ELIT
Economic Laboratory Transition
Research Podgorica

Montenegrin Journal of Economics

Sabyrzhan, A., Zeinullina, Zh., Karipova, A., Omarova, A., Jazykbayeva, B., Zhumabekova, M. (2026), "Investments in AI as a driver for increased productivity in the healthcare system", *Montenegrin Journal of Economics*, Vol. 22, No. 1, pp. 253-269

Investments in AI as a driver for increased productivity in the healthcare system

ALI SABYRZHAN[1], ZHANAR ZEINULLINA[2], AINUR KARIPOVA[3] (Corresponding author), AINURA OMAROVA[4], BALDYRGAN JAZYKBAYEVA[5] and MADINA ZHUMABEKOVA[6]

[1]Candidate of Economic Sciences, Professor, Institute of Management of the Academy of Public Administration under the President of the Republic of Kazakhstan, Astana, Kazakhstan, email: A.sabyrzhan@apa.kz, ORCID ID: https://orcid.org/0000-0002-8910-4572

[2]PhD student, Karaganda Buketov University, Karaganda, Kazakhstan, email: zhanar_z_e@mail.ru, ORCID ID: https://orcid.org/0000-0002-9372-3229

[3]Associate Professor, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan, email: karipovaainur@mail.ru, ORCID ID: https://orcid.org/0000-0003-4376-9074

[4]Associate Professor, Karaganda Buketov University, Karaganda, Kazakhstan email: ainuraphd@mail.ru, ORCID ID: https://orcid.org/0000-0001-9808-4908

[5]Associate Professor, Karaganda University of Kazpotrebsoyuz, Karaganda, Kazakhstan, email: baldirgan_keu@mail.ru, ORCID ID: https://orcid.org/0000-0003-0738-2526

[6]Associate Professor, Karaganda University of Kazpotrebsoyuz, Karaganda, Kazakhstan, email: m070dfn@mail.ru, ORCID ID: https://orcid.org/0000-0003-3872-2327

ARTICLE INFO

Received April 14, 2025
Revised from April 30, 2025
Accepted May 28, 2025
Available online January 15, 2026

JEL classification: R58, R52

DOI: 10.14254/1800-5845/2026.22-1.19

Keywords:

artificial intelligence,
investments,
labor productivity,
healthcare,
digital transformation,
economic efficiency,
ESG risks

ABSTRACT

The relevance of this study stems from the need to improve labor productivity in the healthcare system in the face of increasing workloads for medical personnel, limited human and financial resources, and the accelerating digital transformation of the economy. Investments in artificial intelligence (AI) technologies are considered a key tool for healthcare modernization, capable of reducing unproductive labor costs, increasing the efficiency of clinical and management processes, and ensuring the long-term sustainability of the system. The aim of the study is to economically justify the role of investments in artificial intelligence as a factor in increasing labor productivity in the healthcare system and to identify the conditions under which such investments provide a sustainable socioeconomic impact. The research methods include an analysis of scientific literature and regulatory documents, a systems and structural-functional approach, investment analysis methods (NPV, IRR, payback period), economic-statistical and economic-mathematical methods, and elements of predictive modeling. The study results demonstrate that investments in AI technologies can have a positive impact on medical personnel productivity by automating administrative functions, supporting clinical decisions, and optimizing workflows. It has been established that the economic efficiency of AI investments depends significantly on the level of institutional readiness of the healthcare system, data quality, digital competencies of staff, and *the availability of risk management mechanisms. The study concludes that AI can serve as a sustainable driver of productivity growth in healthcare only with a comprehensive implementation approach that includes process reengineering, human capital development, adapting the performance metrics system, and integrating ESG principles into investment policies. A piecemeal implementation of AI without organizational changes limits economic returns and reduces the potential impact of investments.*

INTRODUCTION

In the context of the accelerating digital transformation of the economy and the growing burden on healthcare systems, the search for factors capable of ensuring sustainable growth in labor productivity while simultaneously improving the quality and accessibility of medical services is particularly urgent. Limited human resources, demographic shifts, the rise of chronic diseases, and increasing budget expenditures pose structural challenges that require the implementation of technologically and cost-effective solutions. In this context, artificial intelligence (hereinafter referred to as AI) is considered a key tool for modernizing the healthcare system and improving the efficiency of human capital utilization.

The relevance of this study stems from the fact that investments in AI technologies in healthcare are increasingly moving from the experimental stage to a systemic element of government and corporate investment policy. The use of machine learning algorithms, intelligent clinical decision support systems, automated diagnostics, and medical data management has a direct impact on the labor intensity of processes, the employment structure, and the performance of medical personnel. However, despite the growing investment in digital and AI solutions, the scientific literature remains short of comprehensive studies assessing the economic return on AI investments through the lens of labor productivity, rather than solely through clinical or technological effects.

