

THE TREASURY SERVICING PROCESS MANAGING OF BUDGET EXECUTION BASED ON BLOCKCHAIN TECHNOLOGY

УПРАВЛІННЯ ПРОЦЕСОМ КАЗНАЧЕЙСЬКОГО ОБСЛУГОВУВАННЯ ВИКОНАННЯ БЮДЖЕТІВ НА ОСНОВІ БЛОКЧЕЙН ТЕХНОЛОГІЇ

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The article explores the possibilities and international experience of using multi-functional and multi-level information blockchain technology, the main purpose of which is reliable accounting of financial transactions with various assets.

A mechanism for determining the legitimacy of transactions sequence carried out using distributed ledger technology is considered. The main directions of the distributed ledger technology application by the business community in all spheres and sectors of the global economy are identified. The mechanism of using smart contracts based on block-technology in the Treasury servicing system was designed and presented. The performed mechanism covers the management process of all Treasury servicing procedures of the estimates expenditure part of budget managers. The complex of advantages from the implementation of distributed ledger technology to the Treasury servicing system for state and local budgets is determined.

Key words: distributed ledger technology, Treasury system, cash execution of budgets, budget process, smart contract.

В статті досліджуються можливості та міжнародний досвід використання багатофункціональної та багаторівневої інформаційної технології блокчейн, основним призначенням якої є надійний облік фінансових транзакцій з різними активами. Розглянуто механізм з'ясування правомірності послідовності транзакцій, які здійснюються з використанням технології розподіленого реєстру. Визначено, що стрімкий розвиток блокчейн-технології як у площині функціонування криптовалют, так і у напрямку створення додатків в області економіки і фінансів, що працюють з різними типами фінансових інструментів, викликають багато нововведень, що стосуються питань удосконалення систем управління базами даних. Визначено основні напрями поступового використання потенціалу технології розподіленого реєстру бізнес-спільнотою у всіх сферах та галузях світової економіки та зростання інтересу з боку державних органів. З'ясування характерних рис функціонування інституту казначейства в сучасних умовах, а саме: динамічність саморозвитку, зростання вимог до надійності процесу касового виконання державного та місцевих бюджетів, активізація процесів розширення меж інформаційного середовища, підвищення обсягів оброблюваної інформації, розширення кола контрольних повноважень тощо, дало змогу обґрунтувати доцільність практичного використання блокчейн технології в системі казначейського обслуговування виконання бюджетів різних рівнів. Побудовано та представлено механізм використання смарт-контрактів на основі блокчейн-технології в системі казначейського обслуговування в рамках єдиного інформаційного простору, в якому функціонують казначейство (на рівні якого відкрито реєстраційні рахунки на ім'я розпорядників бюджетних коштів) та комерційні банки (де відкриті рахунки контрагентів розпорядників бюджетних коштів). Представлений механізм охоплює процес управління всіма процедурами казначейського обслуговування видаткової частини кошторисів розпорядників бюджетних коштів: від укладання господарських угод, реєстрації юридичних та фінансових зобов'язань, організації належного рівня попереднього казначейського контролю, здійснення фінансових транзакцій в автоматичному режимі за умови повного виконання договірних умов, до формування фінансової звітності на засадах прозорості та мінімізації дії людського фактору. Визначено комплекс переваг від запровадження технології розподіленого реєстру в систему казначейського обслуговування державного та місцевих бюджетів.

маціонної технології блокчейн, основною метою якої є надійний облік фінансових операцій з різними активами. Розглянуто механізм визначення легітимності послідовності транзакцій, проводимих з використанням технології розподіленого реєстру. Визначено основні напрями застосування технології розподіленого реєстру бізнес-спільнотою во всіх сферах і секторах світової економіки. Розроблено та представлено механізм використання смарт-контрактів на основі блокчейн технології в системі казначейського обслуговування. Сформований механізм охоплює процес управління всіма процедурами казначейського обслуговування сметної расходної частини бюджетних менеджерів. Визначено комплекс переваг від впровадження технології розподіленого реєстру в систему казначейського обслуговування державного і місцевих бюджетів.

