technology will fundamentally change the rules of the accounting system, ensure the integrity of records, providing access to a full cycle of all business transactions without the possibility of corrections. Blockchain technology will help build an accounting ecological accounting-analytical system that will ensure the transparency of all transactions carried out by public sector institutions.

Technologically, the implementation of blockchain involves the construction of a transaction model that is formed separately in each module. The model is built on the collective knowledge and trust of the participants themselves, without intermediaries, allowing all participants to view the information available to them, which gives legitimacy to the transaction, makes it possible to verify and record the transaction. Each module is digitally signed by its owner and contains the corresponding transaction data, a timestamp, and a hash of the previous module, which links all the modules that make up the chain.

The algorithm that generates the hash of each module, regardless of the data content, applies a mathematical function that converts this content into a 256-bit hash. This hash has two very important characteristics: non-iterativeness and unique fingerprint. If

the data changes, the result of the algorithm will also change, and therefore the fingerprints will be different, as illustrated in Fig. 2.

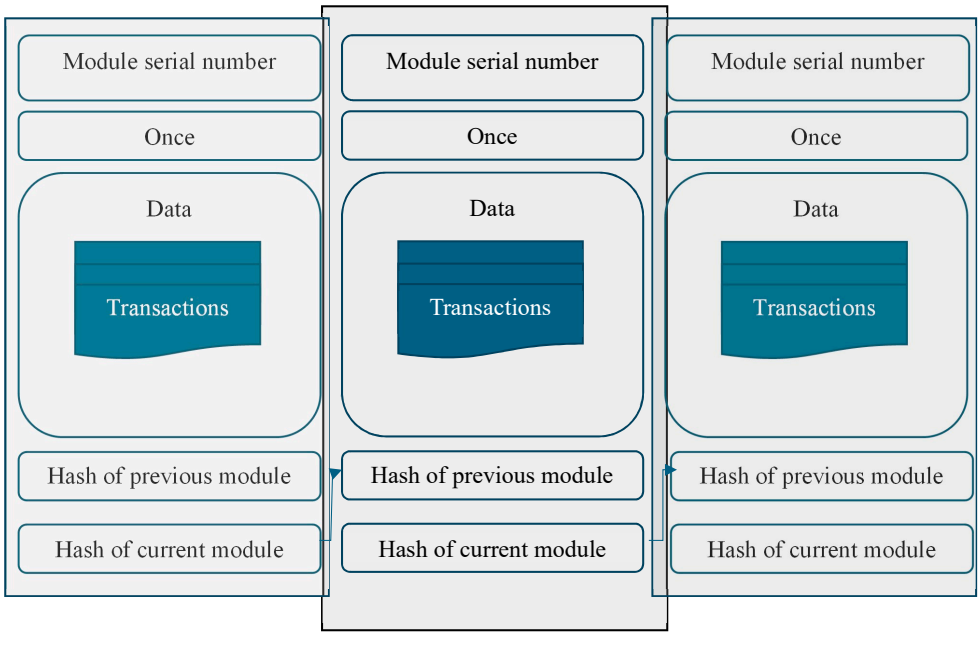

Fig. 2. Blockchain technology operation model
Source: [15]

Since the hash of the previous module is added to each module of data before the hash of the previous module is calculated, the hash of the previous module cannot be changed either. Thus, each module is linked to the previous module. This iteration is performed systematically over a period of time, resulting in successively generated linked modules identified by sequence numbers. To establish control over ownership of digital assets and prevent the risk of double spending, each module also records a transaction date that determines which transaction occurred first.

The operating model of a blockchain involves many participants, each of which can store and exchange information from modules in the network, called nodes. These participants can operate simultaneously with little coordination, and they do not need to be identified because messages are not routed to a specific location. This creates a decentralized network without intermediaries, which increases the reliability of the model. However, since these modules are copied between different nodes, changing a completed module theoretically requires applying the changes to all network participants.

The algorithm for implementing blockchain technology into the accounting-analytical support system in the public sector is given in Table 2.

One can see that the step-by-step algorithm for implementing blockchain into the accounting-analytical support system in the public sector takes into account organizational, technical, legal, and personnel aspects, systematizes the process and minimizes risks in the public sector. Defining clear goals, setting up an interagency working group, analyzing the regulatory framework and adapting IT infrastructure are critical stages to ensure the success of the project.