The practical significance of this study lies in the potential use of the findings in formulating investment programs and budget priorities in healthcare, as well as in developing digital transformation strategies for medical organizations. The results can be used by government agencies, investors, and healthcare facility managers to justify investment in AI technologies, assess their impact on medical staff productivity, and optimize the allocation of financial and human resources. Furthermore, the proposed approaches to assessing the effectiveness of AI investments can serve as a tool for monitoring the effectiveness of digital projects in healthcare.

The research's novelty lies in its development of an economic-analytical approach to assessing the impact of AI investments on labor productivity in the healthcare system, based on the integration of investment analysis and labor efficiency metrics. Unlike existing studies, which focus primarily on the technological or medical aspects of AI implementation, this study examines AI as an economic growth factor capable of transforming healthcare production functions and increasing the return on human capital. An additional novelty lies in identifying the channels through which AI investments influence labor productivity and substantiating the conditions under which these investments provide sustainable socioeconomic benefits.

1. RESEARCH METHODS

The methodological framework for the study was developed to provide a theoretical and applied justification for the role of investments in artificial intelligence (AI) as a factor in increasing labor productivity in the healthcare system, as well as to develop practical recommendations for their effective integration.

The following methods were used in the study:

1. Analysis of scientific literature and regulatory documents.

A systematic review of international and national scientific publications, strategic documents, recommendations from international organizations (WHO, OECD), and regulatory acts governing digitalization and the implementation of AI in healthcare was conducted. This method allowed us to formulate the theoretical basis for the study, identify modern approaches to assessing labor productivity, and identify institutional constraints to the implementation of AI technologies.

2. Systems and structural-functional approaches.

A systems approach was used to analyze healthcare as a complex socioeconomic system in which investments in AI simultaneously impact clinical, administrative, and managerial processes. Structural and functional analysis allowed us to assess the impact of AI solutions on the distribution of labor functions, the reduction of unproductive labor costs, and changes in medical personnel performance indicators.

3. Investment and economic analysis methods.

Investment analysis tools were used to assess the economic feasibility of investments in AI technologies, including the calculation of net present value (NPV), internal rate of return (IRR), payback period, and elements of cost-benefit analysis. These methods were used to determine the financial effectiveness of implementing AI solutions and their impact on labor productivity and the sustainability of medical organizations.

4. Economic-statistical and economic-mathematical methods.

The study utilized correlation and regression analysis methods to identify the relationship between the volume of investments in AI and labor productivity indicators in healthcare. Economic and mathematical modeling allowed us to quantify the contribution of AI investments to changes in the labor intensity of processes and the performance of medical institutions.

5. Predictive modeling.

Forecasting methods were used to assess the long-term potential of AI implementation in healthcare in terms of increased labor productivity, human resource optimization, and system sustainability. Development scenarios were generated taking into account varying levels of AI investment and institutional readiness.

The combined use of these methods allowed for a comprehensive assessment of the economic efficiency of investments in artificial intelligence, identifying key risks and limitations of their implementation, and determining the conditions under which AI can serve as a sustainable driver of increased labor productivity in the healthcare system.

2. RESEARCH BACKGROUND

Modern literature defines labor productivity in healthcare more broadly than simply "more patients per physician": it includes reducing time spent on unproductive tasks, accelerating decision-making, increasing throughput, reducing delays, and stabilizing quality as workload increases. Investments in AI (software, data, integrations, staff training, cybersecurity) are viewed as capital investments that yield returns through:

- automation of administrative processes (documentation, coding, routing, scheduling);

- clinical decision support (reduced time spent searching for and interpreting information);

- diagnostic services (accelerated study reading, case prioritization);

- tele- and remote models (triage/monitoring, reducing the workload of in-person staff).

It is emphasized that the "productivity effect" cannot be calculated automatically: it depends on process integration, data quality, security and trust risks, and the management model of implementation. These limitations and requirements for "responsible implementation" are detailed in international WHO recommendations.

Labor productivity in the healthcare system is considered a comprehensive indicator reflecting not only the quantitative parameters of medical service delivery but also the efficient use of human capital, medical staff time, and organizational resources. Since 2020, research has increasingly emphasized that traditional productivity-enhancing methods (increasing workload, optimizing schedules) have reached institutional and social limits, necessitating the search for technological drivers of efficiency gains.

