

*The object of this study is the innovative activity of enterprises and mechanisms for managing innovation risks in the context of the digital transformation of the economy of the Republic of Kazakhstan. The problem to be solved is the cost-effectiveness of integrating digital technologies into innovation risk management systems. This paper examines theoretical approaches to defining innovation activity, broadens its concept, and investigates the impact of digitalization on innovation risk management processes at enterprises. An analysis of the dynamics of the country's gross domestic expenditure, innovation activity indicators, and the international ICT development index was conducted, revealing trends in Republic of Kazakhstan's sustainable digital development.*

*The study's results demonstrate that digitalization is a driving force for innovation and a tool for improving the effectiveness of innovation risk management. To this end, the costs associated with the development of the digital economy were analyzed, revealing that these expenditures in the Republic of Kazakhstan increased by 63.8% between 2019 and 2024. The study also found that the level of innovation activity at enterprises increased from 10.1% to 14.2%. A key finding of the study is that the implementation of digital solutions reduces losses from innovation risks by 18–34%, while the economic benefits for enterprises, depending on their size, range from 2.16 to 267.2 thousand USD.*

*Therefore, the scope of application includes enterprises of various sizes that need to improve their financial performance through the development of various innovation risk management systems and the implementation of digital transformation programs*

*Keywords: digitalization, innovation, management systems, business, economic, features, financial results*

# IDENTIFICATION OF IMPACT OF DIGITAL TECHNOLOGIES ON BUSINESS MANAGEMENT SYSTEMS AND REDUCING INNOVATION RISKS IN THE DIGITAL AGE

**Bibigul Kopbolsyn**

Master of Economic Sciences\*

ORCID: <https://orcid.org/0000-0001-5665-9718>

**Asel Jakupova**

Master of Economic Sciences\*

ORCID: <https://orcid.org/0000-0001-7962-0285>

**Bakytgul Bazarova**

Corresponding author

Master of Economic Sciences\*

E-mail: [Baktigulbazarova@mail.ru](mailto:Baktigulbazarova@mail.ru)

ORCID: <https://orcid.org/0000-0001-5197-6001>

**Gulnar Talapbayeva**

Candidate of Economic Sciences, Associate Professor\*\*

ORCID: <https://orcid.org/0000-0001-5162-6028>

**Zhanat Yerniyazova**

Candidate of Economic Sciences, Senior Lecturer\*\*

ORCID: <https://orcid.org/0009-0002-8393-3246>

\*Department of Digital Economy and Sustainable Development

Zhangir Khan University

Zhangir Khan ave., 51, Uralsk, Republic of Kazakhstan, 090009

\*\*Department of Economics and Law

Korkyt Ata Kyzylorda University

Aiteke bi str., 29 A, Kyzylorda, Republic of Kazakhstan, 120000

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## 1. Introduction

In today's environment, innovation has become a key factor in ensuring sustainable economic growth for businesses, whilst also enhancing the competitiveness of enterprises, which in turn influences the economic development of nations. The introduction of digitalization, the rapid growth of digital transformation processes and the intensification of global competition are creating new operating conditions for economic actors, in which innovation serves not only as a tool for improving efficiency but also as a necessary condition for economic development. Study indicates that, at present, the development of digitalization linked to innovation has not been sufficiently studied.

Since innovation is characterized by a high degree of risk associated with the instability of the external environment, there is a need for effective mechanisms to manage innovation risks, which can ensure the sustainability of enterprises and enhance the effectiveness of innovation projects – an integral part of economic development.

The need to develop modern approaches to managing innovation risks for enterprises in the context of the digital transformation of the Republic of Kazakhstan's economy underlines the relevance of these studies. Particular attention should be paid to assessing the economic feasibility of implementing digital and innovation risk management mechanisms at enterprises of varying sizes and maturity levels, as well as their impact on the overall business management sys-

tem. This will allow for a more accurate assessment of how digital technologies are changing decision-making processes and improving management efficiency at small, medium, and large enterprises.

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## 2. Literary analysis and statement of the problem

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Papers [1, 2] present the theoretical foundations for understanding risk within the framework of classical economic theory. They demonstrate that risk is an integral part of entrepreneurial activity, which is associated with profit generation. However, the relationship between risk and innovation remains insufficiently explored, as study focused on the general patterns of economic and entrepreneurial functioning, while innovation processes had not yet been widely developed at that time.

Papers [3, 4] examine issues of risk and uncertainty in economic activity. The authors demonstrate that risk influences entrepreneurial decision-making and business performance. Thus, paper [3] places particular emphasis on the distinction between the concepts of “risk” and “uncertainty,” which served as a basis for further economic study. However, these works also focus on general issues of economic theory and do not address risk in innovation. Therefore, it is advisable to study the specifics of risk emergence and management in innovation processes.