The implementation of blockchain will contribute to increasing control and transparency of budget processes, will provide automation of procedures, reduce audit and monitoring costs, and create conditions for more effective interaction between public authorities. It is especially important that technology will contribute to strengthening cybersecurity and protecting confidential data, which is extremely relevant in the context of modern threats.

Table 2

Algorithm for implementing blockchain technology into the accounting-analytical support system in the public sector

Step name	Task
Step 1. Defining goals and justifying the need	Analysis of the current state of the accounting and analytical system and identification of problems (transparency, control, data protection); determining the goals of blockchain implementation, increasing transparency, ensuring data immutability, automation of control
Step 2. Forming a working group	Setting up an interdepartmental team including IT specialists, accountants, analysts, lawyers; appointment of project managers
Step 3. Analysis of the regulatory framework	Study of legislation on the use of blockchain and digital technologies in the public sector; identification of possible legal restrictions and preparation of proposals for their elimination
Step 4. Determining technical requirements and choosing a blockchain type	Determining the type of network: public, private, or consortium, taking into account the level of confidentiality and security; compiling technical specifications, integration with existing systems
Step 5. Preparing IT infrastructure	Assessment and modernization of existing information systems to ensure compatibility with blockchain; procurement of necessary equipment, software
Step 6. Develop and configure a blockchain solution	Choosing a platform (Hyperledger or Ethereum) or developing a proprietary solution; programming smart contracts to automate accounting procedures; ensuring cybersecurity
Step 7. Pilot implementation	Testing the system in a separate unit or within a specific budget program; assessing effectiveness, collecting feedback from users
Step 8. Staff training	Conducting trainings and seminars for users and IT specialists; compiling methodological materials

Source: summarized by an author based on data from [16].

5. 3. Building a structural scheme of accounting-analytical support in the public sector based on the synergy of artificial intelligence and blockchain

The synergy between AI and blockchain technologies into a single model of accounting-analytical support in the public sector will make it possible to maximally use the advantages of both technologies. Blockchain will ensure the reliability and security of input data, which are the basis for the effective operation of AI. At the same time, AI will be able to analyze data, predict the development of financial processes, detect anomalies, and promptly form draft management decisions [17].

The model of accounting-analytical support in the public sector based on the synergy between AI and blockchain should be forced from separate interconnected modules, each of which will perform specific functions in the context of two technologies, AI, and blockchain.

Fig. 3 shows a structural scheme for the model of accounting-analytical support in the public sector based on the synergy between AI and blockchain.

