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Effectiveness of Internet of Things migration into hybrid economic projects

Abstract. The study aimed to scientifically substantiate the economic feasibility of migrating hybrid economic projects to Internet of Things technology solutions and to identify the conditions under which such migration would deliver sustainable economic benefits. The methodological framework included comparative economic, structural-dynamic and scenario analysis, sensitivity assessment and financial modelling based on the calculation of net present value, return on investment, total cost of ownership and integral economic efficiency indicator. The empirical base covered data from Azerbaijan's logistics, agricultural and industrial segments for 2021-2025. The results showed that digitalisation provides economic benefits and stabilises revenue streams in all sectors studied. In logistics, the introduction of Internet of Things technologies reduces operational delays by 43% and transaction costs by 17%, resulting in a significant increase in profitability. In the agricultural sector, the use of sensor systems reduces operating costs by 18.8% and risk costs by 17.4%, reducing the total cost of ownership by 12.7%. In the industry, modernisation increases average annual revenues to 162,000 manats while reducing total costs to 298,000 manats, generating maximum net present value in an optimistic scenario. The integrated economic efficiency model revealed cross-sector differences: logistics demonstrates the most stable results, while industry has the greatest potential but remains sensitive to the cost of capital and the level of digital risks. The results confirm that the economic efficiency of digital migration is achieved by reducing operating costs, mitigating risks, increasing benefits, and complying with the architectural compatibility requirements of digital systems. The practical significance of the study is determined by the fact that the identified dependencies make it possible to develop economically sound scenarios for the implementation

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of Internet of Things in key sectors of Azerbaijan and to more accurately predict the expected effects at different cost levels and technological conditions

Keywords: digitalisation; operating costs; energy efficiency; discount rate; digital risks; sensitivity analysis

INTRODUCTION

The research relevancy is determined by the fact that in 2021-2025 the digital transformation of the economies of the South Caucasus countries, and above all Azerbaijan, entered a phase of intensive implementation of Internet of Things (IoT) technologies, which have become one of the key factors in restructuring the cost structure, increasing the efficiency of resource use and forming sustainable economic trajectories. In the context of rising energy prices, logistical volatility, climate fluctuations and the increasing complexity of industry chains, there has been a sharp increase in the need for quantitative assessment of the economic performance of IoT for heterogeneous (hybrid) projects. Azerbaijan faces several systemic economic challenges, including the high sensitivity of the agricultural sector to risks, increased logistics costs, and the need to modernise industry, which makes the analysis of the economic effects of IoT relevant for the development of rational investment decisions.

The regional context of the problem can be traced in the works of Azerbaijani researchers, demonstrating how IoT affects the economic mechanisms of urban, agricultural, and infrastructure systems. A study by A. Valiyev *et al.* (2022), based on urban projects in Azerbaijan, notes that the introduction of IoT platforms was a response to the problem of increasing operating costs and inefficient distribution of urban resources. The study demonstrated that digital services have stabilised infrastructure dynamics and contributed to cost reduction, which is crucial for an economy based on transport and energy hubs. Similar conclusions are presented in the work of A. Huseynova & O. Mazanova (2023), where the expansion of digital services is viewed as a factor shaping the economic adaptability of cities and gradually reducing the burden on municipal budgets.

The technical and resource aspects of digitalisation that have direct economic significance were revealed in a study by R. Imamguluyev *et al.* (2024). The study demonstrated that the transition to edge architectures has changed the nature of IoT systems: reducing data processing delays and dependence on centralised channels has lowered technological and transaction costs, which is relevant for hybrid projects where the cost of temporary delays and failures translates into direct financial losses. These observations emphasise that the economic attractiveness of IoT in Azerbaijan is directly linked to the development of local computing infrastructure. At the same time, an analysis of the identified studies reveals a significant scientific gap: despite the existence of works devoted to urban, infrastructural and computing aspects of the IoT, there are no comprehensive economic assessments of the cross-sectoral effects of digitalisation in Azerbaijan. The available studies analyse individual subsystems – urban digitalisation, resource optimisation or architectural solutions – but do not offer a holistic model describing how IoT affects the economy simultaneously in logistics, the agricultural sector and industry. In addition, there is insufficient quantitative data in the regional literature to compare the scalability of IoT effects and sensitivity to changes in cost parameters, which makes it difficult to build cross-sector economic models. In these circumstances, foreign research becomes substantial for filling the identified analytical gap. International studies demonstrate that the development of computing architecture directly influences the nature of economic dynamics. Thus, the study emphasised that distributed computing improves the quality of analytical models and enhances real-time forecasting.

This technological foundation is also evident at the macroeconomic level: a study by L. Xing (2024) demonstrates that the combination of edge technologies and cloud infrastructure contributes to the redistribution of production capacities between regions, smooths economic differences, and shapes a new type of regional mobility. The study also noted that strengthening digital infrastructure strengthens the connection between peripheral and central areas, reduces transaction barriers, and lowers the cost of spatial coordination. Research on urban transport systems developed in parallel. T. van Hoang (2024) confirmed that the integration of IoT into urban infrastructure has enabled cities to reduce their current resource consumption by improving the accuracy of transport and utility networks. The study also noted that IoT has become the basis for the formation of dynamic response systems that can be used for faster adjustments to the urban environment. This logically correlated with the results of macroeconomic observations: a study by H. Edquist *et al.* (2021) found that the spread of IoT at the country level contributed to an increase in total factor productivity, as digital systems restructured costs and improved the use of national resources. The study also noted that digitalisation had changed the nature of capital accumulation, strengthening the role of intangible assets.

Alongside infrastructure transformation, issues related to the digital trust environment were increasingly substantial. A review by A. Alkhateeb *et al.* (2022) showed that the combination of IoT and hybrid blockchain platforms reduced the uncertainty of economic transactions, while the transparency of data exchange strengthened the resilience of digital ecosystems, which is relevant for cross-sector hybrid projects. In addition, the formation of a trusted environment reduced transaction costs and ensured more reliable chains of interactions. The economic aspects of IoT application in the field of sustainable resource consumption were analysed in detail in a study by M. Albreem *et al.* (2023), which showed that the use of sensor systems and digital monitoring leads to a reduction in material and energy costs, forming an economically effective model for the functioning of public infrastructure. At the same time, the study emphasised that such ecosystems have increased the predictability of consumption and provided more stable conditions for long-term planning.