The role of innovation in economic development is examined in papers [5–7]. In paper [5], the author notes that innovation is one of the key factors in economic growth and increased competitiveness. Papers [6, 7] demonstrate the connection between innovation, entrepreneurship, and the technological development of enterprises, since technological processes are already being considered during this period. However, these works mainly reveal the essence and significance of innovation, while insufficient attention is paid to the issues of risks arising in the process of innovation.

A comprehensive approach that takes into account the relationship between innovation and risks can be a solution to this problem. The Oslo Manual [8], which presents modern principles for defining and assessing innovation activities, is of particular importance for such an approach. Thus, all this confirms the need for further study of innovation risks and methods for their management.

Studies [9, 10] present the impact of digital transformation on the operations of modern organizations. The authors note that the introduction of digital technologies leads to changes in business models, management methods, and decision-making processes. Digitalization is shown to improve enterprise efficiency and accelerate innovation. At the same time, the study [10] emphasizes that digital transformation affects the level of corporate risk, creating new sources of uncertainty in organizational operations. However, issues of innovation risk management in the digital economy remain understudied, suggesting the need for further study aimed at developing the effectiveness of risk assessment and management during digital transformation.

Studies [9, 11] examine the impact of digitalization on enterprise performance and their ability to adapt to environmental changes. They demonstrate that the implementation of digital technologies contributes to the improvement of data analysis, monitoring, and management decision-making processes, primarily accelerating the implementation and commercialization of innovations. However, the application

of digital tools for innovation risk management remains underdeveloped, owing to the difficulty of assessing new types of risks arising in the context of digital transformation.

Study in the field of innovation, risk, and digital transformation is extensive, but an analysis of academic and practical work in this area reveals a number of unresolved issues. While study primarily focuses on technological implementation and issues related to the intensification of work on new technologies, the cost-effectiveness of integrating digital technologies into innovation risk management systems remains understudied. This suggests the need for further study on theoretical approaches to defining the concepts and characteristics of innovation activity, analyzing the dynamics of digital and innovative development indicators in the Republic of Kazakhstan, and developing practical recommendations for the use of digital technologies to manage innovation risks in business.

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## 3. The aim and objectives of the study

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The aim of this study is to identify the impact of digital technologies on business management systems and innovation risk management processes. This will allow businesses to improve the accuracy of risk assessments, accelerate management decision-making, and adapt the management system to the rapidly changing conditions of the digital economy.

To achieve this aim, the following objectives were accomplished:

- to examine theoretical approaches to defining innovation activity in the works of academics and practitioners, and to identify its key characteristics, taking risks into account;
- to analyze the dynamics of indicators of digital and innovation development in the Republic of Kazakhstan, including indicators of gross domestic expenditure, innovation activity and the international digital development ranking;
- to conduct a study of the economic efficiency of implementing digital solutions in the innovation risk management system of enterprises of various sizes and levels of digital maturity and to develop practical recommendations for integrating digital technologies into business management systems to improve the quality of management decisions, reduce innovation risks, and ensure the sustainable development of organizations in the digital economy.

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## 4. Materials and methods

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The object of this study is the innovative activities of enterprises and mechanisms for managing innovation risks in the context of the digital transformation of the economy of the Republic of Kazakhstan. Its practical significance is based on increasing the efficiency of enterprises by reducing the level of risk in the context of digital transformation.

The hypothesis of the study is based on proposals for the implementation of digital technologies and the use of modern technologies for managing innovation risks.

Assumptions made before the start of the study:

- the level of enterprise development directly affects the quality of innovation risk management, the need to use digital tools that improve the efficiency of innovation activities, enterprises with a high level of digital maturity are more resilient to various economic changes.

Simplifications made in the course of the study:

- the analysis was conducted without taking into account industry-specific characteristics between individual enterprises, but with due regard for enterprise size, analysis of external macroeconomic factors, the impact of digital technologies on the effectiveness of companies' financial results.

The methodological framework of the study is based on general scientific and specialized methods for analyzing innovation activities and managing innovation risks during the digital transformation of the economy. The study employed methods of comparative, systemic and economic-statistical analysis, which enable the identification of the specific ways in which digitalization influences innovation risk management processes within enterprises.

The study used statistical data on enterprise innovation activity, research and development expenditures, and digital development indicators in the Republic of Kazakhstan. Analysis of these data allowed to identify the impact of digital technologies on business management systems and innovation risk management processes.

The study was conducted on the basis of statistical data for the Republic of Kazakhstan covering the period 2017–2025, using indicators such as gross domestic expenditure on the country's digital development, enterprises' innovation activities, and the number of patent applications worldwide. The study also utilized official statistics from various published sources, analytical reports and international data characterizing the level of digital development and innovation activity.

Consequently, to test the proposed approach, it became necessary to use the case study method. This method is based on a comparative analysis of three enterprises that differ in the scale of their operations and level of digital maturity: a small enterprise, a medium-sized manufacturing enterprise and a large construction company.

The results obtained were summarized using a systematic approach, which enabled the formulation of practical recommendations for the implementation of digital technologies in the innovation risk management system at enterprises of various types.