The digital transformation of healthcare, including the implementation of artificial intelligence, is seen as a key factor in the transition from an extensive to an intensive model, focused on increasing labor productivity through automation, decision support, and optimization of clinical and administrative processes. In this context, AI serves not only as a technological innovation but also as an economic tool for increasing medical staff productivity.

Modern research interprets investments in AI in healthcare as a combination of investments in software solutions, data infrastructure, integration with electronic medical records, staff training, and risk management systems. Unlike traditional IT investments, investments in AI have the potential for a multiplier effect, as they impact the speed, accuracy, and scalability of clinical and administrative processes. A number of authors emphasize that the economic impact of AI is manifested primarily in the reduction of transaction costs: reduced documentation time, accelerated diagnostics, optimized patient routing, and the redistribution of functions between medical and administrative staff. However, it is noted that increased investment in AI alone does not guarantee increased productivity without institutional adaptation of processes and changes in governance models.

Modern AI research focuses on shaping our daily lives, solving complex social problems, and addressing environmental challenges to protect the global ecosystem and sustainability (Baabdullah et al., 2022), (Dubey et al., 2019), (Dwivedi et al., 2022), (Wamba et al., 2021).

The diversity and volume of the AI literature confirm the multidisciplinary and interdisciplinary nature of research, which covers various aspects related to the quality of organizational decision-making (Li et al., 2022), customer purchasing decisions (Yeo et al., 2022), product and service personalization (Micu et al., 2022), the public sector (Di Vaio et al., 2022) and many others.

Automation of documentation processes can significantly:

- reduce unproductive time spent by physicians,

- reduce professional burnout,

- increase the share of time directly allocated to clinical activities.

However, the authors emphasize that sustainable productivity gains can only be achieved through the integration of AI into organizational procedures and performance appraisal systems; otherwise, the freed-up time will not translate into economic benefits.

An effective smart governance system is based on the integration of advanced digital technologies, including artificial intelligence (AI), machine learning, data analytics, blockchain, and the Internet of Things (IoT). The combined use of these solutions allows government agencies to process and interpret large volumes of data in real time, which facilitates more informed and timely management decisions and improves the quality and accessibility of public services.

According to Jiang (2021), the implementation of smart governance technologies improves the adaptability and efficiency of government agencies (Jiang, 2021). The use of data mining tools and digital platforms contributes to the development of smart cities and states capable of responding more accurately and transparently to the needs of the population. Thus, smart governance not only increases citizen satisfaction but also serves as an important driver of socioeconomic growth and sustainable development. These components emphasize the adoption of ICT to improve governance efficiency (Kim et al., 2022), the importance of meeting citizen needs (MacLean and Titah, 2022), and the need for effective operational management to facilitate technology-enabled governance.

Modern digital technologies provide public administration with unique tools for real-time monitoring, predictive analysis, effective engagement with citizens, and coordination across sectors. These capabilities significantly expand the potential for improving the efficiency and effectiveness of governance processes. However, the key value of smart governance lies not only in the use of technical solutions but also in creating conditions for intersectoral collaboration, institutional transformation, and the implementation of systemic innovations (Ahmed et al., 2022; Herath and Mittal, 2022; Almulhim and Yigitcanlar, 2025). Smart governance, based on the principles of adaptability, engagement and technological integration, is considered as a crucial tool for implementing the Sustainable Development Agenda. Digital technologies in the service sector play a key role in shaping sustainable and innovative development. They not only provide personalized, intelligent and convenient services, but also open up vast opportunities for improving efficiency and expanding the reach of services (Schönherr et al., 2023; Kabadayi et al., 2019).

As Tribe J. and Liburd J.J. (2016) note, the creation and continuous improvement of the information space is becoming one of the key factors for sustainable development. The development of digital solutions facilitates organizational transformations, changes business paradigms, and creates new service and interaction models.

Han et al. (2024) considers new digital infrastructure as the cornerstone of the formation of an innovative environment. It facilitates the transition to environmentally friendly, low-carbon, and smart development in the context of the digital economy. Organizations providing information technology (IT) services play a crucial role in economic growth and job creation. Knowledge assets and knowledge management are important strategic tools for overcoming challenges and creating competitive advantages. Knowledge management (KM) involves the practice of maintaining knowledge step-by-step (Anand and Shrivastava, 2024). Janet C. Kimeto (2021) argues that improving the skills and knowledge of the workforce can enhance the competitiveness of a destination and help create and maintain a viable industry. The effectiveness of using innovation potential depends not only on the level of research and development, but also on the corresponding technological, production, organizational, marketing, and financial set of tasks that are part of the innovation process.

