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## **DIGITAL TRANSFORMATION OF INTERNAL AUDIT IN KAZAKHSTAN**

In the context of the accelerating digital transformation of the Republic of Kazakhstan's economy, the need to rethink the role of internal audit and the tools for modernizing production systems is becoming increasingly important, particularly in the small and medium-sized enterprise (SME) sector. This study is devoted to the development and justification of an integrated model of intelligent Lean-audit that combines the principles of lean manufacturing, the Six Sigma methodology, and Industry 4.0 concepts. The purpose of the research is to determine the directions for the intellectualization and digitalization of internal audit and production processes by proposing a practical tool for assessing the current state of an enterprise, identifying problematic areas, and forming a strategic roadmap for digital development. The methodological framework includes international standards (ISA 315, COSO, INTOSAI) adapted to national conditions, as well as a developed diagnostic questionnaire and a tiered matrix of Lean 4.0 methods. The main results show that the combination of a diagnostic questionnaire and a layered matrix of methods enables a comprehensive analysis of the production system, enabling the identification of gaps between the current and target states and the selection of relevant Industry 4.0 tools. The developed Lean 4.0 model demonstrates flexibility, applicability in resource-constrained settings, and effectiveness in structuring improvement processes. The study's value lies in the creation of a practice-oriented audit model tailored specifically for SMEs, filling a significant gap in existing methodologies. Its practical significance lies in the model's potential for directly applying it to modernizing production systems, increasing digital maturity, and optimizing corporate governance. The transformation of internal audit is becoming a strategic foundation for a sustainable and transparent economy in Kazakhstan: the use of digital technologies and AI creates an intelligent control system focused on risk prevention, increasing trust, and supporting long-term development.

**Keywords:** internal audit, digital transformation, Lean 4.0, Industry 4.0, Six Sigma, Big Data.

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### **Ішкі аудиттің цифрлық Қазақстандағы трансформациясы**

Қазақстан Республикасының экономикасының жедел цифрлық трансформация жағдайында ішкі аудиттің рөлін қайта қарастыру және өндірістік жүйелерді, өсірепе шағын және орта кәсіпорындар (ШОК) секторын модернизациялау құралдарын жетілдіру қажеттілігі артады. Бұл зерттеу интеллектуалды Lean-аудиттің интеграцияланған моделін өзірлеуге арналған, ол тиімді өндіріс принциптерін, Six Sigma әдістемесін және Индустрія 4.0 концепцияларын біріктіреді. Зерттеудің мақсаты – ішкі аудит пен өндірістік процестерді интеллектуализациялау және цифрандыру бағыттарын анықтау, кәсіпорынның ағымдағы жағдайын бағалау, проблемалық аймақтарды айқындау және цифрлық дамудың стратегиялық жол картасын жасауға арналған практикалық құрал ұсыну. Методологиялық, база халықаралық стандарттарды (МСА 315, COSO, INTOSAI) қамтиды, олар ұлттық жағдайларға бейімделген, сонымен қатар арнағы өзірленген диагностикалық сауалнама мен Lean 4.0 әдістерінің деңгейлік матрицасы қолданылады. Зерттеудің негізгі нәтижелері диагностикалық сауалнама мен әдістердің деңгей матрицасының үйлесімі ағымдағы және мақсаттың күй арасындағы алшақтықтарды анықтауға және Индустрія 4.0 сәйкес құралдарын таңдауға мүмкіндік беретін өндірістік жүйені жан-жақты талдауды қамтамасыз ететінін көрсетеді. Өзірленген lean 4.0 моделі икемділікті, шектеулі ресурстар жағдайында қолданылуды және жақсарту процестерін құрылымдағы тиімділікті көрсетеді.

үшін арнайы бейімделген тәжірибеге бағытталған аудит моделін құру болып табылады, бұл қолданыстағы әдістемелердегі Елеулі олқылықтың орнын толтырады. Практикалық мәніздылығы өндіріс жүйелерін модернизациялау, цифрлық жетілуді арттыру және корпоративтік басқаруды оңтайландыру үшін модельді тікелей пайдалану мүмкіндігінде көрінеді. Ишкі аудитті трансформациялау Қазақстанның орнықты және ашық экономикасының стратегиялық негізіне айналады: цифрлық технологиялар мен АИ қолдану бақылаудың зияткерлік жүйесін қалыптастырады.

**Түйін сөздер:** ішкі аудит, цифрлық трансформация, Lean 4.0, Индустрія 4.0, Six Sigma, үлкен деректер.

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## Цифровая трансформация внутреннего аудита в Казахстане

В условиях ускоряющейся цифровой трансформации экономики Республики Казахстан возрастает необходимость переосмысления роли внутреннего аудита и инструментов модернизации производственных систем, особенно в секторе малых и средних предприятий (МСП). Настоящее исследование посвящено разработке и обоснованию интегрированной модели интеллектуального Lean-аудита, объединяющей принципы бережливого производства, методологию Six Sigma и концепции Индустріи 4.0. Цель работы – определить направления интеллектуализации и цифровизации внутреннего аудита и производственных процессов, предложив практический инструмент оценки текущего состояния предприятия, выявления проблемных областей и формирования стратегической дорожной карты цифрового развития. Методологическая база включает международные стандарты (МСА 315, COSO, INTOSAI), адаптированные под национальные условия, а также разработанную диагностическую анкету и уровневую матрицу методов Lean 4.0. Основные результаты исследования показывают, что сочетание диагностической анкеты и уровневой матрицы методов обеспечивает комплексный анализ производственной системы, позволяя выявлять разрывы между текущим и целевым состоянием и подбирать релевантные инструменты Индустріи 4.0. Разработанная модель Lean 4.0 демонстрирует гибкость, применимость в условиях ограниченных ресурсов и эффективность в структурировании процессов улучшения. Ценность исследования заключается в создании практико-ориентированной модели аудита, адаптированной специально для МСП, что восполняет существенный пробел в существующих методологиях. Практическая значимость проявляется в возможности прямого использования модели для модернизации производственных систем, повышения цифровой зрелости и оптимизации корпоративного управления. Трансформация внутреннего аудита становится стратегической основой устойчивой и прозрачной экономики Казахстана: применение цифровых технологий и ИИ формирует интеллектуальную систему контроля, ориентированную на предупреждение рисков, рост доверия и поддержку долгосрочного развития.

