ЭКОНОМИКА, БИЗНЕС ЖӘНЕ МЕНЕДЖМЕНТ
ЭКОНОМИКА, БИЗНЕС И МЕНЕДЖМЕНТ
ECONOMY, BUSINESS AND MANAGEMENT

https://doi.org/10.31489/2024Ec4/7-15
JELO33
УДК 330.47
Received: 29.03.2024. | Accepted: 28.08.2024.

A.A. Abaidullin[1*], A.Sabyrzhan[2], N.K. Ashirbekov[3]

[1, 2] Karaganda Buketov University, Karaganda, Kazakhstan
[3]«Center for the Civil Law Research» LLP, Karaganda, Kazakhstan

[1]Alish.abaidullin@gmail.com, [2]alisher-aliev-79@mail.ru,[3] aiza_yo@mail.ru

[1]https://orcid.org.0009-0005-1279-2134
[2] https://orcid.org.0000-0002-8910-4572
[3]https://orcid.org.0000-0002-8843-2515

[2] Scopus Author ID: 57222593357
[2] Researcher ID: B-5709-2019

The research of the world experience in the use of blockchain technologies

Abstract

Object: To explore experience of using blockchain and identification of problems those hinder its development in Kazakhstan.

Methods: General scientific methods employed in this study included descriptive, retrospective, system analysis, synthesis of the subject, as well as system-structural and system-functional analyses. In addition, specific methodologies such as modeling, formal logic, comparative analysis, comparative legal analysis, SWOT, and PEST analyses were utilized. Processing of the data was carried out through the EXCEL.

Findings: Digital technologies are becoming the main trends. Their promotion changes life and stimulates to work on development of social, economic spheres. It is accepted that they increase the efficiency of not only personal life, but also the economy.

*Conclusions:*The solution to the problems is possible through the harmonization of legislative standards, investments in educational programs and the involvement of international experience. The example of the eGov 3.0 initiative has shown the importance of algorithmic approaches and predictive management for optimizing the interaction between the state and society. Based on the above, blockchain acts as a strategic tool for modernizing the economy and increasing its sustainability. The introduction of distributed ledger technologies, taking into account global experience, will allow Kazakhstan to effectively adapt to global challenges, strengthening the institutional environment and stimulating innovative development.

Keywords: *blockchain technology, bitcoin, integration, cryptocurrency, smart contract, digitalization, digital technology.*

Introduction

The current economy is progressively embracing digitalization, introducing blockchain technologies that serve as effective tools for optimizing transactional processes and enhancing transparency across various sectors. Development of decentralized platforms such as blockchain contributes to the transformation of institutional environment and the creation of new opportunities to improve competitiveness of national economies.

According to the research, the use of blockchain solutions in Kazakhstan reached new levels in 2023 when the share of electronic government services grew to 83.7 % exceeding previous figures by 15 %. This index is expected to grow to 90 % by the end of the year. Success as this is associated with the active imple-

* Corresponding authors e-mail address*: Alish.abaidullin@gmail.com*

mentation of intelligent technologies such as smart contracts, which reduce transaction costs and improve financial transaction transparency. Georgia sets a perfect example of successful implementation by registering property rights using the Exonum platform that managed to reduce both process costs by 90 % and processing time from three days to several minutes.

Despite the above, the widespread use of blockchain is still associated with a number of challenges including the need to unify regulatory standards and develop technological infrastructure. Case in point, Kazakhstan is still facing a shortage of qualified information and communication technology experts. This leads to the need to engage international experience and attract investment in educational programs. In 2021, the eGov 3.0 initiative has demonstrated the importance of implementing digital solutions such as predictive management and flexible identification protocols, which increased the volume of services provided more than eightfold compared to previous periods.

Globally, blockchain is seen as a driver of sustainable economic growth. The UN is setting the goal to modernize infrastructures and move to sustainable technological systems by 2030. In countries like the Netherlands, integration of decentralized pension infrastructure management systems illustrates the successful use of blockchain to address complex institutional issues.