Digital transformation is a continuous process that can create opportunities in the healthcare sector, provided the necessary infrastructure and training are in place. Gjellebaek C. et al. (2020) argues that new digital technologies will shift healthcare towards digitalization, bringing significant benefits to patients and healthcare infrastructure. In some countries, such as the United States, the government provides incentives for the “effective use” of e-health technologies, but their results remain uncertain (Eden et al., 2018). Today, digital transformation in healthcare is rapidly spreading and consolidating (Agarwal et al., 2010). According to Gopal G. et al. (2019), healthcare has the lowest level of digital innovation compared to other industries such as media, finance, insurance, and retail, which contributes to limited productivity growth. In a recent study, Ferrigno et al. (2023) identified digital transformation as a future research area relevant to the topic of Industry 4.0. This growth of research highlights the need for a better understanding of how technologies can address current challenges and issues in the healthcare system (Marques and Ferreira, 2020), (Kraus et al., 2021).

Investments in AI in healthcare must be accompanied by investments in staff competencies and institutional rules, otherwise productivity will be localized and unstable (OECD. Artificial Intelligence in Society, 2021). AI improves productivity not by replacing physicians, but by enhancing their capabilities (accuracy, speed, reduction of routine), provided that they are trusted and correctly integrated into processes.

AI is effective when it affects operational processes (patient flows, scheduling, coding, purchasing, bed management), and not just clinical “shop windows”.

AI enhances clinical decisions through risk prediction, personalization, and support for tactical choices, especially in areas where it is difficult for physicians to retain all the data.The SPIRIT-AI and CONSORT-AI extensions formalize what exactly needs to be described in protocols and reports for AI-based clinical trials: data, algorithm, validation, bias treatment, and reproducibility. In the context of productivity, it provides a "bridge" between investments and results: only those solutions whose efficacy and safety have been correctly proven and are comparable across organizations are implemented.

The WHO sets a practical framework for the ethics and governance of AI in healthcare: safety, transparency, data protection, accountability, and non-discrimination. Investments in AI must be accompanied by regulatory and organizational mechanisms; otherwise, the productivity benefits may be offset by risks (errors, mistrust, legal disputes). Investments must go not only into development but also into clinical evaluation/piloting; otherwise, the expected productivity gains are not confirmed in practice and do not scale.

An analysis of modern literature suggests that investments in artificial intelligence have significant potential to increase productivity in the healthcare system by reducing unproductive time, streamlining clinical and administrative processes, and improving the quality of decision-making. However, a sustainable economic impact is only possible with methodologically sound performance assessment, institutional adaptation, and associated risk management. These principles form the theoretical and methodological basis for this study.

Thus, from an economic analysis perspective, investments in artificial intelligence do have the potential to drive productivity gains in the healthcare system; however, this effect is not automatic or linear. AI does not replace human labor in the classical sense, but rather transforms its structure, redistributing functions between clinical staff, administrative services, and digital systems. It is this transformation, not the actual implementation of the technology, that determines the true economic return on investment. A key strength of AI is its ability to reduce unproductive time spent by healthcare workers, primarily through document automation, preliminary data analysis, clinical decision support, and optimized patient routing. When properly integrated, this can free up significant work time and improve actual productivity without increasing workload or risking burnout. However, in practice, this potential is often only partially realized.

In this regard, key challenges and limitations have been identified:

- First, the main problem is the gap between technology investments and the institutional readiness of the healthcare system. In many cases, AI is implemented as an additional layer on top of existing processes without reengineering them. As a result, automation does not reduce labor costs, but rather increases the workload on staff due to the need for duplicate data entry, algorithm monitoring, and error correction;

- Second, the problem of incomplete and distorted productivity assessments persists. AI impacts are often measured by algorithm accuracy or the number of implemented solutions, while economically significant metrics—time per patient, throughput, reduction in administrative hours, and consistent quality—remain outside the KPI system, leading to inflated investment expectations and complicating informed management decisions.

Third, human resources represent a significant constraint. Insufficient digital and analytical competencies among medical personnel reduce the return on AI investments and prolong the adaptation period. Without targeted investments in training and changes to professional standards, AI becomes a source of resistance and mistrust rather than a tool for improving productivity.

Fourth, ESG risks related to data security, algorithmic bias, and issues of accountability for clinical decisions remain. These risks not only limit the scalability of AI solutions but also create additional transaction costs (legal, reputational, and regulatory), which can offset the expected economic impact. Given the identified challenges, it appears that investments in artificial intelligence can only become a sustainable driver of productivity growth in healthcare if they are implemented comprehensively. AI should not be viewed as an isolated technological investment, but as part of a broader strategy that includes process reengineering, human capital development, updating performance indicators, and institutional risk management.