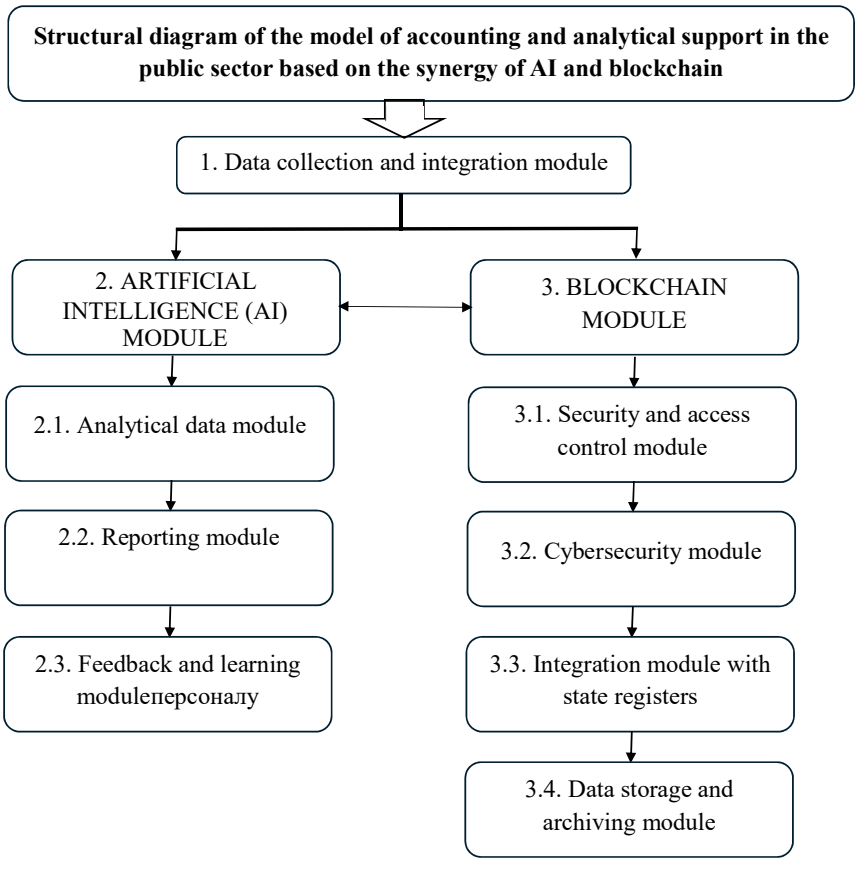

Fig. 3. Structural diagram for the model of accounting-analytical support in the public sector based on the synergy between AI and blockchain
Source: devised by an author based on [17, 18]

The basis of the structural scheme of the model is the centralized collection and unification of data from various information sources. For AI purposes, the proposed model in the form of a separate module provides an array of high-quality data for further analysis, forecasting and training of models. The blockchain module implies guaranteeing the reliability and security of primary information, which is recorded in a distributed registry.

The combination of these technologies builds a single model of accounting-analytical support where the blockchain warrants the reliability of input data and processing results, records all transactions in a secure registry; AI converts this data into analytics, generates forecasts, recommendations, and draft management decisions.

As a result of the synergy of these two technologies, a transparent and secure system is designed that reduces the risks of manipulation and distortions in reporting; ensures automation of routine processes; increases the speed and quality of management decisions; creates new standards of responsible financial management in the public sector.

Thus, the proposed structural diagram of the model includes the following modules: data collection and integration, artificial intelligence, blockchain, security, analysis, reporting, feedback, training, cybersecurity, integration with registries, archiving. The primary module is the data collection and integration module separately for the implementation of AI and blockchain technology. In turn, the artificial intelligence (AI) module is responsible for processing, analyzing, and summarizing weighted conclusions based on this data, automating reporting, and making models of management decisions. The blockchain module is responsible for security, storage, access, control, and interaction with official sources, that is, for the reliability and immutability of information. Together, they form an effective system of accounting-analytical support where information is reliable and protected (blockchain), and analysis and management are intelligent and effective (AI). Each of the identified modules has its specific purpose, tasks, and role in the model. Table 3 gives a matrix of "purpose-function-role" of the modules in the structural diagram of the model of accounting-analytical support in the public sector based on the synergy between AI and blockchain.

One can see that the modules of the structural diagram of the model in the AI part play a key role in transforming large volumes of data into valuable information for decision-making. The data collection and integration module ensures prompt and high-quality receipt of source information in a single format, which is a necessary basis for further analytics. The main analytical module of artificial intelligence performs complex functions of modeling, forecasting, and anomaly detection, which makes it possible not only to improve the accuracy of financial and budgetary forecasts but also promptly detect potential fraudulent transactions or errors. Owing to the analytical dashboard, managers and auditors receive a convenient tool for monitoring key indicators in real time, which significantly increases management efficiency. Automated reporting makes it possible to significantly reduce the burden on accountants and analysts, freeing them from routine operations and focusing on analysis and making strategic decisions. At the same time, the feedback and training module of the system ensures continuous improvement of AI algorithms, adaptation to changes in the regulatory

framework and the specificity of the institution's activities, which warrants the relevance and accuracy of analytics in the long term.

Table 3

The "purpose-function-role" matrix of modules in the structural diagram of the model of accounting-analytical support in the public sector based on the synergy between AI and blockchain