**Ключевые слова:** внутренний аудит, цифровая трансформация, Lean 4.0, Индустрія 4.0, Six Sigma, большие данные.

## Introduction

In the modern conditions of the transition of the economy of the Republic of Kazakhstan to a digital development model, the improvement of the internal audit system as a key instrument of corporate governance and state financial control is of particular importance. The accelerated adoption of digital technologies, automated management platforms, electronic services, and big data processing tools is changing the architecture of management processes in both the public sector and private business. This leads to the need to transform control systems fo-

cused not only on fixing violations, but also on timely prevention of risks.

Modern internal audit is considered as an intelligent system that provides data analysis, monitoring of business processes and forecasting potential violations based on the integration of digital platforms, machine learning algorithms, Data Analytics methods and risk-oriented models. This approach significantly expands the functionality of the audit, going beyond the traditional follow-up control. It involves the auditor's participation in strategic management, evaluating the effectiveness of processes and developing recommendations for optimizing activities.

However, digital transformation is also accompanied by a number of challenges.

Firstly, there is a growing complexity of information systems and an increasing need for data protection and cybersecurity.

Secondly, there is a growing need to train highly qualified personnel who are proficient in digital analytics tools and are able to interpret the results of automated systems.

Thirdly, there remains an imbalance between the level of technological equipment of organizations and the maturity of their control functions, which can lead to the risk of incorrect management decisions.

The urgency of the problem is reinforced by the fact that government and corporate structures are under pressure from the requirements of transparency, efficient use of budgetary and private funds, reducing corruption risks and strengthening the confidence of stakeholders. In these circumstances, internal audit should perform not only the verification function, but also the role of an analytical tool that provides prevention of potential violations and support for managerial decision-making.

Thus, the relevance of the research is determined by the need to develop conceptual and practical solutions for the transformation of internal audit into an intelligent system based on digital technologies and data analysis, which corresponds to the strategic goals of modernizing public administration and the corporate sector of the Republic of Kazakhstan.

Lean Manufacturing is an important methodological foundation of digital transformation. Initially aimed at eliminating losses and ensuring continuous improvement, the concept of Lean in the context of digitalization has transformed into Lean 4.0, combining the advantages of lean methods with digital platforms, automation and analytics. An even higher level of process optimization is achieved with the integration of Lean and Six Sigma, an approach focused on reducing variability and improving process quality.

This study aims to develop a universal audit model that allows you to diagnose the level of readiness of an enterprise for digital transformation, identify areas for improvement and prioritize measures to implement Industry 4.0 technologies. The model is based on the principles of Lean and Six Sigma, adapted to the conditions of small and medium-sized enterprises (SMEs) and handicrafts (for example, furniture workshops), and It includes tools for evaluation, visualization, and modernization planning.

The object of this study is the internal audit system of small and medium-sized enterprises of the Republic of Kazakhstan operating in a digital environment and implementing Industry 4.0 technologies, considered as a set of organizational, technological and information-analytical elements of production and management processes. The study answers the following questions:

1. Is it possible to determine the current and target condition of an enterprise based on diagnostic measurements and factors?

2. Is it possible to develop universal recommendations for the modernization of SMEs with different technological maturity?

3. Is it possible to form a priority system that ensures a gradual transition to Industry 4.0?

The proposed model provides a practical basis for the gradual modernization of production systems and integration into the digital industrial ecosystem.

Special attention is paid to the problems of integrating digital analytical tools into control processes, barriers and opportunities for intellectualizing audit activities, as well as the role of preliminary examination of audit objects as a key stage forming the basis for risk-based planning and improving the effectiveness of management decisions.

## Literature review

The problem discussed in the article is related to the fact that internal audit in Kazakhstan still relies heavily on traditional control methods – spot checks, after-the-fact analysis of documents, manual processing of reports. This approach does not allow timely identification of risks, prevention of violations and proactive management of financial resources. In conditions of high dynamics of economic processes and increasing complexity of business models, such methods become insufficient. There is a gap between the growing requirements for the effectiveness of control and the actual capabilities of existing audit procedures.

Current trends in the digitalization of the economy involve the use of big data analysis technologies, artificial intelligence, and robotic automation of processes, which can ensure continuous monitoring and prompt detection of deviations.

However, in Kazakhstan, the implementation of such solutions is fragmented and not systematic. Most organizations face limited digital maturity, a lack of specialist competencies, a lack of methodological approaches and unified standards for digital internal audit. This makes it difficult to move from

a traditional control function to digital risk management.

Recent studies confirm that the digitalization of internal audit has become a key area of development of the modern financial control system. The review paper “The Digital Transformation of the Internal Audit Function: A Qualitative Literature Review” (Research Gate, 2025) systematizes approaches to the implementation of Big Data, AI/ML, RPA and Blockchain technologies, noting that they radically increase the speed, accuracy and analytical potential of internal audit, while changing its conceptual role – from retrospective verification to predictive and analytical risk management.

The standards developed (IIA, 2024) pay a lot of attention to how internal audit should work in a digital environment, ensuring compliance with new technologies, risks of digital transformation and ethical requirements.

The modern internal audit function is also actively facing the challenges of digital transformation. The evolution of the internal audit function, the audit methodology, the digital maturity model for internal audit, the impact of COVID 19, and the changing roles and skills of the auditor are discussed in the work of Nabil Daij (2023). The author examines a systematic analysis of how technological changes (data analytics, RPA, clouds, AI, blockchain) affect internal audit, its methodologies, tasks, and competencies.