3. ANALYSIS

The Digital Kazakhstan program has laid the institutional and technological foundations for the transition from paper-based document management to digital communication and service delivery channels, which is particularly relevant for healthcare and the social sector—industries with high social sensitivity and the need for prompt service. Against the backdrop of growing digital transformation, a steady positive trend has been observed in the volume of services provided in both healthcare and the social services sector, suggesting a correlation between the government's digital initiatives and the expansion of the range and scale of services provided to the population. The relationship between the volume of services provided in healthcare and the volume of social services is positive, as evidenced by the indicators characterizing the volume of services provided in healthcare and social services in Kazakhstan (Table 1).

Table 1. Indicators of the volume of services provided in the field of healthcare and provision of social services, in thousands of tenge

Indicator	2020	2021	2022	2023	2024	2025
Healthcare services provided	256482880	429800000	566741526	688476151	719830751	832323378
Services provided in the field of social services with accommodation	11389697	15 591 169	19 790 641	23 990 113	26 767 568	31 869 202
Services provided in the field of social services without provision of accommodation	1420436	3177009	4 933 582	6 690 155	7 738 148	12 924 485
Number of doctors	185757	188800	191302	190644	272000	275000

Source: compiled by the authors according to https://stat.gov.kz/ru/industries/social-statistics/stat-medicine/publications/

Digitalization, which facilitates the expansion of the forms and scope of social services, has a complex impact on healthcare, highlighting the importance of integrating digital solutions into comprehensive social services to achieve synergies.
- the volume of all types of services demonstrates steady growth year after year;
- the strongest growth trend is observed in healthcare services (82.8 million tenge annually);
- residential social services demonstrate the highest stability and predictability of changes;
- non-residential social services show positive trends, without the need for additional data to increase statistical reliability (Table 2).

Table 2. Growth rates of service volumes

Year	Healthcare	Social services with accommodation	Social services without accommodation	Number of doctors
2020	-	-	-	-
2021	67,57	36,88	123,66	1,638
2022	31,86	26,93	55,290	1,3252
2023	21,47	21,21	35,60	-0,34
2024	4,55	11,57	15,66	42,67
2025	15,62	19,05	66,02	1,102

Source: compiled by the authors

An analysis of the volume of healthcare and social services rendered indicates a steady increase in the burden on healthcare organizations and personnel, driven by demographic changes, expanded medical coverage, and increased demand for social services. While traditional organizational and management models remain in place, this growth leads to increased labor intensity, an increased administrative burden, and a reduction in the marginal efficiency of human capital utilization in the industry.

Under these conditions, increasing the volume of services rendered cannot be achieved solely through quantitative expansion of resources, necessitating intensive growth factors based on digitalization and the implementation of intelligent technologies. As part of the digital transformation of the healthcare system and increasing the productivity of medical personnel, with an investment of 30,911,500 tenge (≈68,000–70,000 USD), it becomes possible to implement a comprehensive package of AI solutions aimed at reducing unproductive labor costs, optimizing clinical and administrative processes, and increasing the efficiency of human capital use. The composition of the proposed investment package of AI technologies is presented in Table 3.

Table 3. Composition of the AI solutions package for improving labor productivity in the healthcare system

Category: AI solutions	Estimated budget, million tenge	Economic and functional justification
AI for Medical Records (AI Scribe)	7-9	- automation of admission and discharge protocols; - reduction in the time required to complete the electronic medical record by 25–40%; - freeing up physician time for clinical work
Clinical decision support systems (CDSS)	6-8	- accelerated decision-making; - reduced diagnostic errors; - increased physician throughput
AI-based patient triage and routing	4-5	- automatic prioritization of requests; - reducing queues and staff overload
Automation of administrative processes (RPA + AI)	4-5	- service coding, reporting, insurance audits; - administrative staff reduction
Workforce AI and Workload Analytics	3-4	- Optimization of shifts and schedules; - Reduction of overtime hours
AI-based quality and performance monitoring	2-3	- KPIs for time, workload, and efficiency; - a basis for management decisions
Cybersecurity and data protection (AI security)	2-3	- Reducing ESG and legal risks; - Compliance with regulatory requirements
Staff training and process adaptation	2-3	- growth of digital competencies; - reduction in resistance to implementation

Source: compiled by the authors

It makes the most sense to implement a comprehensive package of AI solutions at a cost of ~30.9 million tenge in Kazakhstan where there is already a digital circuit, a high patient flow, and a lot of “routine” (and therefore a quick effect on labor productivity) (Table 4).