Module	Purpose	Function	Role in the model
1. Data collection and integration module	Automated collection of primary documents and transactions from various sources (ERP, banking systems, treasury)	Real-time data import; automatic integrity checking; conversion to a single format	Provides fast and error-free receipt of raw data
2. Artificial Intelligence (AI) module	Analysis, forecasting and anomaly detection	Scenario modeling; revenue and expense forecasting; fraud detection	Increases decision accuracy and speed of analytics
2. 1. Analytical data module (Dashboard)	Visualization of indicators for managers and auditors	Real-time reporting; interactive charts; analytics; adaptive settings	Enables quick and informed management decisions
2. 2. Reporting module	Automatic creation of regulated and management reports	Formation of financial, budgetary, statistical, tax and management reporting	Reduces the burden on accountants and analysts
2. 3. System feedback and training module	Adaptation of AI models and algorithms to changes in the regulatory framework and the specifics of the institution	Machine learning based on new data, analysis of the effectiveness of decisions	Increases the accuracy and relevance of analytics
3. Blockchain module	Guaranteeing transparency and immutability of data	Creation of a distributed registry; protection against unauthorized changes; tracing the origin of transactions	Builds trust in data and its legitimacy
3. 1. Security and access control module	Data protection and user rights management	Multi-level authentication, encryption, access logging	Prevents leaks and abuse
3. 2. Cybersecurity module	Protection of the accounting and analytical system from cyberattacks	Data encryption; access control; threat monitoring	Increases system reliability and security
3. 3. Integration module with state registers	Automatic exchange of information with official state platforms	Synchronization with the State Customs Service of Ukraine, State Tax Service, Ministries, asset registers; automatic directory updates	Reduces information exchange time and reduces duplication of operations
3. 4. Data storage and archiving module	Long-term storage of information in compliance with regulatory requirements	Cloud and local storage; backup; archive search	Ensures availability of historical data for audit and analysis

The blockchain modules in the system provide fundamental trust, security, and transparency of information, which are critically important in the public and financial sectors. The main blockchain module creates a distributed transaction register that protects data from unauthorized changes and warrants their immutability, which significantly increases the legitimacy and legal weight of the stored information. The security and access control module implements multi-level authentication mechanisms, encryption, and logging of user actions, which prevents data leaks and abuse of access rights. The cybersecurity module strengthens the system's protection against external and internal cyberattacks, ensuring threat monitoring and prompt response. Integration with state registers automates data exchange with key official platforms (State Service of Ukraine for State Statistics, State Tax Service, ministries), which contributes to increasing the efficiency, accuracy, and transparency of information, as well as minimizing duplication of operations and errors associated with manual data entry. The data storage and archiving module is responsible for long-term storage of information in compliance with regulatory requirements, ensuring the availability of historical data for audit and in-depth analysis.

Thus, the synergy of artificial intelligence and blockchain technologies will form an intelligent, secure, and transparent system of accounting-analytical support in the public sector, which will improve the quality of public resource management. The synergy of these technologies is strategically appropriate for the development of the digital transformation of the public sector and the formation of new standards of effective and responsible management.

5. 4. Assessing the economic effect of implementing an accounting-analytical support model based on the synergy between AI and blockchain

In the process of assessing the feasibility of implementing an accounting-analytical support model in the public sector based on the synergy of artificial intelligence and blockchain technologies, it is advisable to allocate and structure economically justified costs by main items.

Among the key items, it is necessary to allocate costs, namely for implementation of the AI module; development of machine learning algorithms, integration with ERP systems, design of data collection and analytics modules; infrastructure for data processing (servers, cloud services, licenses for specialized software); personnel training (training of Data Scientists, AI engineers, accountants, analysts, administrators); support and updates (regular adaptation of models to legislative changes, technical support).

It is proposed to calculate potential cost savings from implementing an accounting-analytical support model in the public sector based on the synergy between AI and blockchain technologies using the NPV (Net Present Value) formula [18]

$$NPV = \sum_{t=1}^{n} \frac{CFt}{\left(1+r\right)^{t}} - Io, \quad (1)$$

where NPV is the net present value of implementing an accounting-analytical support model in the public sector based on the synergy between AI and blockchain;

CFi (*Cash Flow*) is the cash flow over period i;

r is the discount rate;

n is the total number of periods (intervals, steps);

$t = 0, 1, 2, \ldots, n$ for the entire investment period;

Io is the initial investment (cash outflow in the 0^{th} period).

Accordingly, it is first necessary to calculate the amount of costs required for the initial investment in implementing AI and blockchain technologies in the accounting-analytical support system in the public sector.

To analyze the volume of investments in implementing AI and blockchain technologies in the accounting-analytical support system in the public sector, it is necessary to determine the volume of costs separately for two modules, such as AI and blockchain. Table 4 gives the total costs required to introduce AI and blockchain technologies into the accounting-analytical support system in the public sector.

In the proposed model of accounting-analytical support using AI and blockchain technologies, economic costs are defined as a set of resources required for its design, implementation, and operation.