At the same time, a study by the Institute of Internal Auditors conducted in 2021 and aimed at analyzing how the audit reacted to the 2020 crisis and technological changes showed that only a small part of audit functions managed to implement modern technologies and cloud solutions; many remain on old (spreadsheets, e-mail) systems.

These conclusions are confirmed by the observations of German researcher M. Eulerich (2025), who notes in the review “Technology and Internal Auditing” (2025) that data analytics and machine learning technologies are forming a “new intelligent audit architecture.” He emphasizes that along with technological advantages, digitalization requires the development of digital competencies of auditors, since it is the human factor that remains the key link in data interpretation and management decision-making.

Publications of international professional communities, such as ISACA (“Robotic Process Automation for Internal Audit”, 2020), emphasize that robotization of audit procedures increases labor

productivity and quality of control, freeing the auditor from repetitive operations. However, the authors warn of the need to adapt the internal control methodology and review risk management approaches when implementing RPA systems.

According to practical materials from Deloitte (“Applying COSO ERM to Artificial Intelligence”, 2023), the application of the COSO ERM concept to AI-based projects provides a systematic approach to assessing digital risks, from data security issues to issues of transparency and ethics of algorithms. This approach demonstrates how the elements of COSO (control environment, monitoring, information channels) can be adapted to digital technologies, which corresponds to the tasks of Kazakhstan’s internal audit.

Domestic research also reflects these global trends. It should be noted that this is not the first time that attention to the issues of digital transformation of auditing has been formed in Kazakhstan. Back in the work of Yerdavletova F. (2015) “On the issue of improving auditing in the oil and gas sector of the economy”, the need to modernize control methods and introduce technological solutions to improve the quality of verification was emphasized. Subsequent studies confirm the sustainability of this trend. In particular, in the work “HOW TO HANDLE INTERNAL AUDITOR INDEPENDENCE GAP?” the authors Nurmagambetova A., Abdelrady, H. M., & Mohamed, S. (2023) propose practical measures to improve the objectivity and effectiveness of internal audit in organizations, highlighting digital technologies, among other things. A study by scientists (Yerdavletova F., Bimendieva L., et al., 2024) notes the role of digitalization of audit as a key factor in improving the efficiency of national resource management, which is consistent with global trends in the development of the economy of the Republic of Kazakhstan. Further development of the topic is reflected in the work of V.I. Berezyuk. “Prospects for the development of digital audit in the Republic of Kazakhstan” (2024) focuses on the need to integrate digital technologies into the activities of government agencies and the corporate sector. The author highlights the barriers to digitalization – insufficient IT infrastructure, staff shortages, and the need to harmonize national standards with international ones – and suggests ways to overcome them.

The work of other Kazakhstani authors (Kogut O.Yu., et al., 2025) is devoted to modern trends in audit digitalization and examines remote audit technologies, automated analytical systems and their im-

pact on the quality of control. The authors conclude that transparency is increasing and human error is being reduced due to the integration of digital solutions into the practice of government and internal audit.

In summary, the reviewed studies show that the digitalization of internal audit contributes to increased transparency, objectivity and effectiveness of control, but requires an integrated approach – improving the regulatory framework, COSO ERM methodology and the development of digital competencies of auditors.

Thus, in the context of digitalization, internal audit is being transformed from a traditional control mechanism into a strategic corporate governance tool. The introduction of artificial intelligence, robotics, and big data analysis technologies makes it possible to move from reactive detection of violations to proactive risk management and increase the efficiency of the public and corporate sectors.

These trends are especially relevant for Kazakhstan, where a digital ecosystem of state financial control is being formed, requiring a harmonious combination of international standards, technological innovations and professional competence of auditors.

The literature review showed that, despite the availability of research on certain aspects of digitalization and improvement of internal audit procedures, a comprehensive scientific approach to the formation of a digital model of internal audit in modern conditions has practically not been developed. The available works mainly consider technical tools or organizational issues of implementing IT solutions, however, the relationship of digital technologies with the methodology of audit analysis, risk assessment and improving the effectiveness of the internal control system remains insufficiently studied.

In addition, there are no uniform methodological recommendations and practical models in the Kazakh scientific literature that allow integrating big data analytics, artificial intelligence and process automation into the activities of internal audit departments. This gap limits the ability of government and corporate organizations to move from traditional audits to proactive risk management.

Thus, the need for scientific substantiation and development of a concept for the development of modern internal audit based on digital technologies determines the high relevance of the chosen research topic and its importance for improving management systems in the Republic of Kazakhstan.

## Methodology

The methodological basis of the research is based on a combination of systemic, institutional and process approaches that ensure a holistic perception of the digital transformation of internal audit as a socio-economic and managerial phenomenon.

The theoretical basis was:

- International standards IIA (International Professional Practices Framework);
- the concept of COSO ERM (Enterprise Risk Management);
- INTOSAI GOV 9140 recommendations on internal control;
- strategic documents of Kazakhstan – the Law “On State Audit and Financial Control” (2015), the Digital Kazakhstan program.

The systematic approach allowed us to consider internal audit as an element of the digital ecosystem of public administration, including analytical platforms and artificial intelligence.

The purpose of the study is to substantiate the mechanisms of digital transformation of internal audit in Kazakhstan and identify ways to increase its effectiveness through the introduction of innovative technologies (AI, RPA, Big Data).

Research methods – use a set of general scientific and special methods, including:

- system analysis – identification of interrelations between the elements of internal audit and digital platforms;
- comparative method – comparison of Kazakhstan's practice with international standards (IIA, ISACA, OECD);
- content analysis – processing of publications and regulatory documents;
- expert survey – assessment of the level of digitalization of internal audit functions;
- inductive-deductive analysis – identification of patterns based on empirical data;
- case method – analysis of the implementation of RPA and AI in large organizations in Kazakhstan.

