APPLICATION OF OPEN-SOURCE ARTIFICIAL INTELLIGENCE TECHNOLOGIES AND THEIR ECONOMIC EFFICIENCY

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Abstract: *The rapid development of artificial intelligence has transformed the structure of the digital economy, corporate management, public services, education, finance, logistics and industrial production. In this context, open-source artificial intelligence technologies are becoming an important factor in reducing technological dependence, lowering implementation costs, expanding innovation capacity and increasing the economic efficiency of organizations. The purpose of this article is to analyze the application areas of open-source AI technologies and assess their economic efficiency from the perspectives of cost optimization, productivity growth, innovation acceleration and technological sovereignty. The study uses comparative analysis, systematization, cost-benefit logic and conceptual modeling. The results show that open-source AI creates economic value through five major mechanisms: reduction of licensing costs, acceleration of software development, customization of AI models for local business needs, localization of digital solutions and expansion of knowledge-sharing ecosystems. At the same time, the effectiveness of open-source AI depends on data quality, cybersecurity, human capital, governance mechanisms and the ability of organizations to integrate AI into real business processes. The article concludes that open-source AI should not be viewed only as a cheap alternative to proprietary systems, but as a strategic technological platform for sustainable digital transformation and inclusive economic development.*

Keywords: *open-source artificial intelligence; economic efficiency; digital transformation; productivity; innovation; AI governance; technological sovereignty; cost optimization.*

Аннотация: *Быстрое развитие искусственного интеллекта трансформирует цифровую экономику, корпоративное управление, государственные услуги, образование, финансы, логистику и промышленное производство. В этих условиях технологии искусственного интеллекта с открытым исходным кодом становятся важным фактором снижения технологической зависимости, уменьшения затрат на внедрение, расширения инновационного потенциала и повышения экономической эффективности организаций. Цель статьи заключается в анализе направлений применения открытых AI-технологий и оценке их экономической эффективности с точки зрения оптимизации затрат, роста производительности, ускорения инноваций и укрепления технологического суверенитета. В статье использованы сравнительный анализ, систематизация, логика «затраты–выгоды» и концептуальное моделирование. Исследование показывает, что открытый искусственный интеллект формирует экономическую ценность через пять*

ключевых механизмов: снижение лицензионных расходов, ускорение разработки программных решений, адаптацию AI-моделей к локальным бизнес-потребностям, локализацию цифровых решений и развитие экосистем обмена знаниями. Вместе с тем эффективность открытых AI-технологий зависит от качества данных, кибербезопасности, человеческого капитала, механизмов управления и способности организаций интегрировать AI в реальные бизнес-процессы. Сделан вывод, что открытый искусственный интеллект следует рассматривать не только как дешевую альтернативу закрытым системам, а как стратегическую технологическую платформу устойчивой цифровой трансформации и инклюзивного экономического развития.

Ключевые слова: *искусственный интеллект с открытым исходным кодом; экономическая эффективность; цифровая трансформация; производительность; инновации; управление AI; технологический суверенитет; оптимизация затрат.*

1. Introduction

Artificial intelligence has become one of the most influential technological drivers of the modern economy. It is increasingly used in business analytics, customer service, public administration, logistics, education, healthcare, banking, marketing, software engineering and industrial management. The economic importance of AI is reflected not only in the growth of corporate investment, but also in the increasing integration of AI tools into everyday organizational processes. Stanford HAI reports that AI adoption in organizations rose from 55 percent in 2023 to 78 percent in 2024, while corporate AI investment reached USD 252.3 billion in 2024 (Stanford HAI, 2025).

However, the adoption of AI is accompanied by several challenges: high licensing costs, dependence on proprietary platforms, limited transparency, shortage of qualified specialists, cybersecurity risks and difficulties in adapting models to local economic and linguistic contexts. In this environment, open-source artificial intelligence technologies are gaining special importance because they provide an alternative model of technological development based on openness, collaboration, reuse and customization.

According to the Open Source Initiative, an open-source AI system should provide users with the freedoms to use, study, modify and share the system. This definition is significant because it distinguishes truly open AI from merely “available” or “open-weight” models. Open-source AI therefore represents not only a technical approach, but also an economic and institutional model of innovation (Open Source Initiative, 2024).

The relevance of this research is determined by the need to evaluate open-source AI from the perspective of economic efficiency. For developing economies and organizations seeking digital modernization, open-source AI may provide an opportunity to reduce costs, develop local digital capacity, support small and medium-sized enterprises and strengthen technological sovereignty. Therefore, the article addresses the following research question: through which mechanisms do open-source AI technologies increase the economic efficiency of organizations and economic systems?