They are divided into main cost items, namely:

– costs for technological infrastructure, in particular server equipment / cloud capacity for processing large data sets and operating the blockchain network, licensed software (analytical platforms, database management systems, blockchain solutions, cyber protection tools), data storage systems (archives, data centers, backup);

– costs for development and implementation, in particular the development of AI modules (machine learning algorithms, analytical tools, dashboards); blockchain platform configuration (compiling smart contracts, access protocols, integration with state registers); integration with existing information systems (treasury, ERP systems, accounting programs);

– personnel costs, including salaries of IT specialists (programmers, data analysts, blockchain developers, cybersecurity specialists); personnel training (courses for accountants, financiers, civil servants) on working with the new system; methodological support (experts in accounting, auditing, financial control);

– costs for cyber protection and support, including information security systems (protection against cyber attacks, network monitoring, security audit); updates and technical support (software maintenance, regular updates, user support);

– indirect costs, including organizational costs (changes in regulations, adaptation of legislative acts, coordination with regulatory authorities); time costs (transitional period for adaptation, testing and launch of the system).

Thus, the total costs that must be incurred to implement the accounting-analytical support model were determined, in particular technology (infrastructure + software), human capital (development, training, support), protection and reliability (cybersecurity, support), organizational changes (adaptation of standards, processes). Based on the data obtained, the average costs necessary to implement artificial intelligence and blockchain technologies into the accounting-analytical support system of the public sector were calculated (Table 5).

To calculate NPV to assess the feasibility of implementing an investment project to implement AI and blockchain technologies in the accounting-analytical support system in the public sector, it is necessary to determine the cash flow for a certain period.

In the public sector, the accounting-analytical support system does not generate a direct cash flow but can attain an economic effect from the implementation of AI and blockchain technologies, which can be translated into a conditional cash flow for calculating NPV.

The economic effect includes savings from automating reporting and reducing manual labor, reducing errors and fines, optimizing the use of budget funds through AI analytical data, reducing audit and inspection costs.

Table 6 summarizes the amount of the annual economic effect from the implementation of AI and blockchain technologies in the accounting-analytical support system in the public sector.

Based on our calculations, the cash flow (Cash Flow) is taken to be 240,000 a.u. per year. The project implementation period is set at 7 years.

Table 4

Total costs required to implement AI and blockchain technologies into the accounting-analytical support system in the public sector

Expense item name	Purpose	Cost, a.u.
Costs of implementing an AI module		
AI system development and configuration	Cost of developing machine learning models, integrating with existing ERP and other systems, configuring data collection and analytics modules	50,000–200,000 (depending on complexity)
Data processing infrastructure	Servers, cloud solutions for storing and processing large amounts of data, licenses for specialized software	20,000–100,000 per year
Staff training	Hiring or training data specialists (Data Scientists, AI engineers), accountants, analysts, system administrators	40,000–120,000 per year
Support and updates	Regular model updates, adaptation to changes in legislation, technical support	15–20% of the development cost annually
Costs for implementing a blockchain module		
Development or integration of a blockchain solution	Construction or acquisition of a blockchain platform for maintaining a distributed registry, development of smart contracts, integration with state registries	60 000–250 000
Infrastructure	Servers, network nodes, cloud services for deploying a blockchain network, as well as security solutions	30 000–120 000
Security and access control	Implementation of multi-level authentication, encryption, security system audit	from 15,000
Support and support	Continuous security monitoring, protocol updates, compliance with regulations	15–20% of the initial cost annually
Staff training	Introducing employees to the features of working with the blockchain system	from 5,000
Shared costs and other factors		
Integration of AI and blockchain	Additional costs for system synchronization, development of data exchange interfaces, testing and optimization	10–15% of total costs
Legal support	Consultations on compliance with legislation, execution of contracts and licenses	from 10,000

Source: compiled by an author based on [19].

Table 5

Average costs required to implement AI and blockchain technologies into the accounting-analytical support system in the public sector