In Kazakhstan, the development of blockchain technologies creates favorable conditions for diversifying the economy and strengthening the country's position in the global digital environment. Increasing the level of trust in government services, reducing corruption risks and stimulating investment are key factors in this process. Considering current trends, systematic development and regulation of blockchain technologies will not only optimize resource allocation but also enhance institutional sustainability, which is crucial in a rapidly evolving economic landscape.

Methods

This study is based on a theoretical and methodological framework and integrated approaches, uses systems analysis, system-structure and system-function approaches that form a holistic view of transformation of institutional parameters. Introduction of categorical methods, such as formal-logical, comparative-legal, SWOT and PEST analyses, and the modeling method, contributes to optimization of strategic decisions. The use of computing resources, e.g., MS Excel, ensures reproducibility and transparency of data processing. Our findings indicate the need for long-term planning, intersectoral coordination, and differentiated use of macroeconomic instruments. Adaptation to global market's mobile parameters stimulates sustainability of economic systems. Consequently, systematization of empirical evidence based on multi-level analytical methodologies strengthens scientific and practical potential, improves economic forecasting, intensifies innovation dynamics, and strengthens the institutional environment's competitiveness.

Literary review

The empirical array of data reflected in the analyzed Web of Science Core articles, as well as the results of the "cluster analysis" of key terms form the basis for a strategic reassessment of the role of "blockchain technology" in the modern macroeconomic context. The identified vectors, such as "economic benefit," "financial and technical revolution," and "sharing economy," further emphasize transformational nature of this innovation. In the context of growing importance of the "distributed registry" for optimizing transaction costs and institutional improvement, the study initiated by the UK's Government Office for Science points to the need to build systemic regulatory methodologies. Similarly, the critical reviews by Niforos M. focus on multi-faceted risks associated with institutional adaptation, regulatory consistency and staffing sufficiency.

Given these trends, further analytical reorientation involves development of complex economic and organizational mechanisms capable of integrating innovative digital solutions into long-term structural strategies. The use of multidisciplinary economic tools including neoclassical and institutional paradigms, general equilibrium analysis, quantitative assessment of transaction effects, development of efficient resource allocation indices, and diversification of technological platforms is becoming the cornerstone for the consistent implementation of blockchain practices. The need to harmonize regulatory codes, to internalize external effects, to adapt human resource management, and to form incentive mechanisms for corporate governance predetermine the importance of formulating large-scale industrial and innovative doctrines.

(Min, 2019) has found that an analysis of empirical foundations and strategic scenarios for blockchain reveals how the "potential of blockchain" is creating a new platform for re-evaluating global distribution of economic power and technological benefits. Further integration of such solutions into global production and investment chains requires harmonization of legal frameworks, unification of data protection and intellectual property standards, and ensuring a sustainable institutional framework.

Developing sophisticated economic models that account for the dynamic characteristics of innovative digital ecosystems fosters long-term competitive advantages, enhances the efficiency of business systems, and progressively uncovers the complete economic potential of an emerging technological paradigm.

A review of seven current projects in Europe demonstrates that a comprehensive assessment of the blockchain concept's potential, particularly within financial services, reveals the intricate institutional transformations brought about by the implementation of a distributed ledger. It is becoming obvious that significant challenges arising from regulatory uncertainty, transformation of transaction structures, and the need to improve integration models require a systemic restructuring of basic economic paradigms. In addition, focus on optimization of operational processes reflected in the desire to improve efficiency, stimulates the search for adaptive strategic solutions and ensures a structural shift in management practices.

The collision between innovative trends and existing systems forms a critical point for strategic decision making because flexible implementation of technological platforms is accompanied by institutional regulation and formation of compliance mechanisms. Introduction of smart contracts further decentralizes business operations, expanding horizons of international economic relations. However, systematization of economic benefits from the use of blockchain requires empirically based methodologies stimulating optimal resource allocation, reduction of transaction costs, and development of market mechanisms.