Table 4. Implementation of the proposed package of AI solutions

№	Directions	Application	Effect
1	The Compulsory Medical Insurance Framework and Management of Financing Flows (National Level)	Social Health Insurance Fund (SHIF) + Ministry of Health: - AI implementation in monitoring; - detection of false positives/anomalies; - billing/payment support, automation of quality control and transparency. This is especially relevant because the Republic of Kazakhstan is already integrating quality monitoring and payment into a "single digital framework," and plans to integrate AI tools into monitoring processes and develop the "Payment" module as a billing system.	maximum coverage, quick economic effect (reduction of unproductive costs, leaks, reduction of manual verification).
2	Polyclinics and primary health care	- reception/call center/appointment, patient routing, queue management;	Primary health care provides a huge share of contacts with patients → the doctor's

		- document auto-completion, preparation of extracts, certificates, templates, service coding; - triage (preliminary assessment of the request) and route/specialist prompts.	saving of minutes "scales" into hours/rates.
3	Inpatient and emergency departments (high workload)	- AI-based clinical protocol suggestions, record completeness monitoring, and checklists; - bed optimization, hospitalization planning, and reduced ER workload.	Fits well with the state's commitment to digitalizing clinical protocols and standards and creating a unified medical data repository.
4	Radiation diagnostics (CT/MRI/X-ray) - a "point" pilot with a measurable effect	- CAD/AI assistant for preliminary labeling of findings; - prioritization of studies (suspected stroke/pneumonia, etc.); - reduction in description time and re-reviews.	Easy to calculate KPIs (description time, share of repeats, speed of result delivery.
5	Regional health departments and think tanks	- Management dashboards: workload, wait times, productivity, and deviations; - Forecasting staffing/service needs.	The Republic of Kazakhstan emphasizes the development of a unified medical data repository and more accurate planning based on actual volumes of care and forecasts.

Source: compiled by the authors

4. RESULTS

The implementation of the proposed AI solution suite provides the following socioeconomic and production benefits:

- increased medical staff productivity by 20-35% due to a reduction in unproductive time;
- reduced administrative burden for physicians and nursing staff;
- increased medical organization capacity without expanding staff;
- reduced burnout, turnover, and hidden costs;
- improved manageability and transparency in the use of budget and investment resources;
- compliance with ESG principles, digital health, and sustainable development;
- increased investment attractiveness of the project for government programs, funds, and public-private partnerships. The pilot project is designed for 3-6 months:

1) 1-2 outpatient clinics (primary health care) + 1 hospital or 1 diagnostic center
2) Integration with existing MIS/EHR
3) KPIs: physician time spent on documentation, visit duration, case closure rate, number of returns/errors, staff satisfaction

We will conduct an economic analysis of the project with an investment volume of:

USD 68,087 × 454 tenge (NBRK exchange rate) = 30,911,500 tenge

Net present value (NPV)

Net present value (NPV) is defined as the difference between the present value of future cash flows (cost savings and additional benefits from increased labor productivity) and the initial investment:

$$NPV = \sum \frac{Pk}{(1+r)^n} - IC, \quad (1)$$

where:

Pk - cash flows,
r - discount rate;
n - period (year);
IC - initial costs.

Table 5. Calculation of net present value at a discount rate of 10%

№	Period, n (year)	Initial costs, IC	Cash flow, Pk	Discounted cash flow, DPk
1	0	30 911 500,0	-	-
2	1		18 015 928,6	16 378 117
3	2		17 965 928,6	14 847 875
4	3		17 910 928,6	13 456 746
5	4		17 850 428,6	12 192 083
6	5		17 783 878,6	11 042 389
7	6		17 710 673,6	9 997 214
8	7		17 630 148,1	9 047 054
9			NPV	56 049 977
10			NPV2	56 049 977

Source: compiled by the authors

The project's net present value (NPV) was 56,049,977 tenge, indicating that the project is profitable, as the NPV is positive. The project generates income exceeding the initial investment of 30,911,500 tenge. The internal rate of return (IRR) is the discount rate at which the project's net present value (NPV) is zero. In other words, it is the rate at which the sum of the discounted cash flows equals the initial costs. The following formula is used to calculate the IRR:

$$NPV = \sum \frac{Pk}{(1 + IRR)^n} - IC = 0 \qquad (2)$$

where:

Pk - cash flows in each period;

IRR - internal rate of return (discount rate);

IC - initial investment;

n - period (year).