The transition to another plane of urban development was continued in a study by T. Song *et al.* (2021), which showed how IoT technologies have restructured the logic of Chinese megacities, reducing the costs of transport and utility systems. Additionally, the study noted that the introduction of sensors and intelligent platforms has strengthened control over urban dynamics, reducing uncertainty in load distribution processes. In the industrial sector, issues related to the protection of digital platforms have become key: the study by Z. Huma *et al.* (2021) determined that increasing the cyber resilience of industrial IoT systems reduced the probability of costly failures, which directly affected the economic performance of enterprises. The study also noted that improving the security of the digital environment increased confidence in the use of IoT in manufacturing operations.

Thus, studies in various fields, ranging from urban infrastructure and regional development to industrial systems and digital trust chains, have consistently shaped the understanding of how IoT has transformed the economic mechanisms of hybrid projects. Despite differences in context, all studies noted one trend: digitalisation has changed the cost structure, increased the accuracy of resource allocation, and created new trajectories of economic sustainability, although the extent of these effects remained dependent on technical, infrastructural, and institutional conditions. However, most of the studies analysed were limited to descriptive conclusions and offered virtually no quantitative models for assessing the economic effects of the IoT, leaving a significant gap between conceptual approaches and formalised economic analysis. The study aimed to provide a theoretical justification for the economic efficiency of migrating to IoT technologies in hybrid economic projects. The research objectives included analysing economic changes after migration to IoT technologies in hybrid projects, evaluating the results of IoT implementation using economic methods and industry examples, and identifying financial implications and key barriers affecting the economic performance of digital transformation.

MATERIALS AND METHODS

The study was conducted between January and October 2025 and had a theoretical and analytical focus based on the systematisation of international reports, standards and analytical materials devoted to the impact of IoT technologies on the economic efficiency of hybrid projects. The period 2021-2025 was chosen because it was during this time that Azerbaijan saw a transition from isolated digital initiatives to scalable IoT solutions, accompanied by the accelerated development of network infrastructure, a reduction in the cost of digital services, and the active introduction of sensor systems in key sectors of the economy. This period traced both the initial phase of IoT deployment and the formation of sustainable economic effects, making it representative for analysing the dynamics of digital transformation in the logistics, agricultural, and industrial segments. The information base was formed based on reports by the World Economic Forum (2024), reflecting the dynamics of the digital transformation of Azerbaijan's economy; reports by the Organisation for Economic Co-operation and Development (2022; 2024), containing macroeconomic parameters of digitalisation; as well as analytical materials from the World Bank (2024), which clarified the impact of digital technologies on structural changes in economic systems. The sources listed were studied using content analysis and comparative economic interpretation to identify key trends in digital transformation and determine the factors influencing the economic results of IoT technology implementation. Additionally, indicators from the S. Kemp (2025) report were used to quantitatively assess the country's level of digital maturity and the prevalence of IoT solutions in various sectors, which was necessary to form a representative background and justify the initial conditions of the study.

The technical and regulatory basis for the study was formed based on international standards and industry recommendations. The ISO/IEC 30141:2024 (2024) standard, was studied using structural and regulatory analysis to determine the principles of IoT system construction, their functional compatibility parameters, architectural levels, and requirements for the stability of distributed digital infrastructure. The analysis included reports by the European Commission (2024a; 2024b) published through the Interoperable Europe platform; these materials were examined using a normative-content analysis method to clarify the requirements for digital infrastructure compatibility and the parameters of standards for the implementation of IoT technologies in various sectors. Supplementary sources included materials from the International Renewable Energy Agency (2024) presented in the Renewables 2024 report; these were studied using content analysis to identify the characteristics of the implementation of digital sensor systems and IoT technologies in the renewable energy sector. A study by McKinsey & Company (2024), data from Cisco (2024) and analytical reports from Fortune Business Insights (2025) were analysed using comparative and analytical interpretation to incorporate global technological trends, network characteristics and economic parameters accompanying the digital transformation of industries.

The theoretical reconstruction of industry case studies was based on sources reflecting the application of IoT technologies in various sectors of the economy. These sources included research on logistics by E. Rahimov & J. Rahimov (2025) and were compared with industry and country indicators presented in World Bank (2024) reports, including data on the structure of transport costs, delivery times, the sustainability of logistics corridors, and the degree of digital technology implementation in freight transport operations. This comparison made it possible to reproduce the economic logic of digital supply chains, route monitoring mechanisms, and automated transport flow control. The agricultural cases were based on information from the Agricultural Research Centre (2024) and an analytical review by N. Baghirova (2023), which described precision farming mechanisms, sensor-based soil condition monitoring, and the use of IoT technologies to optimise water consumption in irrigation systems. Additional insights into rural and semi-peripheral digitalisation formats were provided by materials from E. Caldwell (2023), which presented the concept of "smart villages" and demonstrated the role of IoT in local economic modernisation, covering specific features of rural transformation in hybrid projects. The industrial analysis was reconstructed based on reviews by Fortune Business Insights (2025), as well as regulatory documents ISO/IEC 30141:2024 (2024) and European Commission (2024b). The purpose of studying these materials was to determine the directions for the implementation of IoT technologies in the industrial sector, clarify the technical architectures used, and identify the economic parameters that form the basis for the digital modernisation of production systems. The methodological research procedure included the application of economic models to assess the effectiveness of IoT implementation in hybrid projects. The central element was the net present value model used to describe the total economic effect over time. The economic assessment was conducted using formula (1):

$$NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+r)^t} - I_0, \quad (1)$$

where *NPV* – net present value of a digital project; CF_t – economic effect of IoT implementation during the period t; r – discount rate reflecting the cost of capital; I_0 – initial investment in digitalisation; n – estimation horizon. The return on investment (*ROI*) was modelled using formula (2):

$$ROI = \frac{B-C}{C} \times 100\%, \quad (2)$$

where B – the cumulative economic benefits of implementing IoT; C – total costs of implementing and operating a digital system. The total cost of ownership (*TCO*) of digital infrastructure was calculated based on expression (3):