In parallel, further application of this innovation in non-traditional areas including aviation prompts new questions regarding optimization of logistics chains, identification protocols, and intellectual property management. Strategic interaction with global institutions assumes harmonization of regulatory standards, financial directives, and fiscal incentives. Increasing internationalization of economic processes creates an environment where regulatory convergence, institutional transparency, and long-term planning are becoming key factors for success.

Harmonization of economic and legal norms, modernization of management capital and unification of technological regulations will ensure structural balance, minimizing the risk of fragmentation of the innovation environment. The studies we have reviewed including those mentioned in (Pierangelo, 2019) substantiate the need for a systems approach to the development of a technological ecosystem. Consequently, updating strategic guidelines combining sustainable macroeconomic regulation, flexible institutional mechanisms, and innovation stimulation will effectively overcome barriers to blockchain dissemination and form a competitive, open and adaptive economic architecture of the future.

In the long run, consolidation of these blockchain solutions will create conditions that encourage innovative activities, bolster human capital, and accelerate scientific and technological development. Embedding distributed ledger technologies in the management practices of government agencies, financial institutions and manufacturing companies helps increase trust in information systems, minimize distortions in supply chains, and strengthen positions in the global economic architecture. Building the capacity of digital transformation reflected in the articles by the above-mentioned authors and studies by the European Commission, opens up broad prospects for improving institutional efficiency and forming long-term competitive advantages. The direction in question provides a favorable environment for adaptation to ever-changing conditions by strengthening systemic resilience and laying the foundation for further sustainable growth, increasing productivity, and optimizing resource allocation.

Discussion

Drawing on extensive global experiences and our assessment of the adoption of new blockchain technology, we can confidently state that advanced digitalization models lay the groundwork for restructuring institutional frameworks and optimizing transaction costs. Estonia is a striking example of a successful implementation of innovative solutions, a country with a population of just over 1.3 million people that managed to use decentralized registries to consolidate key areas. In the context of the active digital environment development, ensuring sustainable growth requires comprehensive economic and management mechanisms. We would like to emphasize the fact that 99 % of services are integrated into network structures, and 100 % of government data are accumulated in a reliable decentralized circuit minimizing the risks of operational failures and improving efficiency of administrative processes.

Achieving this level of transformation appeared to be the case of strategic implementation of innovative protocols. In 2012, they developed the KSI system that ensured institutional integrity and guaranteed continuity of verification of information flows. The approach in question helps reduce transaction barriers, strengthen trust in digital platforms, and stimulate the spread of modern public policy paradigms. Adoption

of decentralized decisions strengthens competitive positions of national economic entities expanding access to international capital markets, trade networks, and technological alliances.

Analyzing the economic implications of such a transformation, it is important to note that implementation of blockchain solutions creates a synergistic effect for various industries from the financial sector and healthcare to logistics and education. Development of distributed registries contributes to formation of a new logic of interaction between economic agents, reducing transaction costs, and optimizing resource allocation. The direction in question stimulates emergence of new capital formation forms, diversification of export directions, and also strengthens macroeconomic stability.

Deconcentration of institutional structures increases market transparency and promotes unification of information exchange standards, thereby increasing trust in digital platforms. In the long term, the effect of blockchain integration is reflected in improving the quality of public administration, rationalizing budget expenditures, and stimulating innovative activity. An evaluation of implementation practices reveals that successful integration of decentralized technologies into the economic environment provides a favorable institutional environment for long-term growth, adaptation to global challenges, and strengthening competitive advantages in a dynamic digital economy.