The empirical research base includes:

- data from the Ministry of Finance of the Republic of Kazakhstan, the Accounts Committee, the Financial Monitoring Agency;
- reports from the World Bank, OECD, PwC, Deloitte, ISACA;
- scientific publications of Kazakhstani researchers;
- digital platforms: e-Audit, Qoldau.kz, e-Qazyna.

Reliability is ensured:

- using official sources and international standards;

- triangulation – comparison of data from various sources;
- using representative analytical methods.

The scientific novelty is the clarification of the concept of “digital internal audit” and the development of an author’s model for integrating AI, RPA and COSO ERM into the practice of internal control in Kazakhstan.

Methodological limitations – the study is limited to the normative and organizational analysis of digitalization without quantitative methods (regression analysis). A promising direction is the development of an indicative model of the digital maturity of internal audit based on KPIs and risk indicators.

In connection with the methods considered, we considered the Reference Matrix of methods pro-

posed in (Carter, D. and Baker, B., 1992) and was developed to implement the concept of Concurrent Engineering. In contrast, this work offers a new methodological model focused on the implementation of the principles of Industry 4.0, taking into account the Lean Six Sigma approach.

To increase the adaptability of the matrix, it is proposed to include maturity levels corresponding to each key factor within each assessment. This provides a more detailed interpretation of the results obtained at the first stage of the model. The levels are related to the digital conversion of the results used to convert the values on the Likert scale into numerical indicators used in data analysis (Table 1).

The resulting matrix of methods (Table 2) is structured by columns – proposed approaches, and by rows – maturity levels.

**Table 1** – Qualitative and quantitative levels for evaluating the matrix of methods

№	Level	Qualitative assessment	Quantitative assessment
1	Level 1	I totally disagree	0.0
2	Level 2	Rather, I disagree	0.3
3	Level 3	Rather, I agree	0.7
4	Level 4	I totally agree	1.0

Note – Compiled by the authors based on the source Appelbaum et al. (2017).

**Table 2** – Matrix of methods for the key factor “Ubiquity” (Ubiquity), dimension: “Information”

Level	Readiness	Maturity: the initial stage	Maturity: a transitional stage	Maturity: advanced stage
1 (0.0)	No parameters have been defined for measuring production performance.	There are no sensors for monitoring any production sites.	There are no digital interfaces or touch devices in the workplace.	Augmented reality devices are not used for real-time data visualization.
2 (0.3)	The basic parameters (input/output) for individual production operations are defined.	Sensors are installed to monitor individual production sites.	Some workplaces have digital visualization and/or data interaction interfaces.	Classical devices are used to display asynchronous information.
3 (0.7)	The parameters for measuring individual aspects of production (inputs, processes, outputs) are defined.	The sensors are implemented on several production lines.	Digital interfaces and sensors for visualization and interaction with data are installed on some of the workstations.	Digital devices (screens, wearable gadgets, etc.) are used to display data in real time.
4 (1.0)	Parameters have been defined to measure most of the production aspects (inputs, processes, outputs).	Intelligent sensors of various types have been installed to monitor most production lines and centers.	Most workplaces have digital interfaces and smart sensors.	Augmented reality devices are used to visualize production information in real time.

Note – Compiled by the authors on the basis of, with the use of Alles et al. (2008)

The proposed matrix of methods defines the necessary tools to ensure the successful implementation of the production system in accordance with

the requirements of Industry 4.0. Similar to the assessment questionnaire, the matrix is structured by dimensions, key factors and approaches. Its use

makes it possible to form general methodological recommendations, determine the necessary stages of maturity and adapt implementation paths to the specifics of each project and the context of the enterprise.

## Results and discussion

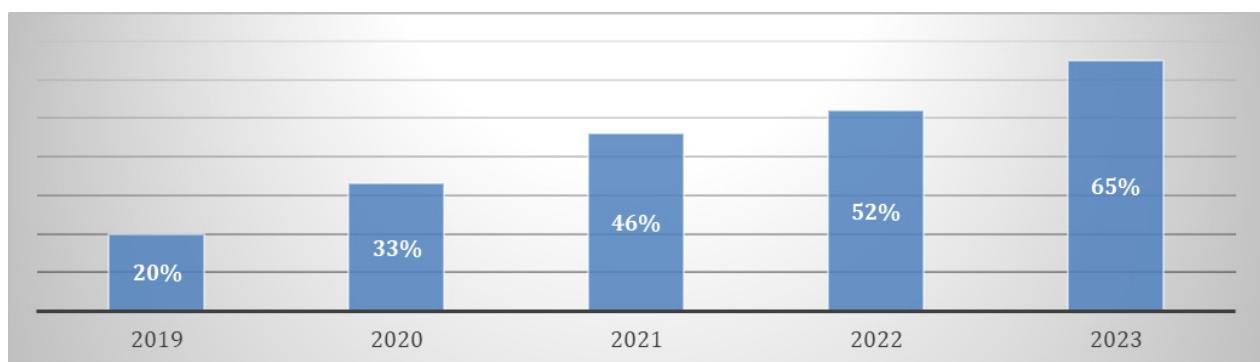
Internal audit, in accordance with international standards (IIA, ISA, COSO), is an independent assessment, consulting and control activity aimed at improving management efficiency, minimizing risks and ensuring the reliability of financial information.

In Kazakhstan, the regulatory framework for internal audit is regulated by the Law of the Republic of Kazakhstan "On State Audit and Financial Control" (2015), internal audit standards approved by authorized bodies, as well as the COSO ERM (Enterprise Risk Management) methodology.

The modern paradigm of internal audit involves a transition from formal control to intelligent risk management. This includes the use of digital platforms, analytical systems, artificial intelligence (AI), and machine learning (ML) to process large amounts of data, predict anomalies, and identify corruption risks.