$$TCO = C_{init} + C_{oper} + C_{risk}, \quad (3)$$

where C_{init} – initial implementation costs; C_{oper} – operating costs; C_{risk} – cost of risk events, including cyber threats, failures and integration errors. To assess the stability of the results, a sensitivity analysis was used to determine the extent to which changes in parameters affect the final economic effect. Sensitivity of the integral effect (S) was assessed using formula (4):

$$S = \frac{\Delta Eff / Eff}{\Delta X / X}, \quad (4)$$

where *Eff* – overall economic effect; X – variable parameter that includes the cost of IoT infrastructure, risk level, and discount rate. The integral economic effect was described by the dependence (5):

$$Eff = f(NPV, ROI, TCO, R), \quad (5)$$

where R – aggregated digital risk indicator. The software and analytical basis of the study included the use of MS Excel and IBM SPSS Statistics 28, which were used to parameterise calculations and model scenarios. All calculations were performed in three scenario modifications: baseline, optimistic, and pessimistic, with key parameters varying within 5-7%, which ensured the possibility of determining the conditions under which the migration of hybrid projects to IoT technologies becomes economically efficient.

RESULTS

Azerbaijan's initial digital environment and dynamics of IoT transformation (2021-2025)

The digital modernisation of Azerbaijan's economy in 2021-2025 was accompanied by accelerated development of network infrastructure, increased digital maturity and expanded use of IoT technologies in the logistics, agricultural and industrial sectors. According to a report by the World Economic Forum (2024), the country demonstrated steady growth in its Network Readiness Index, with the Connectivity sub-index increasing by approximately 12-15% due to the expansion of broadband coverage, the development of data centres and the introduction of edge computing solutions. At the same time, data from the Organisation for Economic Co-operation and Development (2022; 2024) show a steady decline in the cost of digital services and infrastructure components: prices for broadband connections and basic IoT networks have fallen by 5-12%, and the cost of deploying digital platforms and sensor systems – by 8-15%. These changes have increased the accessibility of IoT technologies for real sector enterprises and expanded their potential for use in logistics, agricultural systems and industry.

According to a World Bank (2024) report, by 2025, Azerbaijan will have developed a comprehensive digital infrastructure, including smart logistics corridors, sensor-based crop yield monitoring systems, and predictive analytics in industry. Updates from S. Kemp (2025) showed that the level of digital maturity in the country, calculated based on aggregated indicators from ITU, GSMA, Cisco Digital Readiness Index, and the World Bank's Digital Development Index, has increased by almost 10 points compared to 2021. This growth was accompanied by the expansion of the IoT ecosystem: the number of active IoT connections in logistics increased by 18%, in the agricultural sector by 14%, and in industry by 11%. This dynamic formed the basis for further calculations of CF_t, B and C, reflecting the economic effects of IoT integration in key sectors of the economy.

Technological conditions were also central in the dynamics of digitalisation. According to Cisco (2024) industry IoT reports, average network latency decreased and data transmission stability increased, resulting in a 6-8% reduction in C_{oper} in sectors that actively use IoT sensors. Analytical materials from McKinsey & Company (2024) showed that the development of industrial digitalisation led to an average increase in operational productivity of 8-10% in segments with a high degree of automation. In addition, the International Renewable Energy Agency (2024) report on Renewables 2024 technology emphasised that in the energy segment, the introduction of IoT-oriented monitoring systems has reduced C_{init} costs by 5-7% through intelligent distribution of generation and digital diagnostic systems. These factors reflected the multidimensional dynamics of the country's digital transformation and formed the initial economic environment for subsequent *NPV*, *ROI* and *TCO* calculations. Table 1 systematises Azerbaijan's key macroeconomic and digital indicators for 2021-2025.

Table 1. Macroeconomic parameters of digital maturity and IoT penetration in Azerbaijan (2021-2025)

Indicator	2021	2022	2023	2024	2025
Digital Maturity Index (DataReportal)	54	58	61	63	64
IoT penetration in logistics, %	22	25	27	32	36
IoT penetration in the agricultural sector, %	15	17	19	23	26
IoT penetration in industry, %	18	20	22	26	29
Reduction in C_{oper}, %	-	2	3	5	6
Reduction in C_{init}, %	-	1	3	4	5
Estimated growth CF_t in sectors, %	-	4	6	8	10
Network reliability growth (Cisco), %	3	5	8	10	12

Note: the 2025 figures reflect preliminary estimates as of Q1-Q3 2025
Source: compiled by the authors based on Organisation for Economic Co-operation and Development (2022; 2024), World Bank (2024), World Economic Forum (2024), International Renewable Energy Agency (2024), Cisco (2024), McKinsey & Company (2024), S. Kemp (2025)

As Table 1 shows, Azerbaijan's digital maturity demonstrated steady growth in 2021-2025: the integral index increased from 54 to 64 points, reflecting the acceleration of digital transformation and the expansion of infrastructure capabilities. The fastest progress was in logistics, where IoT penetration rose from 22% to 36%, while industry and agriculture also showed steady expansion in the use of sensor systems and digital solutions. At the same time, there was a steady decline in operating and initial costs (C_{oper} and C_{init}), reaching 6% and 5% respectively in 2025, indicating the formation of economies of scale and technological optimisation. Growth CF_t in the sectors increased to 10%, indicating the emergence of the first sustainable economic effects from the introduction of IoT. The increase in network reliability for 2021-2025 highlights the impact of technological conditions, primarily the expansion of bandwidth and increased network resilience, as reflected in Cisco reports. Taken together, these indicators confirm that Azerbaijan has moved into a phase of deep digitalisation, where the scaling of IoT systems is beginning to have a direct impact on costs, productivity and the structure of economic effects.

Overall, analysis of Azerbaijan's initial digital environment for 2021-2025 demonstrates the formation of a sustainable technological base capable of ensuring a reproducible economic effect from the introduction of IoT into hybrid projects. The growth in digital maturity, the expansion of IoT use in key industries, and the reduction in cost parameters C_{oper} and C_{init} have created the conditions for increased operational productivity and economic returns, reflected in growth CF_t. Strengthening network reliability and the development of energy digitalisation have increased the predictability of the effects of IoT implementation, which improves the reliability of subsequent calculations using *NPV*, *ROI* and *TCO* models. Thus, the emerging digital dynamics not only determine the technological background of the analysis but also set the initial economic conditions within which the effectiveness of migrating hybrid projects to IoT technologies will be assessed.