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## **5. Results of the study of innovation risks and the impact of digital technologies on enterprise management systems**

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### **5.1. Theoretical approaches to defining the concept of innovation and identifying its key features**

In today's world, innovation represents one of the key areas of activity within any economic system, attracting the attention of both academics and business practitioners. Taking into account the risks involved in entrepreneurial activity, it fosters competition and drives the development of enterprises that adopt innovations.

The main aspects of innovation development are as follows:

- innovation is primarily one of the factors that stimulate the development of any economic system;
- innovation is closely linked to the need for significant investment in research and development, for example, the use of innovative technologies or the acquisition of innovative equipment, etc.;
- innovative activity is closely associated with high risk.

In the academic literature on innovation management, the central issue is how to enhance the effectiveness of enterprises' innovation activities, which is primarily linked

to the effective utilization of an enterprise's innovation capacity, as well as the promotion of innovative processes and technologies. At the same time, the risk component is often overlooked, even though for most enterprises it acts as a constraint on innovative development. In an enterprise's economic activities, it is important not only to measure and assess the enterprise's innovation risks during their implementation, but also to formulate optimal strategies aimed at reducing those risks.

As innovation, by its very nature, as outlined above, involves managing processes aimed at economic development through the introduction of innovations. Innovation is not always limited to the processes of developing and implementing know-how; it may also include the following elements:

- scientific and original research and development;
- experimental design work;
- the development and utilization of innovative ideas;
- the acquisition and implementation of modern equipment and technologies;
- the creation of conditions for the enterprise's scientific and innovation system (laboratories, research centers, departments, etc.);
- the integration of new developments into operations, as well as their commercialization;
- retraining and training of specialists within the enterprise to acquire skills in working with modern equipment and technologies.

All of this constitutes the enterprise's innovative activity. Therefore, to identify the full range of elements, it is necessary to consider various approaches.

By analyzing definitions of innovative activity from the perspective of various sources, the following conclusions can be drawn: it constitutes activity aimed at the development of the enterprise through innovation.

Thus, based on the above, several general approaches can be identified:

- the entrepreneurial approach, in which organizations focus on creating new products through innovation;
- the functional approach, in which activities are linked to specific objectives that are achieved through innovation;
- process-oriented, where activities are directed towards ensuring innovative processes in the economy as a whole;
- philosophical, where innovative activity involves the interaction of business, science, the economy and the management system.

Therefore, based on these approaches, let's present the following features of this category (Fig. 1).

These features provide a comprehensive picture of innovation activity. Furthermore, attention should be paid to the characteristics of innovations that distinguish them from novelties, which include:

- scientific and practical novelty;
- the potential for technology implementation;
- the project's ability to deliver results.

On this basis, an innovation, as a fundamental element of innovation activity, can be considered, for example, if it is new from both a scientific and practical perspective, is implemented in the production process, and has the potential to generate financial benefits.

An analysis of the key features of innovation shows that it is not limited solely to the creation and commercialization of intellectual products, but also encompasses the processes of implementing innovations, utilising modern technologies and achieving strategic objectives for practical application.

comprehensive	• a set of measures aimed at implementing innovations
systems	• Innovation should be viewed as a holistic process aimed at achieving specific objectives
targeted	• one of the key objectives of innovation is to create a new product or improve an existing process through innovation and innovative technologies
the presence of an intellectual element	• It is intellectual activity that serves as one of the key factors in transforming an idea into an innovative outcome
commercial focus	• Innovative activity involves the commercialisation of intellectual property and is aimed at generating financial returns, much like entrepreneurial activity

Fig. 1. Features of innovative activity in enterprises

It should be noted, however, that the approaches outlined above, which highlight the key features of innovative activity, do not take into account the fact that risk is one of its most crucial elements.

Therefore, entrepreneurial activity includes, first of all, activities aimed at producing goods, providing services and performing work carried out in accordance with established norms; it is aimed at achieving a certain economic result and is carried out by the entrepreneur at its own risk, with the main goal of making a profit [11].

Based on the objectives of entrepreneurial activity, it is features by the following features:

- it involves the production of goods, the provision of services and the performance of work;
- it is aimed at achieving financial results – generating profit;
- it is conducted in accordance with the laws and regulations established by state authorities;
- and it involves a certain degree of risk.

In any case, innovative activity is directly linked to risks; in particular, the processes of developing and commercializing innovations are closely associated with a fairly high degree of risk, as their outcomes are unknown and the forecasts made have a low probability of being realized. This is because new products and technologies may not be in demand in the market or among end consumers, for a number of reasons.

This is demonstrated by business practice. In the first instance, when a new product was launched at the wrong time; in other words, technology that was ‘ahead of its time’ failed to resonate with potential consumers. For example, there is evidence that the ‘smartphone’, introduced in the 1990s, was not accepted by the market; in other words, consumers at that time did not recognize the value of the new product, as there were technological limitations, such as the internet not being widely available. However, the ‘smartphones’ introduced in 2007–2008 were accepted by consumers and became widely adopted.