Ключевые слова: технология распределенного реестра, казначейская система, кассовое исполнение бюджетов, бюджетный процесс, смарт-контракт.

В статті досліджено можливості використання багатофункціональної та багаторівневої інформаційної технології блокчейн, основним призначенням якої є надійний облік фінансових транзакцій з різними активами. Розглянуто механізм з'ясування правомірності послідовності транзакцій, які здійснюються з використанням технології розподіленого реєстру. Визначено, що стрімкий розвиток блокчейн-технології як у площині функціонування криптовалют, так і у напрямку створення додатків в області економіки і фінансів, що працюють з різними типами фінансових інструментів, викликають багато нововведень, що стосуються питань удосконалення систем управління базами даних. Визначено основні напрями поступового використання потенціалу технології розподіленого реєстру бізнес-спільнотою у всіх сферах та галузях світової економіки та зростання інтересу з боку державних органів. З'ясування характерних рис функціонування інституту казначейства в сучасних умовах, а саме: динамічність саморозвитку, зростання вимог до надійності процесу касового виконання державного та місцевих бюджетів, активізація процесів розширення меж інформаційного середовища, підвищення обсягів оброблюваної інформації, розширення кола контрольних повноважень тощо, дало змогу обґрунтувати доцільність практичного використання блокчейн технології в системі казначейського обслуговування виконання бюджетів різних рівнів. Побудовано та представлено механізм використання смарт-контрактів на основі блокчейн-технології в системі казначейського обслуговування в рамках єдиного інформаційного простору, в якому функціонують казначейство (на рівні якого відкрито реєстраційні рахунки на ім'я розпорядників бюджетних коштів) та комерційні банки (де відкриті рахунки контрагентів розпорядників бюджетних коштів). Представлений механізм охоплює процес управління всіма процедурами казначейського обслуговування видаткової частини кошторисів розпорядників бюджетних коштів: від укладання господарських угод, реєстрації юридичних та фінансових зобов'язань, організації належного рівня попереднього казначейського контролю, здійснення фінансових транзакцій в автоматичному режимі за умови повного виконання договірних умов, до формування фінансової звітності на засадах прозорості та мінімізації дії людського фактору. Визначено комплекс переваг від запровадження технології розподіленого реєстру в систему казначейського обслуговування державного та місцевих бюджетів.

Ключові слова: технологія розподіленого реєстру, казначейська система, касове виконання бюджетів, бюджетний процес, смарт-контракт.

Formulation of the problem. The emergence and active development of blockchain technology became possible due to the appearance of Bitcoin. In 2008, an information resource published article titled "Bitcoin: A Peer-to-Peer Electronic Cash System" authored by a person or persons under the pseudonym Satoshi Nakamoto. This article is devoted to the principles of creating a temporary payment system that is capable of carrying out electronic transactions between participants of such system, leaving aside financial institutions that perform intermediary functions. Recent conditions for the implementation of the

cash execution process of state and local budgets, which in Ukraine is carried out by Treasury bodies, determine the need for constant modernization, aimed at ensuring absolute transparency of the budget process, reliability of transactions with public funds. Consequently, the use of blockchain technology in the Treasury servicing system is noteworthy, since this technology is able to bring the cash execution process of budget expenditures to an entirely new quality level.

Analysis of recent research and publications. The works by the following domestic scientists

and practitioners are dedicated to the problems of Treasury servicing of budgets of all levels in Ukraine: O. Danevich, A. Luchki, B. Malinaka, K. Pavlyuk, V. Stoyan, P. Petruska, O. Chechulina, S. Yuriy, L. Deykalo, L. Litvinenko, M. Ogdansky, L. Pushkarenko etc. At the same time, strategic directions of improvement and information modernization are studied by such scientists as O. Skorik, Yu. Golinsky, L. Luciv, L. Gordienko etc. However, despite the depth and thoroughness of the scientific developments, the issues of information modernization in the Treasury servicing system for the execution of state and local budgets do not lose their relevance and need further elaboration.