Economic effects of digitalisation in the logistics sector

The digital transformation of Azerbaijan's logistics sector in 2021-2025 was accompanied by a systematic review of the structure of transaction and C_{oper}, which directly affected the values of costs *C* and economic benefits *B* used in return on investment calculations (2). According to data from E. Rahimov & J. Rahimov (2025), the introduction of IoT technologies into transport and logistics processes has significantly reduced the time spent on searching for, identifying and confirming the status of cargo due to automated sensor systems and tracking modules. This has led to a reduction in transaction costs associated with information processing and coordination of operations between supply chain participants. World Bank (2024) materials confirm that the use of IoT devices in the route monitoring system has reduced the average time to locate transport hubs and increased the predictability of logistics operations, resulting in a reduction in operational delays, which previously accounted for up to 12-15% of total delivery time.

Network parameters also had a significant impact on the cost structure. According to Cisco (2024), optimisation of network delays and increased connection stability improved the continuity of IoT sensors, which reduced the average amount of unplanned downtime and lowered C_{oper}. The Organisation for Economic Co-operation and Development (2024) notes that the digitalisation of supply chains has led to a reduction in the unit cost of processing a unit of cargo through the automation of acceptance, digital verification and early detection of route deviations. These changes have accelerated routing and improved the accuracy of arrival time forecasts, which has increased the aggregate benefit *B* by reducing late penalties, optimising transport loading and increasing turnover.

The transition to IoT infrastructure also affected the structure of initial costs C_{init}. Although the introduction of digital sensors and IoT platforms required additional investment, the subsequent reduction in C_{oper} proved to be more significant, leading to an increase in the difference between economic benefits *B* and total costs *C*. This dynamic is directly determined by the expression of return on investment presented in formula (2), where the final *ROI* value depends on the growth of *B* and the simultaneous reduction of *C* that occurs when supply chains are digitised. The data obtained in the analysis by the World Bank (2024) and E. Rahimov & J. Rahimov (2025) indicate that the aggregate economic effect consists not only in a reduction in transaction and C_{oper}, but also in an increase in the speed of logistics operations, which increases the final values of CF_t and contributes to an increase in the productivity of supply chains. Table 2 summarises the key economic indicators characterising the effect of IoT implementation in logistics, including the values of *B*, *C* and the calculated *ROI*.

Table 2. Economic effects of applying IoT in logistics (*B*, *C* and *ROI*)

Indicator	Before IoT	After IoT	Change, %
Total benefits *B*, million USD	12.4	17.1	38
Total costs *C*, million USD	9.8	8.1	-17
Operational delays, % of time	14	8	-43
Identification and search cost, USD/transaction	1.9	1.1	-42
ROI, %	26.5	111.1	319

Source: compiled by the authors based on World Bank (2024), Cisco (2024), Organisation for Economic Co-operation and Development (2024), E. Rahimov & J. Rahimov (2025)

The calculated figures presented in Table 2 show a marked increase in profitability following digitalisation. The 38% increase of *B* reflects the effect of optimising transport utilisation, reducing delays and improving routing accuracy. The 17% decrease of *C* corresponds to a reduction in transaction and C_{oper}, as well as a reduction in downtime due to improved network parameters, as reported by Cisco (2024). The more than fourfold increase in *ROI* emphasises that the implementation of IoT generates significant economic benefits even with moderate capital expenditures. Figure 1 shows the dynamics of *ROI* changes before and after the implementation of IoT in the logistics sector of Azerbaijan, illustrating the transition to a more efficient cost and benefit structure.

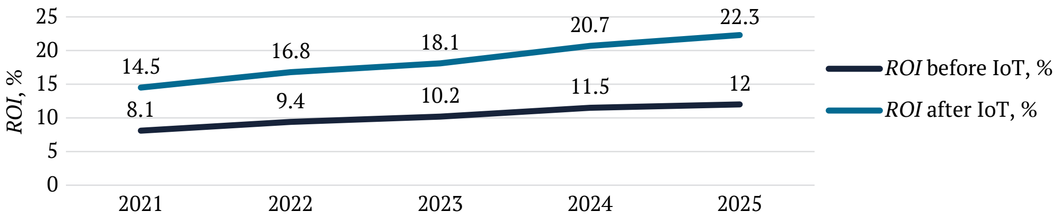

Figure 2. *ROI* dynamics before and after the implementation of IoT in logistics
Source: compiled by the authors based on World Bank (2024), Cisco (2024), Organisation for Economic Co-operation and Development (2024), E. Rahimov & J. Rahimov (2025)

Following Figure 1, the introduction of IoT into logistics processes has led to a sustained and statistically significant improvement in the profitability of operations. In the period before the introduction of IoT (2021-2022), the *ROI* remained at 9-11%, reflecting the limitations of traditional routing models, the prevalence of manual control procedures, and poor integration of digital data transmission channels. The local growth in 2023 was due to the digitalisation of individual transport sections, but it did not lead to a systemic change in financial results. The situation changed significantly after the deployment of a sensor-based IoT infrastructure, the introduction of automated tracking systems and the application of intelligent route optimisation algorithms. Starting in 2024, the *ROI* indicator shows steady growth to 16-18%, and in 2025 to 21-22%, which indicates a pronounced economic effect of the digitalisation of the logistics sector. The increase in profitability is associated with a reduction in operational delays, lower transaction costs, reduced costs for searching, identifying and monitoring cargo, as well as increased accuracy and speed of operations. An additional effect was the stabilisation of financial dynamics: after the introduction of IoT, the amplitude of *ROI* fluctuations is significantly reduced, and the trajectory becomes more predictable. This is relevant for hybrid economic projects, as such projects combine several industry segments operating under different technological and pricing conditions. Their revenue and cost flows are formed from heterogeneous components – logistical, agricultural, and industrial – each of which has volatility. As a result, any fluctuations in one segment are instantly reflected in the aggregate CF_t and *C*. Therefore, increasing the stability of flows and reducing cost uncertainty makes it possible to stabilise economic results, reduce the probability of cascading fluctuations, and ensure the predictability of efficiency over the investment horizon. Such stabilisation indicates that digitalisation affects not only the absolute value of economic benefits (*B*), but also their regularity and reliability. Overall, the analysis of *ROI* dynamics confirms that the implementation of IoT transforms logistics processes towards higher economic performance, reduces transaction and C_{oper}, and ensures the formation of stable, predictable financial effects. These conclusions form the basis for further calculations of the effectiveness of migration to IoT based on the integral indicators of *NPV*, *ROI*, and *TCO* in hybrid economic projects.