The second scenario is a situation where a new product is launched simultaneously with a similar product that offers greater value, leading to a decline in demand for the original product and an increase in demand for its alternative.

In the third situation, the proposed new product may be valuable to potential consumers, but at the same time, it may

be expensive due to its high cost, which limits its adoption and demand.

These situations demonstrate that the level of risk associated with a company’s innovative activities is very high and indicate that company management must, in addition to production, research, and financial aspects, also consider the risk factor –that is, evaluate and measure innovation risks.

Furthermore, in addition to the features discussed, innovative activities are inherently risky, and the degree of risk depends on the specific type of company activity. When introducing innovations and innovative technologies into a company’s business activities, the risk may be low or moderate; however, when conducting research and development, experimental development, and commercializing the results of the company’s own intellectual property, the risks can be significant, which requires special attention.

The final result of the analysis of the features of a company’s innovative activities is presented in Fig. 2.

As an element of entrepreneurial activity, innovation must necessarily include risk factors.

Therefore, it becomes necessary to expand this definition and interpret it as follows: innovation is the activity of an economic entity, consisting of scientific, technical, organizational, financial, and commercial components, aimed at implementing innovative projects for economic development, creating an innovation system, and ensuring its effective functioning, where such activities are associated with a high degree of risk.

This amendment objectively makes it clear to business representatives from the outset that innovative activity is associated with risks; therefore, these risks must be taken into account when developing a business plan. At the same time, when conducting research on innovation, the scientific community will consider the risk factor as a key element in this area, one that must be included in models and mechanisms for the innovative development of economic systems, going beyond the risk assessment of business projects.

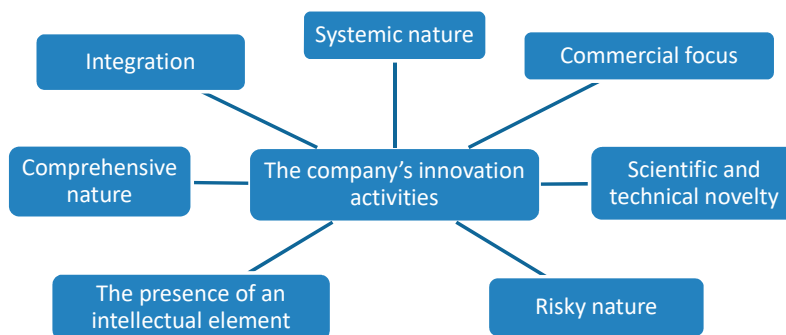


Fig. 2. Special features of an enterprise’s innovation activities

**5. 2. Analysis of key indicators showing digital development and the degree of innovation implementation**

Having conducted this study, it is important to assess the potential of the country’s digital transformation technologies for the development of innovative companies, as the state plays a significant role in the development of entrepreneurship.

Consequently, one of the indicators determining the development of the digital economy of the Republic of Kazakhstan is gross domestic expenditure (Fig. 3). An analysis of the dynamics of this indicator for 2017–2025 reveals a level of active growth and subsequent stabilization.

Thus, according to the table, in 2017, gross domestic expenditure amounted to 4,063 billion tenge, while the expenditure of organizations and households was half that, amounting to 2,177 billion tenge and 1,953 billion tenge, respectively. In 2018–2019, this indicator remained relatively stable: 4,094 billion tenge in 2018 and 3,795 billion tenge in 2019, indicating stable digital infrastructure development during these years.

Significant changes were observed in 2020–2021. In 2020, gross expenditure began to rise to 3,324 billion tenge and peaked at 5,471 billion tenge by 2021. This is due to the impact of the COVID-19 pandemic, which spurred a sharp increase in digitalization. Specifically, household expenditure increased to 3,294 billion tenge, while corporate expenditure amounted to 1,641 billion tenge, demonstrating the active participation of the population in the digital environment. This was due to the need to quickly adapt to online payments and transfers, where the banking sector played a key role by introducing online and remote payments.

In subsequent years, all indicators will decline to 5,161 billion tenge in 2022 and 4,848 billion tenge in 2023, reflecting the completion of several major digital projects and the economic crisis. Organizational expenses will also continue to decline, to 1,210 billion tenge in 2023, reflecting the optimization of business processes [12].

Gross domestic expenditures (GDEX) decreased to 3,850 billion tenge in 2024 and then increased to 4,100 billion tenge in 2025. This indicates the beginning of a new stage in the development of the digital economy, associated with the implementation of innovative technologies, as digital economic development issues are being addressed at the state level and laws for its development have been adopted.

Thus, the dynamics of GDEX in recent years demonstrate not only the development of the digital economy but also a change in its structure, with the increasing role of digital services consumption by both organizations and the public. At the same time, the active implementation of innovations is accompanied by the emergence of certain innovation risks, including high uncertainty regarding investment results, technological dependence, cyber

threats, and rapid technological obsolescence, for which businesses are not yet prepared. Under these conditions, effective management of innovation risks is becoming a key condition for the sustainable development of the digital economy of the Republic of Kazakhstan.