The purpose of the article is to study the ways of implementing blockchain technology in managing the process of Treasury servicing of state and local budgets.

Statement of the main research material. Blockchain is a multi-functional and multi-level information technology, the main purpose of which is to securely account transactions with various assets. This is a technology for distributed copying and storage of records of all previously completed transactions, which in a generalized way is a chain of information blocks, the volume of which is constantly increasing due to the addition of new blocks with records of recent operations. In addition, this database is chronological. The time of making records in the database is necessarily related to the data arrays themselves, which makes the database non-commutative. Information is represented by a

sequence of records, which is constantly updated. All the records and additional data are stored in blocks, which, in turn, exist as a single-linked list. Each system participant is represented by a node, which is in constant contact with other nodes (nodes add new records at the end of the list and inform everyone about changes in the list) and in which all the necessary information is accumulated. Each regular participant, sending a transaction to the next and signs the hash of the previous transaction and the public key of the next participant and adds this information to the end of the transaction. Thus, the recipient can verify the entire transaction chain by checking all signatures of previous transaction participants [1]. It should also be marked that all transactions are performed exclusively based on cryptographic confirmation. All network participants when registering and after installing the necessary software on the workstation receive two different cryptographic keys: the private key – used to encrypt the transaction, the public key – used to verify the transaction. The mechanism for determining the validity of the sequence of transactions is shown in Figure 1.

Thus, each of the system participants signs the hash of the previous transaction and attaches this information to the end of the transactions. In this way, the recipient can verify the entire transaction chain, since information about the signatures of all previous transaction participants is available. At the moment, in the conducted research, experts highlight some technical features that arise when implementing the

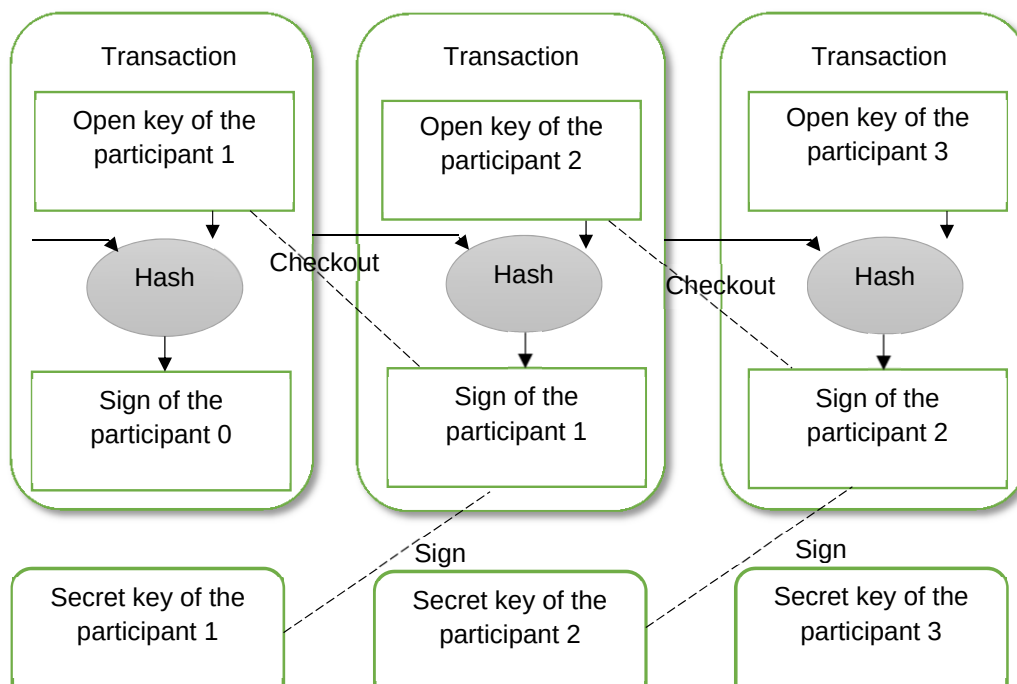


Figure 1. Mechanism for determining the validity of transactions using blockchain technology