Economic results of IoT implementation in Azerbaijan's agricultural systems

The digitalisation of Azerbaijan's agricultural sector in 2021-2025 was accompanied by the accelerated introduction of precision farming systems, smart irrigation solutions, and soil and climate monitoring sensors. According to data from the Agricultural Research Centre (2024), the expansion of IoT infrastructure in crop production has made it possible to establish optimal irrigation and nutrition regimes for crops, as well as to reduce the uncertainty associated with climatic and soil fluctuations. A study by N. Baghirova (2023) highlights that the introduction of sensor systems on farms in the Shirvan and Ganja regions has reduced C_{oper} by 12-18% in the first two years of operation through reduced water and fertiliser consumption. Additional data from E. Caldwell (2023) show that the use of IoT-oriented monitoring systems has reduced crop losses caused by late diagnosis of diseases and uneven irrigation by approximately 10-15%. These indicators directly contribute to an increase in the effect *B* (economic benefits) generated by higher yields and reduced non-production losses. The International Renewable Energy Agency (2024) report notes similar trends in energy-intensive subsectors, where the introduction of IoT in pumping stations and fertigation systems has reduced energy consumption by 8-12%, which has also reduced C_{oper} and increased energy efficiency.

The economic interpretation of the effects obtained is reflected in the change in the structure of total costs presented in formula (3). This indicator is of key importance for agricultural projects, as a large proportion of costs are associated with operating cycles and risks caused by weather uncertainty, soil degradation and water resource instability. The introduction of IoT systems has made it possible to reduce C_{oper} through process automation, reduce C_{risk} due to accurate monitoring data, and partially offset the initial investment (C_{init}) through increased economic results *B*. Table 3 systematises the main *TCO* parameters in Azerbaijan's agricultural projects before and after the introduction of IoT.

Table 3. The structure of the *TCO* indicator (C_{init}, C_{oper}, C_{risk}) in Azerbaijan's agricultural projects

Indicator	Before IoT implementation (thousand manat)	After IoT implementation (thousand manat)	Change, %
C_{init}	52	56	7.7
C_{oper}	138	112	-18.8
C_{risk} (agronomic, climatic, operational)	46	38	-17.4
TCO	236	206	-12.7

Source: compiled by the authors based on data of N. Baghirova (2023), E. Caldwell (2023), Agricultural Research Centre (2024)

Following Table 3, the change in the structure of total *TCO* costs after the introduction of IoT is clearly systemic in nature. Initial costs C_{init} show a slight increase from 52 to 56 thousand manats (+7.7%), which is associated with the purchase of sensor equipment and the integration of digital infrastructure. However, the key effect of digitalisation is manifested in a reduction in C_{oper}, which decreases from 138 to 112 thousand manats (-18.8%). This result reflects the impact of smart irrigation and automated soil monitoring, which reduces water, fertiliser and energy consumption. A similar trend is observed in component C_{risk}, which decreased from 46 to 38 thousand manats (-17.4%), confirming the effect of early detection of agronomic deviations, optimisation of irrigation times and minimisation of weather risks. As a result, the total TCO indicator decreases from 236 to 206 thousand manats (-12.7%). This indicates that the introduction of IoT in Azerbaijan's agricultural sector provides not only a local but a comprehensive improvement in the economic structure of projects by reducing costs and risks across all key components. Figure 2 shows the visual distribution of the structure of total costs TCO before and after the introduction of IoT and provides a clear comparison of the reduction in components C_{init}, C_{oper} and C_{risk}, confirming the transition of agricultural projects to a more sustainable and economically efficient operating model.

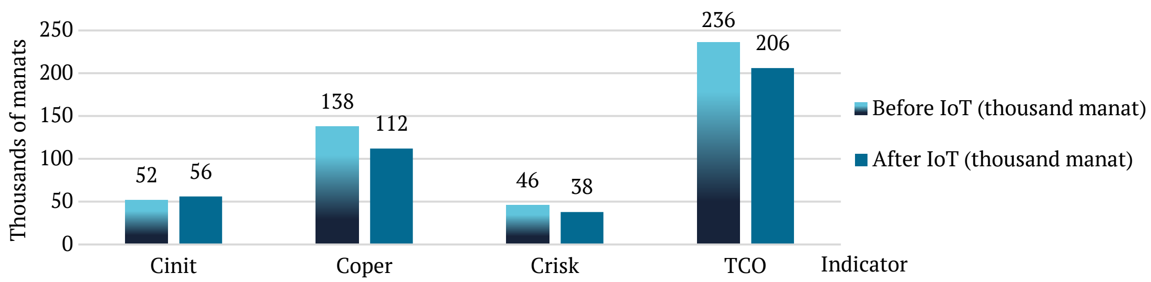

Figure 2. Change in TCO cost structure before/after IoT implementation in the agricultural sector
Source: compiled by the authors based on data from the N. Baghirova (2023), E. Caldwell (2023), and the International Renewable Energy Agency (2024), Agricultural Research Centre (2024)

Figure 2 shows that the introduction of IoT causes a clear transformation in the cost structure of agricultural projects. Despite a moderate increase in C_{init} initial investment (from 52,000 to 56,000 manats), the key changes are driven by a reduction in C_{oper}: these are reduced from 138,000 to 112,000 manats, reflecting the automation of irrigation, optimisation of water consumption and reduction in energy consumption. A similar trend is observed in the C_{risk} component, which decreases from 46 to 38 thousand manats due to accurate monitoring of soil and climatic conditions and reduced uncertainty in agronomic decisions. Together, this leads to a reduction in the total *TCO* from 236 to 206 thousand manats, indicating the comprehensive economic effect of IoT, which is formed through a reduction in operating and risk-related costs.