One of the key indicators of digital technology development is the ICT Development Index, calculated by the International Telecommunication Union. Since digital technologies are an integral part of innovation, it seems appropriate to assess the Republic of Kazakhstan’s position in international digital development rankings (Fig. 4) [12].

Fig. 4 shows that the ICT Development Index 2025 for the Republic of Kazakhstan demonstrates a relatively high level of digital infrastructure development and ranks 47<sup>th</sup> globally, ahead of developed countries such as Canada, Turkey, and Italy. This confirms the country’s steady progress in digitalization. Among Asian countries, it ranks first, which is considered a positive indicator. The index score is approximately 90.5 points, placing the Republic of Kazakhstan among countries with a high level of ICT development.

It’s important to note that the index’s dynamics indicate a consistent improvement in the country’s position. Previously ranked 53rd, by 2025 it has secured a place in the middle of the global rankings, reflecting the effectiveness of its government’s digitalization policy.

Thus, the ICT Development Index indicators confirm that the Republic of Kazakhstan is achieving sustainable digital development. At the same time, its significant gap with leading countries indicates that certain limitations to development still exist, such as the level of digital skills, the availability of modern technologies, and the effectiveness of their implementation. Technological dependence, cyber threats, and the high cost of implementing new solutions also pose innovation risks and impact the number of patent applications. Despite this, the country maintains a relatively high level of innovation activity, which is a positive factor on the path to digital transformation.

To analyze digital development, it is necessary to study the dynamics of gross domestic expenditure and the Republic of Kazakhstan’s position. Based on this indicator, international digital development rankings suggest that conditions have been created at the state level for the transition to a qualitatively new stage of innovative development. However, this transition is accompanied by accelerated technological development, growing dependence on digital platforms, and an increase in cyberthreats [13].

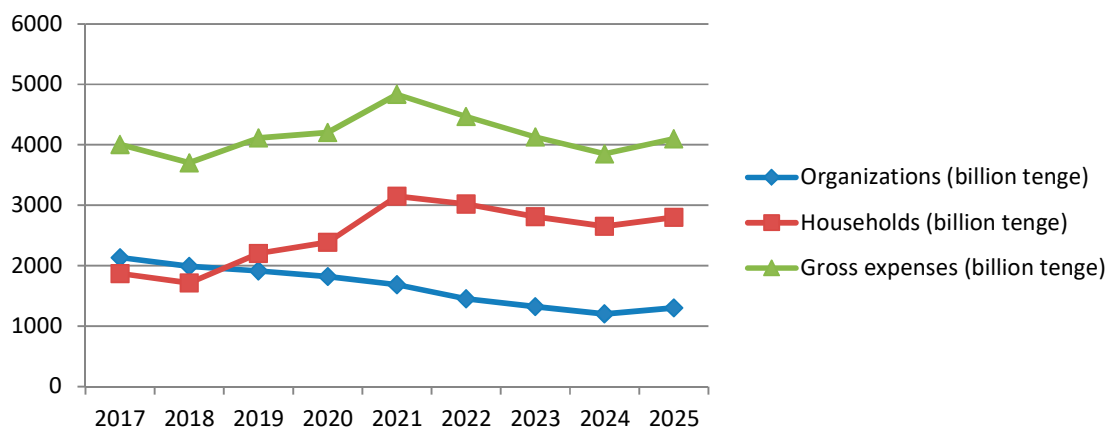


Fig. 3. Gross domestic expenditure on the development of the digital economy in the Republic of Kazakhstan