Table 1. The List of Blockchain Projects

N	Projects	Country	Application Field	State Participation Level
1	Exonum, land plot registration	Georgia	Land registry, transactions in real estate	National
2	Blockcerts, academic credentials	Malta	Academic certificates and verifications, individual record keeping	National
3	Chromaway, transactions in real estate	Sweden	Transactions in real estate, land titles transfer	National
4	Pension infrastructure	The Netherlands	Pension system management	National
5	Infrachain, management structure	Luxembourg	Management blockchain	National
6	Stadjerpas, smart vouchers	The Netherlands	Low-income group benefits management	Local (Groningen City Municipality)
7	uPort, decentralized identification	Switzerland	Digital ID: Proof of residence, e-voting, bike rental and parking payments	Local (Zug City Municipality)
Note — Compiled by the authors based on				

Having analyzed presented global experience and various cases of new innovative technologies implemented in different jurisdictions, we feel important to note that Blockchain technology acts as a strategic driver of structural transformations and diversification of economic systems. The Australian government implements a policy to stimulate competition in the financial system, to manufacture competitive products, and to prioritize consumer interests. Said policy reinforces the need to reduce regulatory barriers and encourages the emergence of effective digital platforms. Inclusion of innovative protocols in employment value chain and spread of smart contract mechanisms among recruitment agencies, educational institutions, and firms offering educational services, form the basis for long-term institutional restructuring integrated into priorities of the roadmap reflected in (The national blockchain roadmap, 2020).

International examples, including insights from Malta's Ministry of Education and Employment, illustrate the effectiveness of a pilot project launched in October 2017, which employed the Blockcerts Open Standard developed in 2015 in collaboration with the Massachusetts Institute of Technology (MIT) and Learning Machine. This initiative improves the management of academic records, expands the potential of decentralized infrastructures, and simplifies the issuance of academic certificates. Such developments hasten the evolution of global educational markets, improving transaction efficiency, minimizing information asymmetries, and fostering greater trust in digital ecosystems (Grech, 2017).

A further illustration can be seen in the case of the National Agency of Public Registry (NAPR) of Georgia, which commenced using blockchain technology for registering digital ownership certificates in April 2016. Its partnership with Bitfuri Group, leveraging the Bitcoin protocol, has successfully addressed issues of corruption, improved property claim resolution, and enhanced public trust in record maintenance. This approach illustrates the technology's ability to restructure institutional frameworks, improve transparency, and strengthen legal guarantees (Eurasianet. Georgia, 2017).

These examples collectively demonstrate that the implementation of decentralized registries fosters greater efficiency in resource redistribution, encourages innovative development, and strengthens the competitiveness of national economies. Diversification of blockchain applications does not cover only segments

related to healthcare or the financial system, but also more widely integrates digital solutions into public-private interactions, optimizing distribution of transaction costs and forming institutional sustainability. Transitioning to decentralized mechanisms in various sectors, from improving property rights to optimizing educational and labor processes, sets the vector for long-term macroeconomic stabilization, capitalization of technologies, and strategic growth. After reviewing international experiences, it can be argued that the systemic integration of blockchain fosters a conducive institutional environment for the growth of innovative markets, enhancing productivity and bolstering global economic competitiveness.

Results

A comprehensive analysis of the dynamics of implementing innovative digital mechanisms and institutional transformations tells us that results reflected in 2023 indicate a qualitative shift in the development of public e-government. An improvement in the ranking by one position from 29th place in 2020 to 28th among 193 countries illustrates strengthening of competitive positions in a global comparison. The biennial assessment allows us to record systematic progress and identify potential for further optimization. The persistent desire to improve ICT infrastructure has resulted in 83.7 % of public services already being provided while the goal of reaching 90 % by the end of the year reflects a steady trend towards increasing the coverage of digital services.

A significant increase in accessibility is evidenced by the fact of provision of over 115 million services while introduction of effective technologies has allowed reaching 13.8 million services received online, which is over eight times higher than in previous periods. Starting in 2021, the eGov 3.0 initiative, which assumes integration of intelligent interfaces and algorithmic approaches into operational circuits, sets new standards for interaction between the state and citizens. Reducing transaction costs, minimizing intermediaries and reorienting towards platform solutions contribute to strengthening institutional sustainability.