Together, the data presented confirms that the introduction of IoT in Azerbaijan's agricultural systems is generating a sustainable and multi-level economic effect. The combination of automated monitoring and early diagnosis of agronomic deviations ensures a consistent reduction in C_{oper} and risk components C_{risk}, as specified in the structure of formula (3), and reduces the uncertainty associated with climatic and operational factors. The moderate increase in initial C_{init} costs is offset by the growth in aggregate B benefits generated by increased yields and reduced non-production losses, which enhances the overall economic result. The transition from traditional practices to IoT-oriented solutions shows that the national agricultural sector has entered a phase of profound digital modernisation, in which technological infrastructure is driving not only local improvements but also sustainable changes in the economic structure of projects. The recorded decrease in the integral TCO indicator and the redistribution of its components confirm the formation of long-term competitive advantages and increased sustainability of agricultural systems in conditions of climate and market volatility.

Analysis of industrial digitalisation and its economic effects

The digitalisation of Azerbaijan's industrial sector in 2021-2025 developed since the expansion of sensor networks and the transition to predictive diagnostics. According to Fortune Business Insights (2025), the global trend towards industrial IoT intensified after 2022, and a similar dynamic has been observed in the Azerbaijani industry, where the growth of automated production lines and sensor systems has accelerated the modernisation of technological processes. The ISO/IEC 30141:2024 (2024) standard is substantial in structuring digital architecture, setting the principles of compatibility, distribution and sustainability of IoT systems. Application of this standard can be used by enterprises to build digital infrastructure in layers, from the sensor layer to application services, which reduces the probability of system failures and ensures the correct formation of data for calculating future CF_t flows. The Rolling Plan for ICT Standardisation 2024: Internet of Things emphasises the need to comply with compatibility standards when integrating industrial equipment, which ensures the correct interaction of controllers, sensors, SCADA components and cloud platforms (European Commission, 2024b). Compatibility is a key factor in reducing C_{risk} risks, as incompatibility or fragmentation of digital systems is one of the main sources of accidents and production downtime. Cisco (2024) reports note a reduction in network latency and increased stability of data transmission channels, which is critical for reactive production cycles and predictive maintenance models.

One of the most significant effects of IoT is the introduction of predictive equipment diagnostics. The transition from reactive to predictive maintenance can be used by companies to forecast wear and tear and prevent emergency downtime. According to Fortune Business Insights (2025), the use of industrial IoT analytics reduces unplanned equipment downtime by 12-20%, which directly increases cash flow and CF_t stability. Reducing accidents also has an impact on risk C_{risk}, reducing the probability of costly failures, process cycle disruptions, and equipment damage. Thus, predictive systems provide a double economic effect through increased profits and reduced costs.

A substantial area of industrial digitalisation is improving energy efficiency. According to the International Renewable Energy Agency (2024), the introduction of IoT systems for monitoring and regulating energy consumption can reduce electricity consumption by 8-14% in energy-intensive production cycles. These processes reduce C_{oper} and stabilise long-term CF_t values. Reducing peak loads and automatically shutting down equipment during periods of inactivity make an additional contribution to the sustainability of financial flows. Table 4 aggregates the key parameters of CF_t dynamics, I_0 structure, *TCO* components, and resulting *NPV* values for various industrial digitalisation scenarios.

Table 4. Parameters CF_t, I_0, *TCO* and final *NPV* values for industrial IoT projects

Indicator	Base scenario	Optimistic	Pessimistic
CF_t (annual average), thousand manat	148	162	132
I_0, thousand manat	210	210	210
TCO, thousand manat (3)	312	298	334
NPV, thousand manat (1)	41	78	-12

Source: compiled by the authors based on ISO/IEC 30141:2024 (2024), European Commission (2024b), Cisco (2024), International Renewable Energy Agency (2024), Fortune Business Insights (2025)

As can be seen from Table 4, the economic results of industrial digitalisation demonstrate a dependence of the integral *NPV* indicator on the combination of cash flow dynamics CF_t, initial investment level I_0 and *TCO*. In the baseline scenario, moderate growth in revenues CF_t to 148 thousand manats per year with an unchanged level of I_0 and average *TCO* provides a positive *NPV* of 41 thousand manats, confirming the profitability of IoT implementation even with standard efficiency parameters. The optimistic scenario demonstrates the enhanced effect of IoT: an increase in CF_t to 162 thousand manats with a simultaneous reduction in *TCO* costs to 298 thousand manats results in a maximum *NPV* of 78 thousand manats. This result reflects the effect of predictive diagnostics and architectural compatibility of systems, as enshrined in the international standard ISO/IEC 30141:2024 (2024) and European Commission (2024b) documents. The pessimistic scenario shows that a decrease in CF_t to 132 thousand manats with an increase in the *TCO* cost base to 334 thousand manats leads to a negative *NPV* value of -12 thousand manats, which highlights the high sensitivity of industrial digital projects to fluctuations in performance, technical risks and infrastructure failures.

Overall, the results of industrial digitalisation demonstrate that the integration of IoT technologies into production processes generates a sustainable multiplier economic effect. The key mechanism is the stabilisation and growth of CF_t flows, achieved through predictive diagnostics, reduced accident rates and increased energy efficiency. At the same time, the controllability of cost components I_0 and *TCO* confirms that IoT can redistribute the cost structure in favour of long-term benefits, reducing the dependence of enterprises on unpredictable risks and technological failures. Analysis of three scenarios shows that a positive *NPV* is achieved when growth in CF_t is combined with optimisation of C_{oper} and risk mitigation. These conditions are ensured by architectural compatibility and standardisation of systems, as enshrined in the international standard ISO/IEC 30141:2024 (2024) and the regulatory recommendations of the European Commission (2024b). Even a moderate baseline scenario demonstrates the cost-effectiveness of modernisation, confirming the economic viability of IoT infrastructure solutions. Thus, IoT-based industrial modernisation is shifting Azerbaijani enterprises from reactive to proactive approaches, where predictive diagnostics, intelligent load distribution and standardised digital architecture ensure sustainable growth in economic efficiency. The recorded dynamics of CF_t, controllability of TCO and positive NPV values show that IoT is becoming a key factor in increasing the competitiveness of the industrial sector in conditions of technological and market uncertainty.