Source: created by the authors based on [2]

blockchain, namely, ensuring network bandwidth for the normal operation of the blockchain and providing the node with the necessary amount of disk space [3].

The blockchain protocol provides special limitations on the maximum possible number of transactions at the level of each block, namely the number of transactions at a certain time interval, which, accordingly, affects the number of generated blocks for a certain time. The duration is required to generate blocks in different systems based on the blockchain can be different.

However, work is underway to reduce of the blocks generation time and improved methods are replacing the previously used generation methods PoS (Proof-of-stake) and PoW (Proof-of-work), for example, those that are used on the BitShares platform and Delegated Proof-Of-Stake. An example of possible improvements in this area can also be the Lightning Network technology in which transactions are sent directly between counterparties and only "control points" are stored in the blockchain similar to Bank and insurance deposits. Another problem is related to the large number of transactions and the need to store transaction information on each node included in the blockchain system [2].

Melanie Swan, a researcher and founder of the Blockchain Research Institute, outlines three directions for the use of this technology [4]: Blockchain 1.0 is a currency; Blockchain 2.0 is contracts; Blockchain 3.0 is an application.

It should also be noted that the rapid development of blockchain technology causes many innovations regarding the improvement of database management systems. Thus, the Tkeycoin financial platform created the TKEY core, taking the next generation protocol as a basis, and providing a fundamentally new, higher level of quality for security and functional characteristics of the digital ecosystem. Application of original software solutions and approaches allowed to solve some problems related to file system reliability, scalability, performance, system bandwidth, some aspects related to the specifics of data storage, synchronization with other existing systems, support for a significant number of connections to single database. In contemporary conditions, it is inherent that various projects aimed at the implementing of distributed ledger technology are actively being developed in all segments of the financial market. Extremely high level of security for data storage and financial transactions is the absolute appeal of blockchain technology. The potential of the distributed ledger technology began to be fully assessed by the business community in 2015 and today there is a very active interest in it both from the side of large multinational companies and banks and from the government bodies of many countries of the world. The huge number of academic and corporate developments and studies confirms this. Many experts note that the implantation and use of

distributed ledger technology in all areas and sectors of the world economy is as important as the creating of a global network. Blockchain technology, due to its separatedness, validity, and connectivity, provides a wide range of advantages, including reliability and data security. This is achieved by the inability to fake and delete data, exception to the need to contact financial intermediaries, lack of technological failures, etc. As a result of the rapid development of blockchain technologies, there has been a significant increase in interest in them from public authorities and private structures. The possibilities of using this innovative technology in various fields began to be actively studied: from financial markets to public administration. In early 2016, the UK Government Office for Science conducted a detailed study of blockchain technology and published a report [5]. This report is devoted to defining the main tasks of the state in relation to the use of blockchain technology in the context of providing services to citizens, taking into account the fact that the distributed ledger technology can significantly affect business processes and the mechanism of public administration. The implementation of distributed ledger technology will help achieve significant levels of regulatory compliance, accountability, and cost-effectiveness. In addition, representatives of the Council of the Federal Reserve System and the Federal Reserve Banks of New York and Chicago conducted research on the prospects for using blockchain technologies. It was evaluated the possibility of using this technology in making payments and operational management, as well as the risks and benefits associated with the full-scale and long-term implementation of distributed ledger technology.