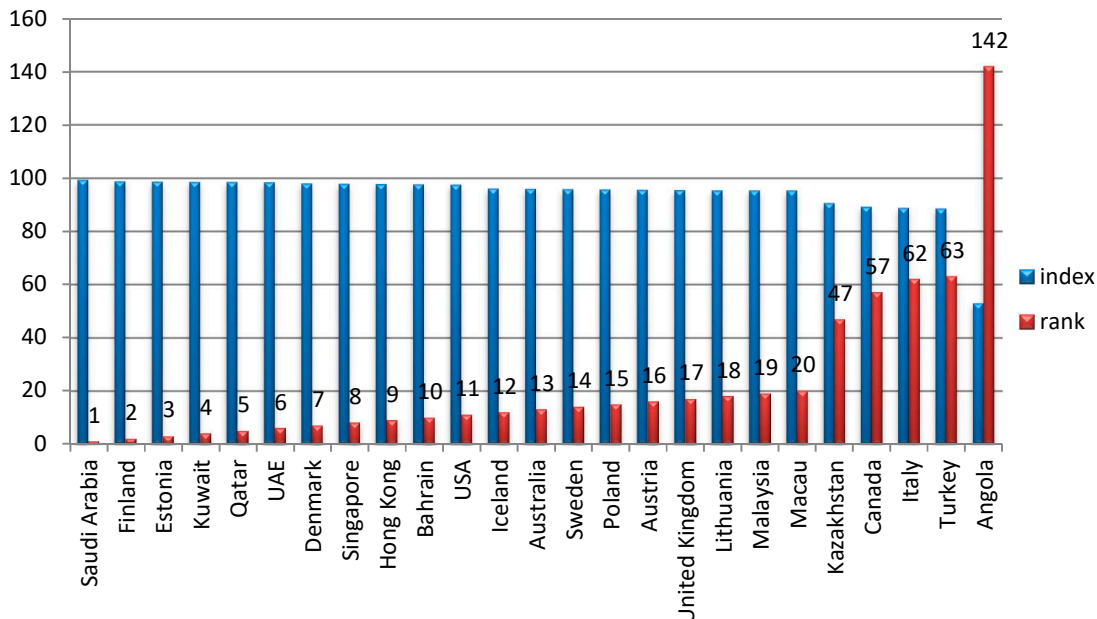


Fig. 4. Dynamics of filing patent applications for inventions in the field of information and communication technologies

In this situation, it is necessary to use digital technologies to manage innovation risks. Previously, enterprises relied on expert opinions, but in today’s environment, they rely on big data, artificial intelligence, and machine learning to assess risks, predict situations, and make various decisions, such as:

- improving the accuracy of risk forecasting for new projects;
- making prompt management decisions in emergency situations.

In general, at the current stage of economic development, digitalization is not only a driving force for innovation but also a tool for transforming risk management mechanisms, necessitating the development of new approaches and methodologies for risk assessment.

Further study requires an analysis of the main trends in the development of innovation in the Republic of Kazakhstan (Table 1). The table presents data reflecting the sustainable transformation of innovation and economic efficiency for 2019–2024. Analysis of these indicators allows to assess the effectiveness of the country’s innovation policy and identify the relationship between innovation costs, profitability, and the state of innovation activity at enterprises.

The study was conducted in national currency; when converting to USD, the average exchange rate of 521.59 tenge to 1 dollar as of 2025 was used [14].

lion to 1.8 billion USD, an increase of almost twofold (63.8%), demonstrating the country’s innovative development. A year-over-year analysis reveals a significant increase in 2021, reaching 1.49 billion USD, reflecting the recovery from the pandemic. Analyzing the share of innovative products, a significant decline can be seen in 2020, from 9.2% to 8.7%, reflecting the impact of external economic shocks. This was followed by steady growth from 2021 to 2024, from 10.5% to 12.8%, respectively. This indicates the gradual development of commercialization in innovation, as well as its increasing role in the production structure [15].

An analysis of profitability trends reveals instability. After falling to 11.2% in 2020, this indicator is gradually recovering, failing to reach the 2019 level of 13.9% in 2024. Despite the increase in investment, profitability remains stable over the long term, demonstrating the effectiveness of innovation investments. The share of companies implementing innovation is growing from 10.1% to 14.2%, indicating stability. This is one of the most consistent trends in the sample; its increase of more than 4% demonstrates the expansion of innovative engagement in business.

Thus, the country’s data indicate a transition from an extensive to an optimal model, as investments are beginning to yield significant economic results. If trends continue at this level, further growth in innovation efficiency and strengthening of competitiveness are expected.

Table 1

Analysis of trends in the Republic of Kazakhstan’s innovation development

Year	Innovation expenditure (billion USD)	Share of innovative products (%)	Rentability (%)	Innovation activity (%)
2019	1.11	9.2	14.5	10.1
2020	1.18	8.7	11.2	9.5
2021	1.49	10.5	13.8	11.3
2022	1.64	11.2	12.6	12.1
2023	1.7	12.0	13.1	13.4
2024	1.8	12.8	13.9	14.2

According to Table 1, investment in innovation has grown steadily over the period under review, from 1.11 bil-

### 5. 3. A study of the economic efficiency of implementing digital solutions in innovation risk management systems at enterprises

For further research, a case study was used involving three companies with varying scales and levels of digital maturity: a small business, a medium-sized manufacturing company, and a large construction company (Table 2). The analysis focused on assessing the economic feasibility of implementing digital tools for managing innovation risks. Therefore, the following key parameters were used: annual risk management costs, estimated investments in digital solutions, projected reduction in losses

from innovation risks, the payback period for implementation, and the company’s level of digital readiness.

Table 2

Analysis of the impact of digital solutions on reducing enterprises’ innovation risks

No.	Indicator	Small enterprise	Medium enterprise	Large enterprise
1	Annual turnover, thousand USD	671	4 601	34 509
2	Risk management costs, thousand USD	6.7	34.1	182.1
3	Losses from innovation risks, thousand USD	23.0	11.1	786.0
4	Investments in digital solutions, thousand USD	15.0	53.0	306.7
5	Expected reduction in losses, %	18	26	34
6	Economic effect, thousand USD	4.14	28.9	267.2
7	Payback period, years	3.7	1.9	1.1
8	Digital readiness level	Low	Medium	High

The table shows that for small businesses, including sole proprietors, the implementation of complex digital tools, including artificial intelligence, has limited economic viability. Despite a potential 18% reduction in losses, the economic benefit is only 4.14 thousand USD, despite an investment of 15.0 thousand USD. The payback period was 3.7 years, which is long for a small business. Therefore, for this category of businesses, it is best to implement inexpensive digital systems and technologies gradually, for example, first spreadsheets and basic CRM systems, then cloud-based project accounting services and standard risk assessment templates, etc.