2. Literature Review and Conceptual Framework

The economic importance of open-source technologies has been widely discussed in the literature on digital public goods, software ecosystems, innovation networks and platform economics. Open-source software is usually understood as a global technological resource because it allows firms, governments, developers and researchers to use and modify existing technological solutions without building everything from the beginning.

A Harvard Business School working paper by Hoffmann, Nagle and Zhou estimates that the demand-side value of widely used open-source software is approximately USD 8.8 trillion, while firms would need to spend 3.5 times more on software if open-source software did not exist (Hoffmann, Nagle, & Zhou, 2024). This finding is important for understanding the potential economic role of open-source AI, because many AI frameworks, model repositories, deployment libraries and data tools are built on open-source foundations.

Open-source AI differs from traditional open-source software in several ways. First, AI systems depend not only on code, but also on training data, model weights, evaluation methods, compute infrastructure and governance rules. Second, the economic efficiency of AI is not limited to software cost reduction; it also includes productivity growth, automation of routine cognitive processes, better decision-making and the creation of new products. Third, open-source AI depends on a dynamic ecosystem of developers, researchers, universities, start-ups and cloud infrastructure providers.

McKinsey Global Institute estimates that generative AI could add USD 2.6 trillion to USD 4.4 trillion annually across analyzed use cases, especially in customer operations, marketing and sales, software engineering and research and development (McKinsey Global Institute, 2023). This suggests that AI's economic value is concentrated in activities where knowledge processing, content generation, communication, programming and decision support are central.

The open AI ecosystem is also expanding quickly. Hugging Face reports that its platform hosts more than 2 million public models and over 500,000 public datasets, illustrating the scale of collaborative AI development (Hugging Face, 2026). The World Bank's Digital Progress and Trends Report 2025 emphasizes that AI adoption requires four foundational conditions: connectivity, compute, context and competency. These foundations are particularly important for developing economies that want to adopt and adapt AI responsibly (World Bank, 2025).

Based on this literature, the conceptual framework of the article interprets open-source AI as a multidimensional economic resource. It is simultaneously a cost-reduction instrument, a productivity-enhancing tool, an innovation platform, a localization mechanism and a basis for technological sovereignty.

Table 1. Conceptual features of open-source AI as an economic resource

Feature	Meaning	Economic implication
Openness	Availability of code, model components, documentation or reusable tools	Reduces barriers to entry and supports technological learning
Modifiability	Possibility to adapt models and software to specific needs	Enables localization and sector-specific efficiency
Community development	Collaborative improvement by developers and researchers	Accelerates innovation and reduces duplication of effort
Transparency	Greater opportunity to inspect logic, dependencies and limitations	Improves trust, auditability and governance
Reusability	Existing models and libraries can be integrated into new products	Shortens product development cycles and lowers R&D costs

3. Research Methodology

This article uses a qualitative and analytical research design. The methodological basis includes comparative analysis, systematization of academic and analytical sources, cost-benefit logic and conceptual modeling. The study compares open-source AI technologies with proprietary AI solutions according to several criteria: implementation cost, flexibility, transparency, security, scalability, localization potential and long-term economic impact.

The research does not present a narrow statistical experiment. Instead, it develops an applied conceptual model that can be used by organizations to evaluate whether open-source AI is economically rational for a specific business function. This approach is appropriate because the economic efficiency of AI depends not only on direct financial costs, but also on organizational capacity, data readiness, managerial maturity and risk governance.

The economic efficiency of open-source AI is assessed through six key indicators: total cost of ownership, return on investment, productivity effect, innovation effect, localization effect and risk-adjusted efficiency. These indicators make it possible to evaluate open-source AI not as a “free” technology, but as an integrated economic system requiring infrastructure, skilled personnel, data management and institutional control.

Table 2. Indicators for assessing the economic efficiency of open-source AI

Indicator	Explanation	Measurement logic
Total cost of ownership	Overall cost of implementation and maintenance	Software, infrastructure, staff, training, cybersecurity and governance costs

Indicator	Explanation	Measurement logic
Return on investment	Financial return from AI implementation	Savings plus additional revenue divided by AI-related investment
Productivity effect	Time saved through automation and decision support	Hours saved, tasks automated and process speed
Innovation effect	Acceleration of product, service or process development	Shorter development cycle, faster testing and prototype creation
Localization effect	Adaptation to local language, law, sectoral data and business needs	Model accuracy, user satisfaction and relevance of outputs
Risk-adjusted efficiency	Economic benefit after considering operational and legal risks	Benefit minus cybersecurity, compliance, quality and governance risks

4. Application Areas of Open-Source AI Technologies

Open-source AI technologies can be applied in many sectors of the economy. Their most important advantage is flexibility: organizations can modify models, integrate them into internal systems, fine-tune them using sector-specific data and deploy them on private infrastructure. This makes open-source AI especially useful in sectors where data sensitivity, linguistic specificity or regulatory requirements limit the use of external proprietary platforms.