Some expert's express confidence that in the future it will be possible to carry out even an electoral process without the possibility of falsification of results based on this technology, as one of the main advantages of blockchain technology is that the recorded information cannot be corrected, removed or substituted. Special unique encryption algorithms create this extremely useful feature of the technology.

In recent years, the steady growing interest in the blockchain has been caused by the active development of financial and technological platforms and startups, which are developed and implemented at the intersection of finance and information technology. The business models of these startups are much more profitable on the financial services market than those presented by large investment banks. Financial and technological startups, which are based on blockchain technology, are currently attracting huge investments. Evidence of this is Digital Assets Holdings, a company founded by Blythe Masters, a former top manager at J.P. Morgan. Now, the startup Masters has attracted investments in excess of 50 million USD [6].

The most significant consequence of the blockchain technology implementation in the operational management of banking sector entities' processes is the reduction of data transmission costs and, as a result, the decrease of system risks of operational activities. This suggests that in the future most financial and economic valuation models with forecasting functions undergo significant transformation. In addition, it should be noted the possibility of creating reliable financial instruments using distributed ledger technology. Experts have already noted the possibility of creating specialized innovative assets. The fact of trade option organization implemented by Ethereum allows specialists to claim that based on blockchain technology it is possible to organize trade in a large number of specialized financial instruments. Therefore, the distributed ledger technology is quite suitable for use in the Treasury servicing system for budget execution at various levels. Let us justify mentioned above.

The dynamic development of the Treasury system in all developed countries, which use a treasury form of the budget's implementation, the growing requirements for the reliability of the cash execution process of state and local budgets intensify the processes of expanding information environment boundaries of the Treasury system. This will lead to an increase in the volume of processed information and the number of transactions. At the same time, quality parameters of Treasury functioning are changing, among them: expanded range of control powers, actively introduced information technologies, changed function parameters etc.).

According to A. Skorik, in Ukraine, the use of automated systems ensures the creation of a single information space that covers all functional areas of the budget sphere and all participants in the budget process. The core of building a single information space for the budget sphere is the full automation of the Treasury budget servicing process. This ensures the optimization of integrated budget accounting, financial control and effective management of state and local financial resources [7].

The use of modern information technologies implies the creation of quality new forms of organization of the activities of the State Treasury servicing of Ukraine and their structural divisions [8]. In the context of the foregoing, the introduction of electronic digital signature in the Treasury system plays a major role. The first stage in the development of this direction was the use of a mechanism for remote servicing of budget institutions using the software and technical complex "Treasury Client-Treasury", also introduced in Ukraine. In contrast to the traditional Treasury servicing system, the use of the remote service form has a number of advantages for Treasury clients, namely, the optimization of administrative costs for the preparation and delivery of documents;

reduction of paper media; acceleration of information flows; reduction of errors due to the action of the human factor; receiving data on account balances in real time. This is a significant breakthrough in the Treasury servicing system. However, the growing requirements for the functioning of the system, such as: the need to achieve a high level of efficiency in the implementation of cost estimates for budget Managers, transparency, security and reliability of the budget funds transfer process necessitate the search and use of even more innovative forms of settlement.

One of the most effective methods of data transfer and storage when using blockchain technology is a smart contract, which is a generated program code, stored and executed in all blocks of the network simultaneously and in an identical form.

All program logic of a smart contract is recorded and stored in a block, which is a program container. It combines all the messages related to this smart contract. Messages can act as inputs and outputs of the smart contract program code and lead to some actions in a real and digital environment outside of Blockchain [9]. Certain types of concluded smart contracts allow to fully automated process of implementation of contractual relationships between contractors taking into account that such contracts perform the functions of an independent billing or contract system. The term "smart contract" appeared in 1996. Nick Szabo, an IT specialist, a graduate student at the University of Washington, defined the smart contract as "a set of promises expressed in digital form including protocols for the parties to fulfil those promises" [10]. He cited vending machines as an example of a "prototype of a primitive smart contract," which has the ability to independently sell goods and services using automated systems. Therefore, the idea of autonomous execution of operations without human participation appeared long before the creation of blockchain technology. However, the active development of this technology has significantly influenced the increase in attention and the expansion of the practice of applying smart contracts. Elements of a smart contract are the following objects [11]:

- Contract subject. The program must have access to the goods or services for which the contract is concluded and be able to automatically allow or deny access to them;
- Digital signature. All participants initiate the transaction by signing the agreement with their private keys;
- Terms of agreement. Smart contract terms are presented in the form of an exact sequence of operations. All participants must sign these terms;
- Decentralized platform. A smart contract is recorded to a block of chain and distributed data and stored on its nodes.

In the blockchain mechanism, a hash is an array of specific information that is transformed accordingly. In the case of crypto currencies, this is data related to the executed transaction. In the case of using this technology in the Treasury system which is a much more complex process this array is formed as a result of the accumulation of information about smart contracts and the actual state of the entered unique alphanumeric program code. Thus, the use of public and private keys by system users is the basis for a high level of security of blockchain technology (Figure 2). Consequently, provided that the proposed mechanism is implemented within the framework of the single information space where the Treasury operates (at the level of which registration accounts in the name of budget funds managers are opened) and commercial banks (where accounts of contractors of budget funds managers are opened), at the first stage an agreement between the budget funds Manager

and an entrepreneur is concluded. This agreement, subject to the use of distributed ledger technology, turns into a smart contract.

At the second stage, by registering the obligations of budget Managers, the Treasury's powers to exercise preliminary financial control are implemented. It should be noted that the registration of financial obligations goes to the plane of an automatically implemented process. The technology generates a certain program code with the help of which the obligations are registered in automatic mode, provided that these documents (invoices, bills of lading, certificates of work performed or services rendered, etc.) and those confirming the fact of their occurrence will be properly executed simultaneously with the moment of reflection of these obligations in the accounting of the budget Manager. Thus, in a single information space of distributed ledger technology, accounting and budget accounting are merged.