For medium-sized manufacturing companies, the economic benefits of implementing digital solutions are more pronounced. It is clear that with an investment of 53.0 thousand USD in innovation, the expected 26% reduction in losses yields an economic benefit of 28.9 thousand USD. The payback period is 1.9 years, leading to the conclusion that implementing innovation and digitalizing innovation risk management provides an economically viable development path. For such companies, the implementation of analytical systems, such as automated equipment and risk forecasting tools, is essential [16, 17].

The greatest economic benefit can be seen when analyzing large companies, in this case a construction company, as this industry is more widespread and developed in the country. With an investment of 306.7 thousand USD, the expected reduction in losses is 267.2 thousand USD, and the payback period was only 1.1 years, despite seasonality. This is due to the company’s scale of operations, the number of innovative projects being implemented, and its higher level of readiness for digitalization. For large organizations, the implementation of artificial intelligence tools and big data analytics

systems is justified because even a small reduction in the likelihood of errors, delays, or inefficient resource allocation leads to significant financial results – that is, profit.

Thus, the study demonstrates that the impact of digital technologies is directly linked to the business management system, which significantly depends on the scale of the enterprise and its level of digital maturity (Table 3).

Table 3 shows that digitalization in small businesses is primarily aimed at automating key management processes, including accounting, document management, and day-to-day operations. For medium-sized enterprises, digital solutions are becoming a tool for improving the efficiency of strategic planning, monitoring production processes, and managing innovation risks. Large companies utilize digital technologies in all areas of business management. The use of artificial intelligence, big data analysis, and modern analytical systems helps process information faster, make more informed decisions, and promptly identify potential risks. All this contributes to increased innovation management efficiency and reduced uncertainty in the implementation of new projects. Thus, as a company grows, individual digital tools are gradually integrated into a unified business management system, ensuring more efficient operations.

Table 3

The impact of digital technologies on elements of the business management system

No.	Element of a business management system	Small enterprise	Medium enterprise	Large enterprise
1	Strategic management	Basic digital reporting and CRM	Analytical decision support platforms	AI and predictive analytics
2	Operational management	Accounting and document management automation	Production process monitoring	Integrated ERP systems
3	Innovation management	Standard project evaluation tools	Innovation risk analysis systems	Digital innovation management platforms
4	Risk management	Electronic risk registers	Automated risk monitoring	Big Data and intelligent forecasting
5	Control and decision making	Electronic dashboards	Real-time analytical reports	Intelligent decision support

Thus, the study showed that the economic feasibility of implementing digital solutions for innovation risk management directly depends on both the size of the enterprise and its level of digital maturity [18, 19]. As a company grows, individual digital tools are gradually integrated into a unified business management system, ensuring more efficient operations.

**6. Discussion of study results of innovation risks and the impact of digital technologies on business management systems**

The study shows that the development of innovation and digital transformation in the Republic of Kazakhstan from 2017 to 2025 was accompanied by a stable growth in the main indicators of innovative and digital development (Table 1). Expenditures on innovation increased from 1,11 billion USD in 2019 to 1,8 billion USD in 2024, while the level of innovative activity of enterprises increased from 10.1% to 14.2%. An analysis of the dynamics of gross domestic expenditure on the development of the country’s digital economy (Fig. 3) and the indicators of the international ICT Development Index (Fig. 4) demonstrate the development of the digital system and investments in the digitalization of the economy. It

is also necessary to emphasize that the digitalization of innovation is accompanied not only by an increase in quantitative indicators of innovative activity (Table 1, Fig. 3, 4), but also by qualitative transformations in the management systems of enterprises of different sizes. The main factor here is the introduction of innovative digital systems for data analysis, system monitoring and innovation risk forecasting (Table 2). They thereby ensure more effective management decisions at the enterprise, reduce decision uncertainty, and increase the economic resilience of enterprises in the digital economy. All these obtained results can be compared with the findings of OECD studies, which state that digital transformation and the development of innovation activities contribute to increased efficiency of enterprise management and accelerated technological development of the economy as a whole [20].

Unlike many existing studies, which focus on the economic indicators of digitalization or innovation activity in isolation, this study's weakness is the limited empirical data on the impact of digitalization on enterprise innovation, as the active implementation of digital technologies is a relatively new area. In the future, it will be possible to conduct a more comprehensive study of digital technologies at enterprises in various industries and regions of the Republic of Kazakhstan [21, 22]. However, such a study may face challenges related to the lack of detailed statistical data across industries, differences in the level of digitalization of companies, and the difficulty of assessing actual digital technologies in businesses [23, 24]. Overall, the study's results confirm the positive impact of digitalization on business development, but also indicate that digital technologies reduce innovation risks and improve the financial stability of enterprises.