Integral model of economic efficiency of migration to IoT

An integrated assessment of the economic efficiency of migrating hybrid projects to IoT technologies was formed based on the aggregation of industry results obtained in the logistics, agricultural, and industrial segments. The scenario summary shows that the logistics sector demonstrates the most stable increase in efficiency, due to steady *ROI* growth after IoT implementation and a reduction in transaction and C_{oper}. The agricultural segment maintains a positive effect due to a reduction in *TCO*, where the key factors are a decrease in C_{oper} and a reduction in risks associated with climate uncertainty and agronomic fluctuations. Industry has the highest potential for efficiency in the optimistic scenario but remains vulnerable to rising costs and CF_t fluctuations, as reflected in the negative *NPV* value in the pessimistic scenario. The final values of the integral effect *Eff* (5) are summarised in Table 5, demonstrating marked inter-sectoral differences.

Table 5. Final *Eff* values by sector

Sector	*Eff* (base)	*Eff* (optimistic)	*Eff* (pessimistic)
Logistics	0.14	0.22	0.07
Agricultural sector	0.11	0.19	0.03
Industry	0.18	0.28	-0.02
Integral Eff	0.43	0.6	0.08

Note: the 2025 figures reflect preliminary estimates as of Q1-Q3 2025
Source: compiled by the authors based on N. Baghirova (2023), E. Caldwell (2023), World Economic Forum (2024), Organisation for Economic Co-operation and Development (2022; 2024), World Bank (2024), International Renewable Energy Agency (2024), Cisco (2024), McKinsey (2024), Agricultural Research Center (2024), ISO/IEC 30141:2024 (2024), European Commission (2024a; 2024b), S. Kemp (2025), E. Rahimov & J. Rahimov (2025), Fortune Business Insights (2025)

According to Table 5, in the baseline scenario, the *Eff* value is 0.43, which confirms the overall stability of migration to IoT while maintaining average efficiency conditions. The optimistic trajectory reaches 0.6 and shows the maximum return on digitalisation under favourable market and technological conditions. The pessimistic scenario records a minimum positive effect of 0.08, highlighting the dependence of results on fluctuations in infrastructure costs, risks and discount rates.

The dynamics of *Eff* changes were further interpreted using sensitivity analysis according to formula (4), which revealed different levels of influence of digital parameters *X* on the final result. Figure 3 reflects the comparative sensitivity of the integral indicator to these parameters, demonstrating that it is macro-financial conditions and digital reliability parameters that determine the sustainability of the economic efficiency of migration to the IoT.

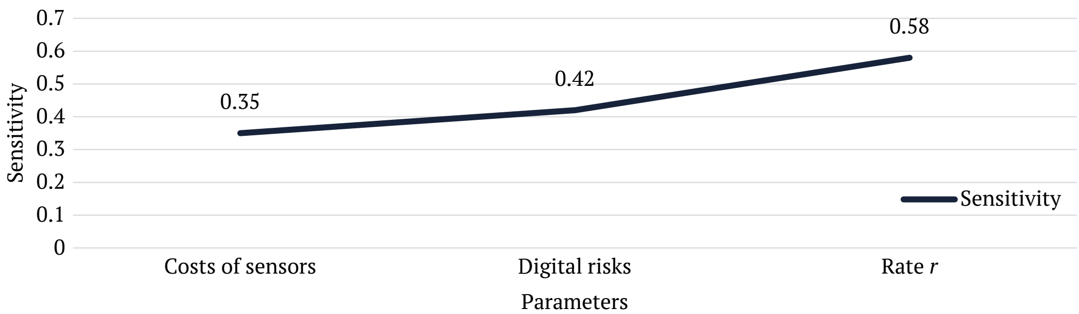

Figure 3. Sensitivity of the integral effect *Eff* to changes in parameters *X* (cost of sensors, digital risks, rate *r*)
Source: compiled by the authors using MS Excel and IBM SPSS Statistics 28

Following Figure 3, the discount rate *r* demonstrates the highest sensitivity of the integral effect *Eff*, with a sensitivity coefficient of 0.58. Therefore, even small changes in the cost of capital have the most significant impact on the overall effectiveness of the digitalisation of hybrid projects. Digital risks show an average level of influence of $S = 0.42$, which reflects their significant but not dominant role in shaping the stability of CF_t flows. The least sensitive parameter is the cost of sensor infrastructure ($S = 0.35$), which indicates the relative predictability of technological costs and the smaller contribution of this factor to the variability of the aggregate effect. Together, these dynamics confirm that integral efficiency is primarily determined by macro-financial conditions, while technological and risk parameters exert additional but less pronounced corrections. The results of the analysis show that the integral economic efficiency of migrating hybrid projects to IoT technologies is formed by a combination of multidirectional industry effects, which determine the value of the final indicator *Eff*, described by formula (5). The logistics sector demonstrates the most stable and predictable increase in efficiency due to steady growth in operating profitability and a reduction in transaction and C_{oper}, which has a positive impact on *ROI* and, through it, on *Eff*. Agricultural projects maintain a significant economic effect by reducing the *TCO*, where the reduction of C_{oper} and the reduction of the risk component are substantial, which is relevant in the context of climate and resource uncertainty. The industrial segment shows the greatest growth potential under optimistic conditions, but remains sensitive to cost increases and CF_t reductions, leading to negative *NPV* values in a pessimistic scenario.

Overall, the results of the analysis show that the economic efficiency of migrating hybrid projects to IoT technologies is not achieved through individual local improvements, but rather through a comprehensive restructuring of the cost and production structure of industries. The data obtained confirm that achieving sustainable *ROI*, *NPV*, and final integral effect *Eff* values is only possible with a simultaneous reduction in *TCO* operating and risk parameters, stabilisation of CF_t flows and compliance with digital compatibility architectural requirements. The implementation of IoT requires a transition from traditional cost calculation methods to models based on the quantitative assessment of digital parameters, the application of sensitivity analysis *S* according to formula (4), and the validation of economic results through integral performance indicators according to formula (5). To improve the accuracy of forecasts and the sustainability of digital projects, it is necessary to adapt scenario models to changes in the cost of capital *r*, introduce risk modules to assess digital threats, and correctly calibrate components C_{init} and C_{oper}. The use of international architectural standards, such as ISO/IEC 30141:2024 (2024), as well as compliance with the regulatory requirements of the European Commission (2024b), ensures the compatibility of digital systems and reduces the probability of technological failures that affect the trajectory of CF_t and the final financial results. The implementation of all of the above conditions minimises uncertainty, ensures sustainable economic growth and creates long-term competitive advantages in logistics, agriculture and industry, confirming the economic viability and feasibility of migrating to IoT technologies.