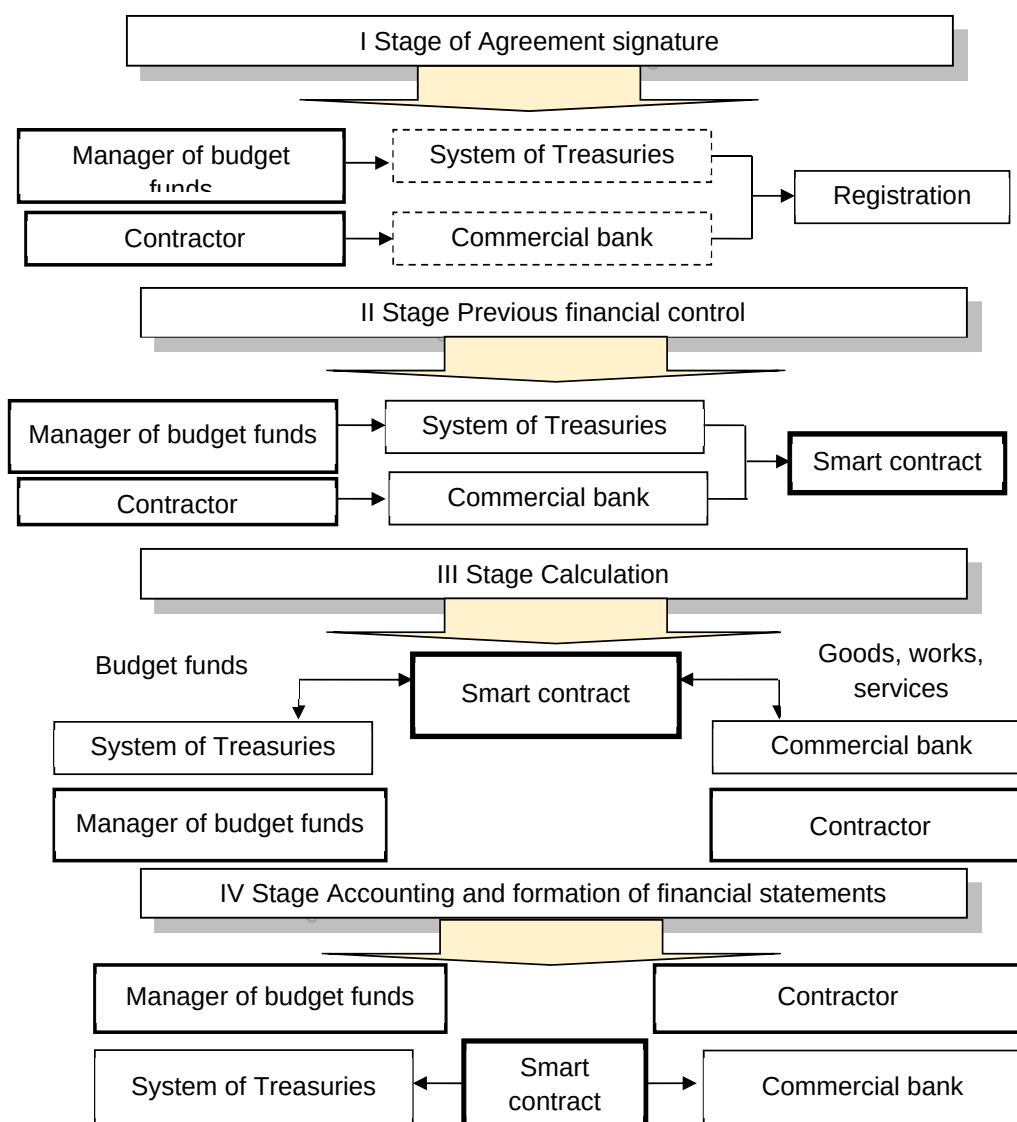


Figure 2. Mechanism for using smart contracts based on blockchain technology in the Treasury servicing system

Source: designed by the authors

The third stage provides for automatic transfer of funds from accounts opened at the Treasury level in the name of budget Managers in favour of contractors in accordance with the terms specified in the agreement and based on previously registered obligations. A payment order which is now formed and submitted in paper and electronic form to the Treasury authorities, requires appropriate work by a responsible employee and therefore some very significant time (with a significant number of payment orders). When applying blockchain technology, the procedure is reduced to a program code, which is formed by the system. The electronic digital signature of the responsible officers of the Manager and the Treasury necessarily confirms the code. At the last fourth stage, financial reports generated synchronously on the execution of estimates of budget-funded managers at both the level of the budget Manager and the Treasury. The reporting process takes on the features of exceptional transparency and reliability.

Conclusions. In summary, the results of the research presented the following. The study has revealed that the main result of the development of modern information technologies is the creation of innovative systems, the main characteristics of which are reliability, transparency and extraordinary adaptability to application in almost all spheres of human activity. Blockchain technology is gradually taking new positions in almost all parts of the financial system and this process is steadily gaining momentum. In turn, the Treasury servicing system in all countries is a function of the state power, the purpose and specific features of which encourage the system to constant self-improvement, expansion of opportunities to create effective and reliable means of communication, to develop measures for the introduction of the newest information technologies, which unify the treasury procedures and thus can significantly increase the efficiency and transparency of the state and local system of cash execution. The use of distributed ledger technology will lead to a significant simplification of the Treasury servicing process of budget execution at all levels, reduction of resource costs, decrease of document circulation, and full automation of financial transactions when all conditions stipulated fulfilled by contractual relations. The implementation of these innovations should result in high efficiency of the use of state financial resources and proper state control at all stages of the budget process, which will prevent violations of legislation in the budgetary sphere.

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