Therefore, for the Republic of Kazakhstan, the results of this study identify the following economic effects associated with the digitalization of innovation in business management systems.

The innovation is not only the process of creating and implementing innovations, but also a system of scientific, technical, organizational, and commercial processes, which is accompanied by a high degree of risk. Furthermore, it has been established that risk is one of the main characteristics of innovation activity, as processes related to the commercialization of innovations, the introduction of new equipment, and the implementation of innovative projects are characterized by a high degree of uncertainty regarding results and a decrease in financial indicators (Fig. 1, 2).

An analysis of digital and innovation development indicators in the Republic of Kazakhstan shows that innovation expenditures are steadily growing, enterprises are actively pursuing innovation, and the country's digital development indicators are also growing dynamically (Table 1, Fig. 3, 4). Particularly noticeable is the increase in gross domestic expenditure on the development of the country's digital economy and the improvement in Republic of Kazakhstan's position in the international ICT Development Index for patent applications, confirming that economic digitalization is advancing. Furthermore, it was found that digitalization is accompanied by an increase in innovation risks, including technological dependence, cyber threats, and the high cost of implementing digital systems.

A study of the economic efficiency of implementing digital solutions in innovation risk management systems at enterprises of various sizes and activities showed that the economic impact of digitalization directly depends on both the size of the enterprise and its level of digital maturity (Table 2). For

small businesses, basic digital systems and cloud services are the most effective; for medium-sized enterprises, specialized analytical platforms and monitoring systems; and for large enterprises, comprehensive digital tools, including big data analysis and the implementation of artificial intelligence.

The study's results demonstrate that digitalization is having a significant impact on business management. Digital technologies are used in strategic and operational management, innovation management, and risk management, contributing to the increased efficiency of management processes. The implementation of digital tools improves the quality of information for decision-making, helps reduce uncertainty in the implementation of innovation projects, and allows companies to adapt more quickly to environmental changes. This increases business resilience and reduces potential losses associated with innovation risks.

This study has several limitations:

- the analysis was conducted solely on statistical data, as there is no industry-specific data. The sample was taken from three companies by production size, so the results cannot fully reflect the situation across all sectors of the economy;

- secondly, the study primarily examined quantitative indicators of digitalization and innovative activity, while qualitative factors related to personnel training and management characteristics were practically not examined.

The study can be further expanded to include a larger number of companies from different industries and regions. This will provide a more comprehensive understanding of the impact of digitalization on companies' innovation activity and identify the specifics of this process in various economic sectors.

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## 7. Conclusions

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1. A study of theoretical approaches to defining innovation revealed that innovation is a complex of scientific, technical, organizational, and commercial processes that can be associated with significant risks. The study demonstrated that, when developing an innovation infrastructure, risk components must be directly included in the definition of innovation activity. This is explained by the fact that innovation processes are characterized by high uncertainty of results, significant investment costs, and dependence on many external and internal factors.

2. Analysis of the indicators of digital and innovative development of the Republic of Kazakhstan shows a stable growth in innovation spending – from 1.11 billion USD in 2019 to 1.8 billion USD in 2024, while the level of innovative activity of enterprises increased from 10.1% to 14.2%. At the same time, Republic of Kazakhstan strengthened its position in the international ICT Development Index, taking 47<sup>th</sup> place in the world with an index of 90.5%. Thus, unlike many developed countries, the Republic of Kazakhstan has a higher rate of digitalization and development of innovative infrastructure, which is explained by active state support of digital processes in economic transformation.

3. Analysis of enterprise data showed that the economic effect of implementing digital solutions in innovation risk management systems is high. And also that the effectiveness of digitalization directly depends on the size of the enterprise and the level of its digital maturity. For small businesses, the most effective are basic digital systems and cloud services; for medium-sized enterprises, specialized analytical platforms and monitoring systems; and for large enterprises, complex

digital tools, including big data analysis and the implementation of artificial intelligence. For a large enterprise, the expected economic effect was 267.2 thousand USD with a payback period of 1.1 years. Thus, the results confirm that digital technologies can reduce losses from innovation risks, increase forecasting accuracy and improve the quality of management decisions at enterprises.

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#### Conflict of interest

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The authors declare that they have no conflict of interest in relation to this study, whether financial, personal, authorship or otherwise, that could affect the study and its results presented in this paper.

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#### Financing

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The study was performed without financial support.

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#### Data availability

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All data are available, either in numerical or graphical form, in the main text of the manuscript. Manuscript has no associated data.

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#### Use of artificial intelligence

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

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#### Authors' contributions

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**Kopbolsyn Bibigul:** Investigation, Formal analysis; **Assel Jakupova:** Validation, Writing – original draft; **Bakytgul Bazarova:** Visualization, Writing – review & editing; **Gulnar Talapbayeva:** Supervision, Project administration; **Zhanat Yerniyazova:** Conceptualization, Methodology.

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