Open-source AI can automate document processing, report generation, customer inquiries, internal knowledge search and routine analytical tasks. For example, companies can use open-source language models for drafting contracts, summarizing internal documents, preparing reports or assisting employees in knowledge management. The economic effect appears in the reduction of time spent on repetitive work. Instead of replacing employees mechanically, open-source AI can increase the productivity of existing staff by allowing them to focus on analytical, creative and managerial tasks.

AI coding assistants based on open-source models can support code generation, bug detection, documentation, testing and software modernization. This is economically important because software development is one of the most expensive parts of digital transformation. Open-source AI tools allow companies to reduce dependence on expensive closed platforms and customize coding assistants for internal programming standards, cybersecurity rules and documentation requirements.

In education, open-source AI can be used for adaptive learning systems, automated feedback, translation, tutoring and creation of digital educational content. For universities and training centers, open-source AI is especially valuable because it can be adapted to local curricula and languages. Open educational AI systems may also support lifelong

learning, reskilling and professional development, which are important components of digital transformation.

Governments can use open-source AI for citizen service chatbots, digital document classification, public policy analysis, procurement monitoring and administrative decision support. The key advantage is that public institutions can maintain greater control over data and algorithms. Nevertheless, the use of AI in public administration requires strong governance. Transparency, accountability, data protection and human oversight must be built into the implementation process.

In the financial sector, open-source AI can be used for fraud detection, customer segmentation, credit scoring support, anti-money laundering analytics, risk forecasting and automated reporting. Economic efficiency emerges from faster decision-making, reduced operational risk and improved customer service. Since finance is a high-risk sector, open-source AI must be implemented with strict model validation, auditability, cybersecurity controls and compliance with national regulations.

Table 3. Application areas and expected economic effects of open-source AI

Sector	Typical use cases	Expected economic effect
Corporate management	Document automation, internal analytics, knowledge management	Lower administrative costs and faster management decisions
Software development	Code generation, testing, documentation, debugging	Shorter development cycles and lower programming costs
Education	Adaptive learning, translation, digital tutors, automated feedback	Personalized learning and broader access to digital education
Public administration	Citizen services, policy analysis, classification of documents	Higher service efficiency and improved institutional transparency
Finance and banking	Fraud detection, risk scoring, customer support, reporting	Lower operational risk and faster financial analysis
Manufacturing and logistics	Demand forecasting, predictive maintenance, route optimization	Reduced downtime, optimized resources and improved planning
Small and medium-sized enterprises	Marketing automation, accounting support, customer analytics	Affordable digital tools and improved competitiveness

5. Comparative Analysis: Open-Source AI and Proprietary AI

Open-source AI is often presented as a low-cost alternative to proprietary AI. This interpretation is only partly correct. The main advantage of open-source AI is not simply that it may reduce licensing costs. Its deeper advantage is that it gives organizations more

control over technological architecture, data flows, adaptation processes and long-term innovation trajectories. Proprietary AI, in contrast, may provide easier access, stronger vendor support and faster initial deployment, but it can also create dependence on external platforms and limit customization.

The economically rational choice between open-source and proprietary AI depends on the use case. If the organization needs a standard solution with minimal technical complexity, proprietary AI may be more convenient. If the organization needs local deployment, specific data control, sectoral customization or long-term technological independence, open-source AI may be more efficient. Therefore, the decision should be based on total cost of ownership, risk profile and strategic relevance.

Table 4. Comparative economic characteristics of open-source and proprietary AI

Criterion	Open-source AI	Proprietary AI	Economic interpretation
Initial cost	Usually lower software licensing cost	Often higher licensing or subscription cost	Open-source AI may reduce entry barriers
Customization	High; models and tools can be modified	Limited or vendor-dependent	Open-source AI is better for local adaptation
Transparency	Higher if code, model information and documentation are available	Usually limited	Transparency supports trust and auditability
Vendor dependence	Lower, especially with local deployment	Higher due to platform lock-in	Open-source AI strengthens strategic autonomy
Technical complexity	Requires internal expertise and infrastructure planning	Often easier to start	Open-source AI needs qualified specialists
Security control	Can be internally audited and isolated	Depends on vendor policies and contracts	Open-source AI may improve control but requires responsibility
Scalability	Depends on internal or cloud infrastructure	Often supported by vendor ecosystem	Proprietary AI may be easier for rapid scaling
Long-term efficiency	High if organizational capacity exists	High if vendor solution fits needs	Choice depends on competence, risks and strategic goals

6. Economic Efficiency Mechanisms of Open-Source AI

The economic efficiency of open-source AI can be explained through several interconnected mechanisms. These mechanisms should be understood as complementary rather than isolated. Cost reduction is important, but it becomes economically meaningful only when combined with productivity gains, innovation acceleration, localization and better governance.