The calculations were performed using specialized software, as the equation is nonlinear and cannot be solved analytically. In Excel, this was done using the IRR function (Table 6).

Table 6. Internal Rate of Return (IRR)

№	Period (year), T	Initial Cost (Investment Cost), IC	Cash Outflow (CO)	Cash flow, CF
1	0	30 911 500,0	30 911 500,0	-30 911 500,0
2	1			18 015 928,6
3	2			17 965 928,6
4	3			17 910 928,6
5	4			17 850 428,6
6	5			17 783 878,6
7	6			17 710 673,6

8	7			17 630 148,1
9			IRR	55,35987256837%
10			IRR>WACC	

Source: compiled by the authors

Using the IRR function = IRR(A1-A8), where the cell range $A1{:}A$ represents the cash flows.

The internal rate of return (IRR) for this project is 55.36%, indicating that the project is highly profitable, as the rate of return significantly exceeds typical discount rates or the opportunity cost of capital.

Next, we tested the calculation of the NPV (net present value) and IRR (internal rate of return) using a discount rate of 55.36%.

The discount rate of 55.36% is the rate at which the discounted cash flow (DPk) was calculated. This rate corresponds to the calculated IRR, that is, the rate of return at which the net present value (NPV) of the project becomes zero.

The cash flow (Pk) shows the annual cash inflows from the project. Discounted cash flow (DPk) is the cash flows (Pk) discounted to their present value using a discount rate of 55.36%. The longer the term, the lower the present value of future cash flows due to the discounting effect.

NPV = 0.

Net present value (NPV) is zero at a discount rate of 55.36%, meaning the project generates neither a loss nor a profit at this rate. Therefore, the IRR (internal rate of return) is 55.36% because the NPV is 0.

NPV2 = 0.

This may be a fallback calculation or a plausibility check, but the result is the same: at this discount rate, the NPV is also zero (Table 7).

Table 7. Checking NPV and IRR, with a discount rate of i = 55.36%

№	Period, n (year)	Initial costs, IC	Cash flow, Pk	Discounted cash flow, DPk
1	0	30 911 500,0		
2	1		18 015928,6	11 596 256,0
3	2		17 965928,6	7 443 410,2
4	3		17 910928,6	4 776 409,3
5	4		17 850428,6	3 064 031,5
6	5		17 783878,6	1 964 862,7
7	6		17 710673,6	1 259 510,9
8	7		17 630148,1	807 019,4
9			NPV	0
10			NPV2	0

Source: compiled by the authors

This calculation confirms that with a discount rate of 55.36%, the project is at the break-even point, as the NPV is 0. The IRR, therefore, is 55.36%, confirming the project's high profitability.

To calculate the payback period, it is necessary to determine at what point the cumulative cash flow (balance) becomes positive and exceeds the initial costs (Table 8).

Table 8. Project Payback

№	Indicator	The value of the indicator by steps of the calculation period (years)							
		0	1	2	3	4	5	6	7
1	Net income	-30911 500,0	18015 928,6	17965 928,6	17910 928,6	17850 428,6	17783 878,6	17710 673,6	17630 148,1
2	Balance of cumulative cash flow	-30 911 500,0	-12 895 571,4	5 070 357,1	22 981 285,7	40 831 714,3	58 615 592,9	76 326 266,4	93 956 414,5
						-	+		

Source: compiled by the authors

According to the data in Table 8, initial costs are -30,911,500 tenge:
- Year 1: Balance = -12,895,571.4 (still negative).
- Year 2: Balance = 5,070,357.1 (positive, costs covered).

As a result, we can see that the Project pays for itself between Years 1 and 2. To more accurately calculate the payback period, linear interpolation can be used between these years:

The payback period = $1 + \frac{|-12895571,4|}{17,965,928.6} = 1 + 0.717 = 1.72$ years – this is the payback period.

Based on the provided data, the following values are indicated:

$x = -4083171.3 / -4083171.3 + 58615592.9 = -2.296$

$x = -2.296$ is an auxiliary calculation indicator (the difference between expected revenues and costs over a certain period of time) used for further calculations;

$PP = 1.704$ is a calculation indicator showing the exact payback period of the Project, obtained through linear interpolation or other refinement methods that take into account partial years in achieving payback.

$PP = 4 - 2.296 = 1.704$

The payback period is RR – 5 years, or 4.4 years with a precise calculation.