An important trend is the introduction of robotic data analysis tools (RPA), which makes it possible to automate routine checks and focus the auditor's attention on analytical, strategic and predictive activities.

The diagram (Fig. 1) below shows the increase in the digital maturity of Kazakhstan's internal audit over the past five years. As you can see, the digital maturity index has increased from 22% to 68%, which indicates the significant impact of the introduction of AI, RPA and Big Data technologies on the effectiveness of control processes.



**Figure 1 – The growth of the digital maturity of internal audit in the Republic of Kazakhstan**  
Note – Developed by the authors according to the sources.

Despite the active digitalization of the public sector and business, the internal audit system in Kazakhstan faces a number of problems:

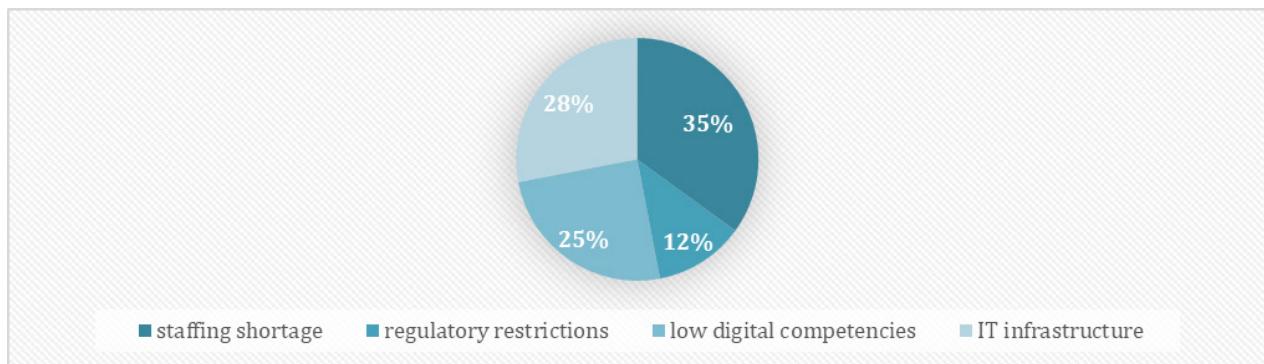
- low level of integration of information control and data analysis systems;
- Lack of a unified national digital audit platform;
- Insufficient training in data analytics and IT auditing;
- Limited use of intelligent algorithms to assess risks and identify inconsistencies;
- The predominance of after-the-fact checks instead of predictive monitoring.

These problems slow down the development of the audit function as an intellectual management link and limit the government's ability to ensure transparency and efficiency of financial flows.

The presented structure (Fig. 2) shows the main barriers to the introduction of digital technologies in the internal audit system of Kazakhstan. Staffing shortages (35%) and insufficient IT infrastructure (28%) are predominant. This indicates the need for systematic training of specialists and investments in digital infrastructure.

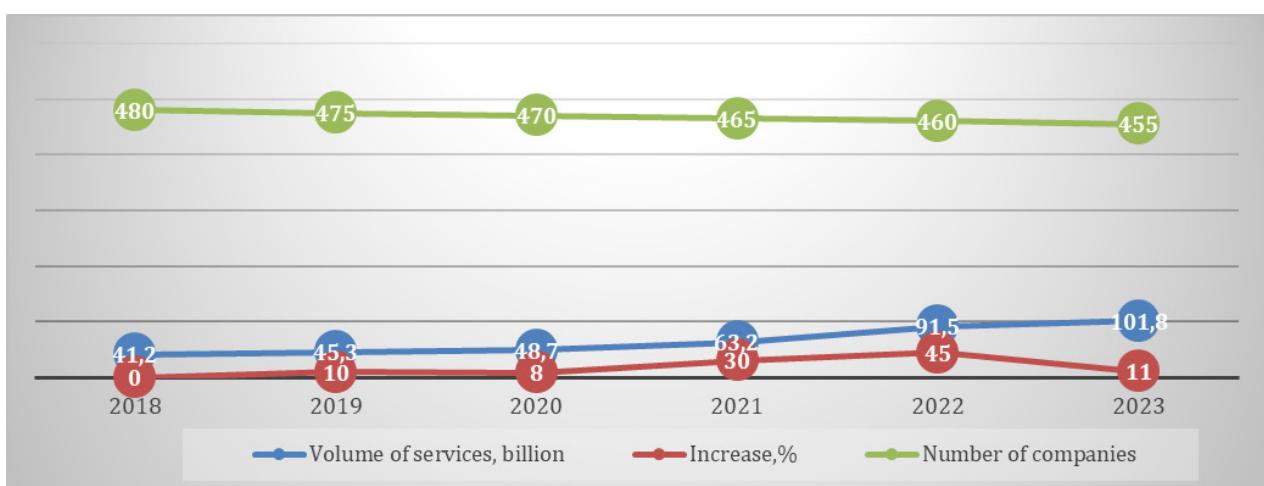
The growth of the market is a significant factor confirming the need for further development of the internal audit system, as the increase in the volume of audits and the complexity of business processes require more highly qualified auditors, the use of modern digital tools and the transition to risk-based assessment and monitoring methodologies.

The graph shown in Figure 3 clearly demonstrates the growth of the Kazakhstan audit services market over a 5-year period (2018-2023) by 2.5 times.



**Figure 2** – The main barriers to the digitalization of internal audit in the Republic of Kazakhstan

Note – Compiled by the author, Березюк В. И. (2024)



**Figure 3** – Dynamics of the audit services market in the Republic of Kazakhstan

Note – Compiled by the author, according to the Audit Committee of the Ministry of Finance of the Republic of Kazakhstan (2024)

Thus, the current level of digitalization of internal audit in Kazakhstan remains insufficient for a complete transition to a risk-based and predictive control model. The fragmentation of information systems, the lack of a unified national audit platform, and the lack of specialists in data analytics and IT auditing continue to limit the ability of internal audits to promptly identify and prevent violations. Despite the expansion of the market and the active introduction of digital solutions, auditing is still largely focused on after-the-fact checks. Overcoming the identified barriers requires targeted training of professional personnel, modernization of digital infrastructure and the introduction of predictive and analytical tools, which will transform audit into an intelligent mechanism for supporting management decisions.