The impetus provided by strategies that go back to the Digital Kazakhstan program is encouraging formation of an effective digital ecosystem by integrating flexible identification protocols, intelligent resource allocation and predictive management scenarios. The introduction of blockchain solutions and smart contracts heralds a transformative era in economic systems, enhancing transparency and efficiency in decision-making processes. This transition embodies a structural shift toward a more dynamic and accountable framework that meets the ever-evolving demands of modern economic landscapes. By deepening analytical methodologies and broadening end-to-end technology functionalities, organizations can foster an environment of heightened awareness and proactive decision-making.

In the long term, key sustainability factors will hinge on the optimization of organizational and legal frameworks, the establishment of uniform data exchange standards, and the modernization of regulatory oversight. Institutional stimulation of innovation will play a pivotal role in nurturing a robust digital ecosystem. Increasing maturity of the digital environment is reflected in the qualitative growth of electronic services, the transformation of interaction models between government agencies, business entities and citizens, as well as in ensuring strategic competitiveness in the global arena. The analysis of experience captured in the presented indicators (Cifrovoj Kazahstan, 2021) reveals how the collaborative efforts of the government, private sector, and scientific community foster a supportive institutional environment for establishing a new digital paradigm. This collaboration lays a strong foundation for economic growth, enhances management efficiency, and addresses public needs. A more in-depth examination of the involved parties can be conducted using tools like SWOT analysis (Table 2).

Table 2. SWOT Analysis of Information and Communication Technologies

Strengths	Weaknesses
- Increase in 4G coverage (65.5 % in 2015, 69 % in 2016), - Availability of KazSat 2, KazSat 3 space systems with a total capacity of 2160 MB, - 7000 earth stations of satellite and cellular communications, - An “e-government” has been formed, - The Astana Hub international technology park has been launched, - ¾ of the adults are digitally literate, - ¾ of the citizens has Internet access.	- Corruption: Financial resources earmarked for program implementation often fail to reach intended beneficiaries fully, undermining trust and efficacy. - Lack of Expertise: The shortage of skilled professionals in information and communication technology (ICT) can stifle innovation and hinder progress across sectors. - Technical Deficiencies: An underdeveloped technical base limits the potential for effective deployment and integration of advanced technologies. - Investment Gaps: Insufficient investment in ICT hampers growth and the scaling of technological solutions.
Opportunities	Threats

- An increasing number of ICT users signifies a growing digital engagement among the populace. - Improvements in communication quality enhance connectivity and information dissemination. - Public services are becoming more accessible and efficient through digital transformation. - There is potential for technology companies to engage with governmental efforts, positioning regions as leading fintech hubs. - Productivity among enterprises is on the rise, driven by digital solutions. - Demand for innovative digital technologies is accelerating, fostering a competitive landscape.		- Continued lack of investment in ICT infrastructure and initiatives. - Weak legislative support can thwart the momentum needed for digital growth. - Poor implementation of existing strategies aimed at fostering ICT development leads to wasted resources and potential. - Inconsistent technology rollout hampers cohesive progress.
	Opportunities Achieving sustainable economic growth and forming dynamic technological clusters are impossible without systemic stimulation of innovation, expansion of investment flows and transformation of manufacturing industries. Structural reorganization of economic system that includes development of IT competencies, integration of advanced business models, and resource enhancement for infrastructure transformations creates conditions for forming a highly adaptive ecosystem. Widespread introduction of digital solutions and products strengthens competitive positions and reduces transaction costs contributing to growth of total factor productivity.	Threats
Strengths		To truly accelerate economic development and improve quality of life through digital technologies, a comprehensive approach is required. This calls for the full utilization of available technological development tools, ensuring these systems support a digital economy that is resilient, equitable, and sustainable.
Weaknesses	To achieve these goals, it is essential to minimize corruption risks and enhance transparency in all procedures concerning the financing and execution of state programs. Foreign experts need to be involved to facilitate the exchange of knowledge in information and communication technologies while also enhancing local professionals' expertise.	Considering the existing challenges, such as a fragile technical foundation and threats posed by corruption and data security, an integrated approach can effectively address both vulnerabilities and risks.
Note — Compiled by the authors		