Expense item name	Average cost, a.u.
1. Costs for implementing the AI module:	
Development and configuration of the AI module	(50 000 + 200 000) / 2 = 125 000
Infrastructure for data processing	(20 000 + 100 000) / 2 = 60 000
Staff training	(40 000 + 120 000) / 2 = 80 000
Support and updates (17.5% of development)	125 000 × 0.175 = 21 875
Total costs for implementing the AI module	125 000 + 60 000 + 80 000 + 21 875 = 286 875
2. Costs for implementing a blockchain module	
Blockchain module development or integration	(60 000 + 250 000) / 2 = 155 000
Infrastructure	30 000 + 120 000) / 2 = 75 000
Security and control (average cost)	15 000
Support and maintenance (17.5% of development)	155 000 × 0.175 = 27 125
Staff training (average cost)	5 000
Total cost of blockchain module implementation	155 000 + 75 000 + 15 000 + 27 125 + 5 000 = 277 125
3. Shared expenses	
AI and blockchain integration (12.5% of total costs)	286 875 (AI) + 277 125 (blockchain) = 564 000 a.u.*12,5% = 70 500
Legal support	10 000
Total costs for implementing AI and blockchain technology model	564 000 + 70 500 + 10 000 = 644 500

Table 6

Annual economic effect of implementing AI and blockchain technologies in the accounting-analytical support system in the public sector

Source of effect	Cost, a.u.
Automate reporting and reduce manual labor (reduce payroll and paper document flow costs)	80 000
Reduce errors and fines (real-time control, blockchain transparency)	50 000
Optimize the use of budget funds through AI analytics	70 000
Reduce audit and inspection costs	40 000
Total annual economic effect	240 000

Discounted flows were calculated by year during the period of implementation of AI and blockchain technologies into the accounting-analytical support system in the public sector (Table 7).

Table 7

Discounted flows by year during the period of implementation of AI and blockchain technologies into the accounting-analytical support system in the public sector

Year	Cash flow, CF	Discount factor $\left(\frac{1}{(1+0.12)^t}\right)$	Discounted cash flow, a.u.
1	240,000	0.892857	214,285.71
2	240,000	0.797194	191,326.53
3	240,000	0.711778	170,826.66
4	240,000	0.635520	152,524.80
5	240,000	0.567429	136,182.96
6	240,000	0.506631	121,591.44
7	240,000	0.452353	108,564.69
8	ΣDCF		1,095,302.79
9	NPV		1,095,302.79 – 644,500 = = 450,802.79

The results of our study include the following conclusions: the net present value (NPV) of the project is 450,802.79 a.u., which is a positive result and indicates the economic feasibility of implementing an accounting-analytical support system based on the synergy of artificial intelligence and blockchain technologies in the public sector. The obtained NPV value means that after the return of the initial investment (644,500 a.u.), the project produces an additional economic benefit of more than half a million a.u. in present value over a period of 7 years.

The annual economic effect of 240 thousand a.u. is formed through:

– reduction of costs for processing and preparing reports;
– reduction of the number of errors and penalties;
– optimization of the use of resources and budget funds;
– reduction of costs for audits and inspections.

In particular, even taking into account the discount rate of 12%, the project remains economically profitable, and the payback period in discounted terms is expected to be within 3–4 years. Thus, the implementation of the project will have a financial and socio-economic effect, in particular increasing trust in state institutions, transparency in public finance management, and acceleration of digital transformation processes.

Based on the results of our study, the following conclusions were drawn: the net present value (NPV) of the project is 450,802.79 a.u., which is a positive result and indicates the economic feasibility of implementing an accounting-analytical support system based on the synergy of artificial intelligence and blockchain technologies in the public sector. The obtained NPV value means that after the return of the initial investment (644,500 a.u.), the project produces an additional economic benefit of more than half a million a.u. in present

value over a period of 7 years. The annual economic effect of 240 thousand a.u. is formed through the reduction of costs for processing and preparing reports; reduction of the number of errors and penalties; optimization of the use of resources and budget funds; reduction of costs for audits and inspections.

In particular, even taking into account the discount rate of 12%, the project remains economically profitable, and the payback period in discounted terms is expected to be within 3–4 years. Thus, the implementation of the project will have a financial and socio-economic effect, in particular increasing trust in state institutions, transparency in public finance management, and acceleration of digital transformation processes. improve the methodology related to calculations.

6. Results of investigating the integration of artificial intelligence technology into the accounting-analytical support system: discussion

Our model of accounting-analytical support for the public sector is characterized by comprehensive integration, covering technical, managerial, and regulatory aspects of implementation. Modern technologies, in particular blockchain and artificial intelligence, were increasingly used in the global practice of accounting and analysis, offering new opportunities for automation, transparency, and reliability of data [20]. The combination of these technologies in the public sector opened a new level of accounting-analytical support, where blockchain guaranteed data immutability and protection, and artificial intelligence provided their deep processing and forecasting.