One of the most visible advantages of open-source AI is the reduction of direct software costs. Proprietary AI systems often require monthly subscriptions, API payments or enterprise licenses. Open-source models may reduce these costs, especially when deployed on internal infrastructure. However, "free access" does not mean "zero cost." Organizations still need to pay for servers, cloud infrastructure, cybersecurity, data preparation, model fine-tuning, monitoring and specialists. Therefore, the correct indicator is not licensing cost alone, but total cost of ownership.

Open-source AI allows companies to build on existing models and tools. Instead of developing AI systems from the beginning, organizations can fine-tune available models, adapt them to specific tasks and integrate them into business processes. This accelerates innovation because developers can test hypotheses faster, create prototypes more cheaply and shorten the time from idea to implementation.

AI can reduce the time required for document analysis, customer communication, code writing, reporting, translation and knowledge search. McKinsey's analysis of generative AI emphasizes large potential value in knowledge-intensive functions such as software engineering, customer operations, marketing and sales, and research and development (McKinsey Global Institute, 2023). For open-source AI, productivity growth is especially important because models can be adapted to internal terminology, local documents and sector-specific workflows.

For many countries, including Uzbekistan, one of the most important advantages of open-source AI is localization. Closed AI systems may not fully reflect local languages, legal concepts, institutional terminology or sectoral realities. Open-source AI can be fine-tuned using Uzbek, Russian, English and sector-specific datasets. This increases practical usefulness in education, public administration, banking, agriculture, logistics and small business support.

Open-source AI contributes to technological sovereignty because organizations and states can reduce dependence on a limited number of foreign vendors. Technological sovereignty does not mean isolation from global innovation. It means the ability to understand, adapt, control and govern critical technologies according to national and organizational priorities. This aspect is particularly relevant for public institutions and strategic sectors of the economy.

Discussion

The analysis shows that open-source AI has a dual economic nature. On the one hand, it is a cost-saving instrument because it reduces dependency on expensive proprietary systems. On the other hand, it is an innovation platform because it allows organizations to

build new products, services and business processes. This duality explains why open-source AI should not be treated merely as a technical resource. It should be integrated into the broader system of strategic management, human capital development and digital transformation.

The economic logic of open-source AI is especially strong for developing economies. First, it lowers the entry barrier for small and medium-sized enterprises. Second, it helps universities and research centers access advanced technologies. Third, it allows public institutions to develop AI systems that correspond to local language, law and administrative practice. Fourth, it supports the emergence of local AI ecosystems. These advantages are consistent with the World Bank's emphasis on connectivity, compute, context and competency as the foundations of effective AI ecosystems.

At the same time, open-source AI should not be idealized. If organizations adopt open-source AI without data governance, cybersecurity, staff training and clear business goals, the expected economic effect may not appear. McKinsey's 2025 global survey shows that 88 percent of organizations regularly use AI in at least one business function, but many remain in experimentation or pilot stages, with only about one-third reporting that they have begun to scale AI programs (McKinsey & Company, 2025). This means that the central problem is not only access to AI technology, but the ability to transform organizational processes.

Therefore, the application of open-source AI requires a balanced implementation strategy. Organizations should begin with narrow, measurable use cases; calculate total cost of ownership; define success indicators; prepare data; train employees; and establish governance mechanisms. Only after successful pilot projects should open-source AI be scaled across departments or sectors.

Conclusion: Open-source artificial intelligence technologies are becoming a strategic factor of economic efficiency in the digital economy. They reduce licensing costs, accelerate innovation, increase productivity, support localization and strengthen technological sovereignty. Their role is especially important for organizations and countries that seek affordable and adaptable digital transformation.

The study concludes that open-source AI should be evaluated not merely as a low-cost substitute for proprietary systems, but as a complex technological and economic ecosystem. Its effectiveness depends on the quality of data, availability of skilled specialists, cybersecurity, governance mechanisms and integration into real business processes. Without these conditions, open-source AI may remain a technical experiment rather than a source of measurable economic value.

For enterprises, open-source AI can improve operational efficiency, reduce dependence on vendors and accelerate product development. For public administration, it can support transparent and locally adapted digital services. For education and research, it can expand access to modern AI tools and strengthen human capital. At the same time, successful implementation requires a balanced approach: organizations must calculate total cost of ownership, assess risks, develop internal expertise and establish AI governance

frameworks. Only under these conditions can open-source AI become a source of sustainable economic growth, innovation and inclusive digital development.

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