Conclusions

An examination of global implementations of blockchain technologies reveals their significant potential for transforming economic systems. A tool capable of significantly increasing efficiency and reducing costs. Implementation of blockchain solutions stimulates development of digital economy by automating processes, minimizing human factor, and improving transparency of operations.

Countries like Estonia, Georgia, and the Netherlands set examples of blockchain implementation demonstrating a key role in reducing transaction times and operating costs. Case in point, registering land ownership in Georgia using Exonum technology has reduced the time required for document processing from days to minutes and reduced costs by 90 %. In Estonia, 99 % of public services are integrated into the digital environment, which minimizes risks of operational failures and increases trust in government agencies.

However, as noted in the research, the process of integrating blockchain technologies in Kazakhstan is facing a number of challenges. Amongst the main ones, institutional barriers, insufficient development of technical infrastructure, and a shortage of qualified experts, to name a few. Overcoming these obstacles requires improvements to the legislative framework, unification of information security standards, and active development of human capital through educational initiatives.

From an economic perspective, the use of blockchain opens up opportunities for supply chain optimization, smart contract integration, and automation of management processes. In Kazakhstan, implementation of these technologies within the Digital Kazakhstan program has already increased the coverage of digital services to 83.7 % in 2023 with the goal of reaching 90 % by the end of the year. Over 13.8 million online services have been provided under the program, which is eight times increase against previous periods.

To achieve sustainable development of the digital economy, Kazakhstan needs to focus on creating a favorable institutional environment, stimulating investment, and strengthening cooperation between the state, private sector, and scientific community. In the long term, it will create conditions for increasing the country's competitiveness in the global market, increasing innovative activity, and adapting to global challenges.

Based on the above, we can assume that blockchain technologies are a strategic tool for modernizing the economy, increasing sustainability, and transparency. Given the worldwide experience, Kazakhstan is well-positioned to effectively adopt these technologies, which will aid in establishing a new economic framework and enhancing the country's standing within the global digital ecosystem.

This paper has been prepared as part of grant funding for scientific and (or) scientific and technical projects for 2023—2025 by order of the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan on the topic of IRN AR19679658 "Legal Regulation of the Use of Blockchain Technology in the Republic of Kazakhstan: Theory and Practice".

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А.А. Абайдуллин[1], А.Сабыржан[2], Н.К. Аширбеков[3]

[1, 2]Е.А.Бөкетов атындағы Қарағанды университеті, Қарағанды, Қазақстан
[3]«Азаматтық-құқықтық зерттеулер орталығы» ЖШС, Қарағанды, Қазақстан

[1,] https://orcid.org.0009-0005-1279-2134
[2] https://orcid.org.0000-0002-8910-4572
[3]https://orcid.org.0000-0002-8843-2515

[2] Scopus Author ID: 57222593357
[2] Researcher ID: B-5709-2019

Блокчейн-технологияларын қолданудың әлемдік тәжірибесін зерттеу

Аңдатпа

Мақсаты: Блокчейн технологиясын пайдалану тәжірибесін зерделеу және оның Қазақстанда дамуына кедергі келтіретін проблемаларды анықтау.

Әдісі: Жалпы ғылыми әдістер қолданылды: сипаттама, ретроспектива, жүйелік талдау және тақырыпты жалпылау, жүйелік-құрылымдық, жүйелік-функционалдық талдаулар. Арнайы әдістер де қолданылды (модельдеу әдісі, формальды-логикалық, салыстырмалы, салыстырмалы-құқықтық, SWOT және PEST талдаулары). Деректерді өңдеу EXCEL көмегімен жүргізілді.