It is impossible to make the transition to such a model without correctly constructing the initial stage of the audit process. In this regard, a preliminary study of the audit object is of particular importance, ensuring the formation of a holistic understanding of the organization's activities, the structure of business processes and key risk areas. Understanding the context and environmental features of the subject under review serves as the basis for choosing adequate control methods, evaluating the effectiveness of internal procedures, and using digital analysis tools.

A preliminary study of an object in practice means that the auditor gets a comprehensive understanding of the organizational structure, the internal control system, the specifics of the operations performed and potential vulnerability factors. In

accordance with the provisions of the International Standards on Auditing (ISA 315 "Identification and Assessment of the Risks of Material Misstatement through Understanding the organization and its Environment"), this stage forms the basis for subsequent planning of audit procedures, determining audit priorities and selecting relevant analysis methods.

In the context of digitalization, the content of this stage is significantly expanded. Previously, the focus was on studying documents and interviewing employees, but today the auditor has access to a wide range of digital data – information databases, automated registers of operations, log records of systems, analytical panels and visualization tools. The use of big data processing technologies and anomaly detection algorithms allows not only to get a more detailed picture of the processes, but also to detect signs of deviations, inefficiency or potential violations at an early stage.

Thus, the preliminary study of the audit object becomes not just an introductory stage, but an analytical foundation that ensures the transition to proactive audit in a digital environment.

According to the International Standards on Auditing (ISA 315 "Identification and Assessment of the Risks of Material Misstatement through Understanding the organization and its Environment"), a preliminary study is the basis for planning audit procedures.

At this stage, the auditor:

1. Analyzes the organizational and legal structure and constituent documents;
2. Studies internal regulations, accounting policy, and management structure;
3. Evaluates the internal control system (ICS) and the IT infrastructure;
4. Conducts a risk analysis, identifying areas of potential violations;
5. Determines the scope and depth of subsequent checks.

In the context of digitalization, this stage is being significantly transformed. Instead of traditional manual data collection, auditors use:

- Big Data analysis (processing big data on financial transactions);
- Data mining (intelligent analysis and identification of hidden patterns);
- Machine learning (algorithms capable of predicting anomalies);
- Digital twins – virtual simulation of financial flows.

This allows you to conduct a preliminary study of the audit object in an automated mode, identify trends, predict risks and minimize the likelihood of errors at the planning stage.

At this stage, we can present a table showing the impact of Big Data and machine learning on the effectiveness of preliminary analysis. According to research, the use of digital doubles reduces the risk of errors by 25-35%, and automation reduces the preparation time by 40%. The international experience of Germany, Singapore and Canada shows that the integration of risk-based systems can significantly improve the quality of audit planning.

The gradual expansion of the use of digital technologies at the preliminary analysis stage not only increases the accuracy of risk assessment and reduces the complexity of preparation, but also creates the prerequisites for a qualitative change in the internal audit model itself. In the process of implementing automated data processing tools, digital doubles, and analytical dashboards, auditing is shifting from a traditional approach based on verifying operations that have already been performed to a more dynamic and predictive model.

It is here that the tendency towards intellectualization of auditing activities is manifested, which involves a shift in emphasis from fixing violations after the fact to their real-time warning and analysis of processes. This approach allows the auditor not only to identify deviations, but also to understand their causes, predict possible consequences, and make recommendations aimed at optimizing management decisions.

The key areas of development in this context are:

1. Integration of artificial intelligence into the financial flow analysis system;
2. Application of cloud technologies for storage and processing of audit data;
3. Development of a unified platform for state internal audit (based on e-Gov and e-Otinish);
4. Using blockchain technologies to ensure transparency of financial transactions;
5. Creation of intelligent dashboards for monitoring violations in real time.

This transition makes it possible to transform internal audit into a strategic management tool that ensures continuous monitoring of processes and increases the efficiency of the organization.

The intelligent internal audit system is not only a control tool, but also a mechanism for improving the effectiveness of public administration. It forms

a digital ecosystem of trust between government, business and society.

In this regard, the use of artificial intelligence and blockchain technologies in auditing. According to the OECD (2024), organizations using AI increase forecasting accuracy by 50% and reduce costs by 20%. The international experience of the UK, South Korea and Canada shows that the introduction of intelligent systems increases transparency and trust in data, as well as provides operational monitoring of financial risks.