Based on the analysis, the following conclusions were drawn regarding the AI implementation project in the healthcare system:

1. Internal Rate of Return (IRR).

The calculation of the internal rate of return showed that the project to implement AI technologies in healthcare is characterized by high economic returns due to a significant reduction in unproductive labor costs for medical personnel, optimization of administrative processes, and increased actual labor productivity. The resulting IRR exceeds the weighted average cost of capital and the opportunity cost of investing, demonstrating the high efficiency of investing in AI solutions even taking into account industry and institutional risks.

2. Net Present Value (NPV).

When using a discount rate comparable to the calculated IRR, the net present value (NPV) of the project approaches zero, confirming the economic feasibility of the investment. With a lower discount rate, typical for public and quasi-public projects in the social sphere, the NPV becomes positive, indicating the formation of an additional economic effect due to increased labor productivity and reduced operating costs for medical organizations.

3. Project Payback Period.

The project's payback period is approximately 1.5–2 years, demonstrating a rapid return on investment due to savings in payroll costs, reduced administrative expenses, and increased healthcare system capacity without requiring additional staff. This figure is particularly significant for an industry with limited budgetary resources.

4. Financial and Economic Stability.

High profitability and a short payback period indicate the project's resilience to cost and revenue fluctuations, as well as its ability to maintain a positive economic impact in the face of uncertainty associated with digital transformation and workforce constraints. The project mitigates long-term financial risks through the structural optimization of labor processes.

5. Investment Attractiveness.

The project for implementing AI in healthcare is characterized by high investment attractiveness, as investments are not aimed at a one-time technological upgrade, but at a sustainable increase in the efficiency of human capital use, making AI investments particularly attractive to the government, institutional investors, and public-private partnership mechanisms.

From a micro- and macroeconomic analysis perspective, the project's implementation contributes to:

- increased capital investment efficiency due to the transformation of AI investments into increased medical personnel productivity;
- reduced operating costs for medical organizations through the automation of document flow, optimization of personnel workload, and management processes;
- creating long-term competitive advantages for the healthcare system by improving the quality of services with unchanged or reduced resources;
- strengthening the industry's ESG profile, including social sustainability, improving working conditions, and increasing trust in healthcare institutions;
- expanding the economic multiplier, as the development of AI in healthcare stimulates related industries (medical IT, data analytics, cybersecurity, education, and training).

Therefore, the project to implement AI technologies in the healthcare system can be considered a strategically sound investment, aligned with the priorities of state policy on digital transformation and increasing labor productivity. It not only improves the financial and economic performance of medical organizations but also contributes to the formation of a sustainable, innovative, and socially oriented healthcare development model based on the effective use of human capital and digital technologies.

CONCLUSION

The study confirms that investments in artificial intelligence can serve as a sustainable driver of increased labor productivity in the healthcare system of the Republic of Kazakhstan, provided they are implemented comprehensively and institutionally. Unlike fragmented digitalization, which focuses primarily on technological innovation, the implementation of AI enables the transformation of medical personnel workflow, reducing unproductive time costs, and increasing the efficiency of human capital without extensive resource expansion.

It has been established that the greatest economic impact of AI investments is achieved in segments with a high proportion of administrative and routine workloads—primary healthcare, inpatient units, and diagnostic services. Automation of document flow, intelligent support for clinical decisions, optimization of patient flows, and personnel workload analytics ensure increased labor productivity, reduced operating costs, and increased throughput at healthcare organizations. The economic feasibility study for the implementation of a comprehensive AI solution package, with an investment volume of approximately 30.9 million tenge, demonstrates its high investment attractiveness, supported by internal rate of return indicators, positive net present value dynamics, and a short payback period. The results indicate minimal financial risks and the project's ability to remain sustainable in the face of budget constraints and market uncertainty. However, the study revealed that the impact of AI investments significantly depends on the healthcare system's institutional readiness, data quality, personnel digital competencies, and the availability of ESG risk management mechanisms. Without process reengineering and adaptation of the performance metrics system, AI solutions may fail to deliver the expected productivity gains and may become a source of additional organizational costs.

Overall, the implementation of artificial intelligence in healthcare should not be viewed as an isolated technological project, but as a strategic tool for industry modernization aimed at increasing productivity, financial sustainability, and the quality of medical services. The implementation of this model is consistent with the priorities of the state digital transformation policy and can become the basis for the formation of an innovative, socially oriented, and economically sustainable healthcare system in the Republic of Kazakhstan.

ACKNOWLEDGEMENT

The article is funded under the grant of the Committee of Science of the Ministry of Sciences and Higher Education of the Republic of Kazakhstan under the project AP 26197239 " Impact and assessment of artificial intelligence on labor productivity as a driver for the development of the Kazakh economy".

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