Қорытынды: Цифрлық технологиялар негізгі трендтерге айналуда. Оларды ілгерілету өмірді өзгертеді және әлеуметтік, экономикалық салаларды дамыту бойынша жұмыс істеуге ынталандырады. Сондай-ақ, олар жеке адамның тіршілігін ғана емес, сонымен бірге экономиканың тиімділігін арттырады.

Тұжырымдама: Қазақстанда блокчейнді енгізу үшін негізгі кедергілерге нормативтік-құқықтық базаның жетілмегендігі, білікті кадрлардың жетіспеушілігі және технологияларды әзірлеуге жоғары шығындар жатады. Мәселелерді шешу заңнамалық стандарттарды үйлестіру, білім беру бағдарламаларына инвестициялар салу және халықаралық тәжірибені тарту арқылы мүмкін болады. EGov 3.0 бастамасының мысалы мемлекет пен қоғам арасындағы өзара іс-қимылды оңтайландыру үшін алгоритмдік тәсілдер мен болжамды басқарудың маңыздылығын көрсетті. Жоғарыда айтылғандардың негізінде блокчейн экономиканы жаңғырту және оның тұрақтылығын арттыру үшін стратегиялық құрал болып табылады. Әлемдік тәжірибені ескере отырып, таратылған тізілімдер технологияларын енгізу Қазақстанға институционалдық ортаны нығайта отырып және инновациялық дамуды ынталандыра отырып, жаһандық сын-қатерлерге тиімді бейімделуге мүмкіндік береді.

Кілт сөздер: блокчейн-технология, биткойн, интеграция, криптовалюта, смарт-келісімшарт, цифровизация, цифрлық технологиялар.

А.А. Абайдуллин[1], А. Сабыржан[2], Н.К. Аширбеков[3]

[1, 2]Карагандинский университет имени Е.А. Букетова, Караганда, Казахстан
[3]«ТОО «Центр гражданско-правовых исследований», Караганда, Казахстан

[1,] https://orcid.org.0009-0005-1279-2134
[2] https://orcid.org.0000-0002-8910-4572
[3]https://orcid.org.0000-0002-8843-2515

[2] Scopus Author ID: 57222593357
[2] Researcher ID: B-5709-2019

Исследование мирового опыта применения блокчейн-технологий

Аннотация

Цель: Изучить опыт использования блокчейна и выявить проблемы, препятствующие его развитию в Казахстане.

Методы: Были использованы общенаучные методы: описание, ретроспектива, системный анализ и обобщение предмета, системно-структурный, системно-функциональный анализы. Также были использованы специальные методы (метод моделирования, формально-логический, сравнительный, сравнительно-правовой, SWOT и PEST-анализы). Обработка данных проводилась с помощью EXCEL.

Результаты. Цифровые технологии становятся основными трендами. Их продвижение меняет жизнь и стимулирует работать над развитием социальной, экономической сфер. Общепризнано, что они повышают эффективность не только жизнедеятельности отдельно взятого человека, но и экономики.

Выводы: Решение проблем возможно через гармонизацию законодательных стандартов, инвестиции в образовательные программы и привлечение международного опыта. Пример инициативы eGov 3.0 показал важность алгоритмических подходов и предиктивного управления для оптимизации взаимодействия между государством и обществом. На основании вышеуказанного, блокчейн выступает стратегическим инструментом для модернизации экономики и повышения ее устойчивости. Внедрение технологий распределенных реестров, учитывая мировой опыт, позволит Казахстану эффективно адаптироваться к глобальным вызовам, укрепляя институциональную среду и стимулируя инновационное развитие.

Ключевые слова: блокчейн-технология, биткойн, интеграция, криптовалюта, смарт-контракт, цифровизация, цифровые технологии.