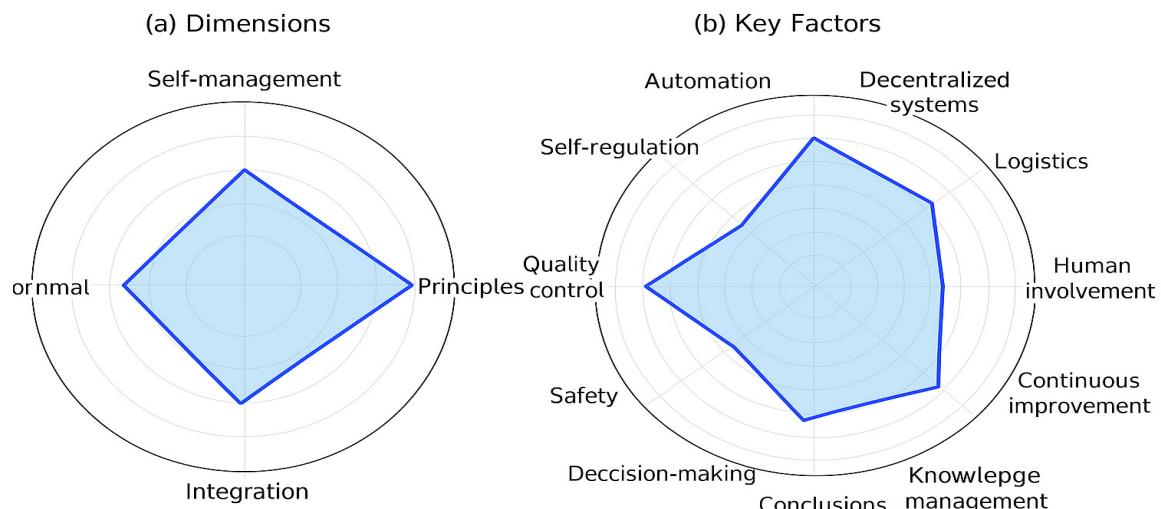
We believe that the development and digital transformation of internal audit in Kazakhstan requires a systematic approach aimed at creating a sustainable digital environment for data control and analysis. One of the key directions is the institutionalization of digital internal audit as a separate element of the national financial supervision system. This implies the normative consolidation of its principles, functions and standards, as well as the creation of a single digital audit data space integrated with existing public administration and e-government platforms.

An important aspect of the development of digital audit is the formation of new professional competencies of specialists combining knowledge in the field of internal control, IT technologies and big data analysis. To do this, it is advisable to introduce specialized educational programs and research initiatives based on leading universities in Kazakhstan aimed at training a new generation of analytical auditors.

In continuation of the conducted research, the results obtained confirm the applicability and effectiveness of the proposed Lean 4.0 audit model for assessing the readiness of SMEs for digital transformation. The analysis of the data obtained in the first phase of the study made it possible to identify maturity levels for each key factor and identify critical areas requiring priority improvement. The addition of a matrix of methods based on Industry 4.0 and Lean Six Sigma concepts to the model improved the accuracy of interpretation of the results and allowed for more detailed recommendations for enterprises.

The priority measurement map is used to identify imbalances in various key factors according to the proposed approaches. This allows us to identify the necessary areas of improvement that will contribute to the effective modernization of the company within the framework of the Industry 4.0 concept, based on the principles of Lean Manufacturing and the Six Sigma methodology.

During the application of the proposed methodology, it was found that the use of a layered approach (from basic to advanced) facilitates the identification of gaps between the current and target state of the production system. In addition, the adaptive structure of the matrix of methods makes it a universal tool applicable to enterprises of various industries, regardless of their digital maturity and resource constraints (Fig. 4).



**Figure 4** – The obtained radial diagrams: (a) measurements and (b) key factors based on the results of the evaluation questionnaire for the production department  
Note – Compiled by the author, according to Ávila-Gutiérrez et al. (2025)

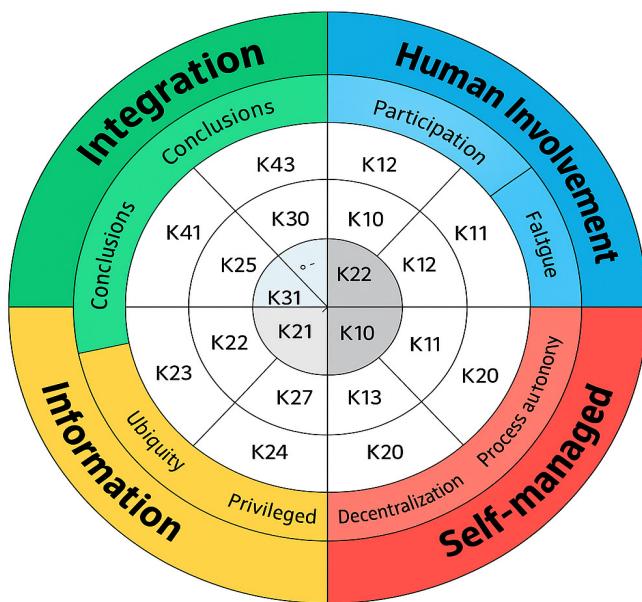
The results obtained demonstrate that the combination of a diagnostic questionnaire and a level matrix of methods provides a comprehensive analysis of the production system, as well as allows you to build a realistic modernization trajectory. This integration contributes to the informed choice of improvement tools, the selection of Industry 4.0 technologies in accordance with the current capabilities of the enterprise and the consistent achievement of digital maturity stages.

In general, the study highlights that the proposed Lean 4.0 model is able not only to identify problem areas, but also to guide the enterprise along the path of structured improvements based on Lean and Six Sigma methodologies. The application of the model

has shown its potential as a practical tool for managing the modernization of SMEs, which is especially important in conditions of limited resources and high variability of production processes.

The results of the study open up opportunities for further scientific developments. In the future, the model can be expanded by (Fig. 5).:

- enabling predictive analytics and artificial intelligence tools;
- development of industry modules for enterprises with different production specifics;
- integration of ESG and sustainable development indicators into the assessment system;
- testing the model on a sample of enterprises in different regions and countries.



**Figure 5** – Updated measurement map for the production department of the audited company  
 Note – Compiled by the author, according to Ávila-Gutiérrez et al (2025)

Thus, the proposed Lean 4.0 model demonstrates high practical significance and is a flexible tool to support the digital transformation of SMEs, providing a systematic and step-by-step increase in their technological maturity.

This study presents an innovative Lean audit model specifically designed to meet the modernization needs and transition to Industry 4.0 of small and medium-sized enterprises (SMEs) in the manufac-

turing sector, especially those that rely on traditional or artisanal production systems. The main purpose of the work was to create a structured tool that allows SMEs to assess their current state, identify key areas for improvement and identify priorities for effective digital transformation. The proposed approach is based on the basic principles of Lean Manufacturing, Lean Thinking, and Lean management, taking into account limited resources (Table 3).