Compared with [21], which noted the gap between academic models and public practice, our model adapted artificial intelligence algorithms to specific accounting rules, including role profiles of public sector users and access control. Unlike general reviews [22], which analyzed the convergence of AI and distributed ledgers in a business environment, the proposed model implemented operational scenarios for accounting for budget processes, including automated event verification, smart contract-based checkpoints, and AI-based risk prediction of financial transactions.

The model, the structural diagram of which is shown in Fig. 3, also differed from commercial platforms based on blockchain and AI [23] as it provided regulatory compliance, audit trails of access and risk management, rather than network effects and customization of corporate processes. Compared with a paper on RPA [24], where automation is often limited to existing procedures, our model transferred critical validations to the registry level, increasing the resistance to changes in interfaces and accounting forms. Based on the data obtained, the average costs for the implementation of AI and blockchain technologies in the accounting-analytical support system were calculated. As given in Table 4, the largest share was occupied by costs for AI modules (286,875 a.u.) and blockchain technologies (277,125 a.u.), which indicated the high capital intensity of the initial stage of digitalization. At the same time, this was consistent with the expected benefits (Table 1), in particular process automation, increased data accuracy, and reduced operational risks.

In addition, a balanced distribution of costs between technical solutions and supporting elements – legal support and staff training (80,500 a.u., Table 2) – ensured the model's comprehensiveness. Using the NPV formula (1) to assess the economic effect showed that despite significant initial investments, the expected benefits from reduced audit costs and increased transparency of accounting processes formed a positive forecast of net present value (Table 3).

Thus, a comparison of costs (Table 4), functionality (Table 1), and implementation algorithm (Table 2) confirms that the high initial cost is a justified investment that provides strategic benefits in the form of increased efficiency and reliability of accounting-analytical data in the public sector.

7. Conclusions

1. A mechanism for implementing artificial intelligence technologies into the accounting-analytical support system has been designed, which is based on a phased and comprehensive approach. It involves careful planning, ensuring high data quality, choosing optimal technological solutions, training personnel, and continuous monitoring of results. The introduction of such a mechanism could contribute to the effective integration of innovative technologies, improve the quality of accounting, reporting and analytics, as well as optimize management decisions in the public sector.

2. An algorithm for implementing blockchain technology into the accounting-analytical support system in the public sector has been developed, representing a structured and consistent action plan that covers key stages – from defining goals and justifying the need to personnel training. This algorithm takes into account both technical-organizational and legal aspects, which provides a comprehensive approach to the integration of blockchain technologies. The proposed phased model is aimed at minimizing risks, increasing the efficiency and transparency of accounting-analytical processes in the public sector, as well as at forming a reliable IT infrastructure and qualified human resources for the successful implementation of the innovative system. Thus, the developed algorithm lays the foundation for the systematic and secure implementation of blockchain, which could contribute to digital transformation and increase trust in public financial processes.

3. A structural diagram of the model of accounting-analytical support in the public sector has been constructed, which is based on the synergy of artificial intelligence and blockchain technology. The combination of the advantages of these innovative solutions ensures transparency, reliability, and efficiency of data processing. The scheme integrates automated data collection and verification, intelligent analysis, forecasting, reporting, as well as warrants security, immutability, and protection of information. This approach contributes to increasing the efficiency of financial resource management, minimizing fraud risks and strengthening trust in public institutions.

4. The economic effect of investments in the implementation of an accounting-analytical support model in the public sector based on the synergy between AI and blockchain has been analyzed. According to the calculation results, the net present value (NPV) was 450,802.79 a.u. This positive indicator confirmed the economic feasibility and prospects of the project implementation, since after covering the initial investment of 644,500 a.u., it is expected to receive additional net economic benefits of more than half a million a.u. in present value over 7 years of system operation. It was determined that the annual economic effect in the amount of 240 thousand a.u. will be formed due to the complex influence of factors. A significant impact was made by reducing the costs of processing, preparing, and automating reporting; reduc-

ing the number of errors and related penalties; optimizing the use of budget resources; reducing the costs of auditing, inspections, and control measures. Taking into account the discount rate of 12%, it was determined that the project is stably profitable, and its payback period in discounted terms is projected to be within 3–4 years, which is acceptable for public investment projects.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study, as well as the results reported in this paper.

Funding

The study was conducted without financial support.

Data availability

All data are available, either in numerical or graphical form, in the main text of the manuscript.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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