**Table 3** – Matrix of methods with levels for the key factor: Continuous improvement (Measurement: Integration)

Levels	Readiness	Maturity: the initial stage (Start-Up)	Maturity: In-Transition	Maturity: Advanced level
1 (0.0)	Traditional Lean tools are not used.	Traditional Lean tools are not used.	Modern Lean tools are not used.	Modern Lean tools are not used.
2 (0.3)	A separate traditional management tool is used that is not related to Lean.	Several traditional management tools that are not related to Lean are used.	A separate traditional management tool is used that is not related to Lean.	Several traditional management tools that are not related to Lean are used.
3 (0.7)	The traditional Lean tool is used sporadically in individual departments.	Several traditional Lean tools are used sporadically in individual departments.	The modern Lean tool is used sporadically in individual departments.	Several modern Lean tools are used sporadically in individual departments.
4 (1.0)	A separate traditional Lean tool is used regularly in most departments; there is an expert staff.	Several traditional Lean tools are used regularly in most departments; there is an expert staff.	A separate modern Lean tool is used regularly in most departments; there is an expert staff.	Several modern Lean tools are used regularly in most departments; there is an expert staff.

Note – Compiled by the authors on the basis of, with the use of COSO (2013)

The main contribution of this study is to develop an integrated audit model specifically focused on the challenges and resource constraints faced by small and medium-sized enterprises (SMEs) on their way to implementing Industry 4.0. Unlike numerous existing models, mainly designed for large companies, the proposed model combines detailed diagnostics, strategic recommendations and a prioritization mechanism, based on the principles of Lean Manufacturing and the Six Sigma methodology. Highlighting four consecutive strategic stages – “Readiness”, “Initial stage”, “Transitional stage” and “Advanced level” – forms a clear and logically structured roadmap for continuous improvement.

In addition, the study adapts and develops existing concepts such as the Carter and Baker Factors Balance Method for parallel engineering, applying them to the specific context of modernization of production systems within the framework of the Lean Six Sigma paradigm and Industry 4.0. The integration of the Likert scale into the assessment questionnaire represents an improvement over dichotomous models, providing a more comprehensive and nuanced data collection.

Thus, the proposed Lean 4.0 audit model is a valuable and practical tool for SMEs seeking to modernize their production processes and effectively integrate digital technologies in accordance with their capabilities. The use of the model as part of a case study confirms its potential to identify critical areas of improvement, form strategic priorities, and develop concrete actions based on Lean principles. These actions ensure a gradual, optimized and sustainable transition to Industry 4.0.

Focusing the model on the specific needs and limitations of SMEs eliminates a significant gap in the existing scientific literature and forms a reliable basis for future modernization initiatives in this key segment of the economy.

Of particular importance is the use of artificial intelligence and machine learning technologies that can not only detect violations after the fact, but also predict their likelihood at an early stage. Intelligent algorithms for risk analysis and modeling create the basis for proactive control and prevent violations even before they occur.

A promising area is also the development of the analytical infrastructure of internal audit – data visualization systems, interactive dashboards and risk maps that ensure transparency and efficiency of management decision-making. The introduction of such tools will increase confidence in audit results and ensure more efficient use of budgetary resources.

In general, the transition to a comprehensive ecosystem of digital internal audit is expected, combining technologies, competencies and regulatory mechanisms into a single intelligent risk and efficiency management system.

The implementation of the proposed measures will lead to a qualitative transformation of Kazakhstan's internal audit, which will transform from a mechanical verification tool into an intelligent risk and efficiency management system based on digital technologies, transparency and a scientific approach.

This will ensure the sustainable development of the country, increase public confidence and integrate Kazakhstan into the international digital financial control space.

## Conclusion

Thus, the development and transformation of the internal audit system in Kazakhstan is not only a requirement of the digital age, but also a strategic necessity for building a sustainable, transparent and efficient economy.

A key element of the new audit model is a preliminary examination of the audit objects using digital technologies and artificial intelligence. This provides predictive control, helps to prevent violations, increase public confidence, and ensure sustainable development.

In the future, internal audit should become an intelligent risk management center that combines science, digital technologies and public responsibility. To achieve this goal, it is advisable to implement the following practical recommendations:

1. Creation of a national digital internal audit platform.

It should combine data from government information systems (e-Gov, e-Kargy, e-Licensing, public procurement portal) in order to automate monitoring and risk analysis in real time.

2. Implementation of artificial intelligence and Big Data tools in control procedures. The use of machine learning algorithms will make it possible to identify patterns and predict anomalies in financial flows, increasing the accuracy and efficiency of the auditor's decisions.

3. Development of the Digital Maturity Model of internal audit. It is necessary to identify key performance indicators (KPIs) of digital processes, the

level of automation and analytical integration in public sector organizations.

4. Improving the digital competencies of auditors. It is necessary to introduce specialized educational programs based on leading universities in Kazakhstan (in particular, al-Farabi Kazakh National University), including courses on data analytics, RPA, IT audit and digital risk management.

5. Harmonization of national standards with international ones (IIA, ISACA, INTOSAI). This will ensure that Kazakhstan's internal audit system meets global requirements for transparency, efficiency, and cybersecurity.

6. Development of scientific and practical cooperation between universities and internal audit bodies. The creation of digital audit research laboratories at universities will make it possible to integrate scientific developments into the practice of state and corporate control.

7. Formation of a unified ethical and legal framework for digital audit. It is necessary to provide for regulatory regulation of the use of artificial intelligence, data protection and responsibility for automated solutions in the field of financial control.

The implementation of these measures will allow Kazakhstan to move from a traditional audit model to an intelligent control ecosystem based on transparency, predictive analysis and digital interaction. The implementation of these approaches will strengthen trust in government institutions, improve the quality of financial management, and ensure the sustainability of the economy in the face of digital transformation.

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