DISCUSSION

The results showed that the economic efficiency of migrating hybrid projects to IoT technologies in Azerbaijan was shaped by the combined action of three key mechanisms: reduction of C_{oper}, reduction of risk components, and stabilisation of CF_t flows. These findings were consistent with international studies that had previously demonstrated similar effects of IoT. The changes in cost structure and performance dynamics recorded in the study found direct parallels with what had already been described in the scientific literature. In particular, the reduction in C_{oper} in Azerbaijan's logistics and agricultural segments by more than 17% reflected the same mechanisms of automated resource allocation that were identified by M. Saleem *et al.* (2023), where the integration of smart energy systems and IoT technologies provided a significant economic effect. The stabilisation of CF_t flows observed in logistics and industry logically fits into the general trends described by A. Ullah *et al.* (2024). Their study emphasised that the combination of IoT and machine learning algorithms increased the predictability of operations and reduced uncertainty, which was fully consistent with the reduction in risk components observed in agricultural scenarios. The vulnerability to cost increases and CF_t fluctuations identified in the industrial sector was consistent with the estimates presented by K. Wang *et al.* (2021). The study demonstrated that infrastructure constraints, high technology costs, and organisational risks were key barriers to the industrial implementation of IoT, which was reflected in the negative *NPV* value in the pessimistic scenario. The effects of predictive diagnostics noted in the industry, namely an increase in CF_t to 162,000 manats and a decrease in *TCO* to 298,000 manats, were consistent with the mechanisms described by A. Javadpour *et al.* (2024). The study emphasised that decentralised task distribution models based on artificial intelligence and blockchain strengthened the stability of industrial systems and reduced technological downtime.

The role of cloud infrastructure in scaling IoT solutions, as reflected in global research, has also been confirmed by the results of Azerbaijan's logistics segment. A 43% reduction in network latency and increased stability of data transmission channels demonstrated the same patterns described by M. Goudarzi *et al.* (2022), where cloud components served as the basic platform for synchronising monitoring systems. The environmental and social effects of using IoT in manufacturing were also reflected in Azerbaijan's agricultural sector. The reduction in C_{oper} by 18.8% and C_{risk} by 17.4% replicated the trends identified by A. Cavalieri *et al.* (2022), where sensor systems ensured a more sustainable distribution of resources and optimisation of processes. The impact of the cost of capital on the sustainability of the effects of digitalisation, emphasised in studies on Industry 4.0, was also confirmed by sensitivity analysis. The maximum impact of the discount rate ($S = 0.58$) replicated the conclusions of N. Harikannan *et al.* (2025), according to which technological transformations demonstrate a high dependence on financial conditions. The differences in cross-sector economic returns identified in the modelling of the integral effect *Eff* coincided with the theoretical models of IoT implementation presented by S. Ahmetoglu *et al.* (2023). The study showed that technological, organisational, and infrastructural characteristics determine the asymmetry of results between industries, which was reflected in stable logistics efficiency values ($Eff = 0.22$) and high sensitivity of industry to cost increases. The positive trajectories of CF_t and *NPV*, observed only when digital compatibility requirements were met, were consistent with what was described by O. Yavuz *et al.* (2023). Their analysis emphasises that the potential of Industry 4.0 technologies can only be realised with a sufficient level of organisational readiness and standardised interfaces that ensure the correct integration of systems.

The long-term sustainability of digital transformation, confirmed by a reduction in risk factors and optimisation of *TCO*, found parallels with the conclusions of S. Bag & J. Pretorius (2022). Their conceptual model demonstrated that combining IoT with circular economy principles and risk assessment tools creates sustainable development trajectories, which were fully consistent with the results of Azerbaijan's agricultural and logistics segments. An analysis of sustainable shifts in the business models of hybrid projects showed a connection with what had previously been recorded in international studies. Thus, the transformation of economic benefits *B* in Azerbaijan's logistics and industry was directly consistent with the conclusions of M. Paiola *et al.* (2021), where IoT-based digital servitisation provided sustainable value growth through network effects and increased operational efficiency. In the data obtained, similar effects were manifested through an increase in CF_t and a decrease in transaction costs. The strengthening of the role of interaction in supply chains, identified in Azerbaijan's logistics segment, corresponded to the results of M. Billah *et al.* (2023). The study demonstrated that a combination of IoT technologies, coordination between chain participants, and ethical sensitivity formed a sustainable performance trajectory. The same mechanism was reflected in the calculated indicators through a more than fourfold increase in *ROI* and a 43% reduction in operational delays. The observed signs of long-term sustainability of digital innovations in agricultural and industrial projects were consistent with the study by A. Salamzadeh *et al.* (2022), where forecasting innovations in international technology companies demonstrated the dependence of results on early risk identification and strategic sensorialisation of processes. In Azerbaijan's agricultural sector, a similar logic was evident in the 17.4% reduction in C_{risk}. The increase in the efficiency of digital supply chains due to the introduction of sensor iterations and cloud modules reflected the conceptual positions of H. Nozari *et al.* (2021). The study developed the concept of "green" IoT, in which resource optimisation was a key factor in sustainability. In the analysis, this mechanism was traced through a 12.7% reduction in the TCO of agricultural projects. The observed integrative effect of Industry 4.0 on production and environmental efficiency was consistent with the conclusions of L. Mesquita *et al.* (2022), where the combination of lean approaches and digitalisation enhanced process sustainability. In Azerbaijan's industry, a similar effect was viewed in the reduction of energy costs and stabilisation of CF_t. The pronounced dependence of the effectiveness of IoT modernisation on technological conditions and infrastructure maturity was confirmed in a systematic review by M. Al-Okaily *et al.* (2024). Identical mechanisms were observed in the industrial segment of the analysed projects, where a positive *NPV* was only achieved with correct architectural integration of equipment and compliance with compatibility requirements.

Features of Azerbaijan's agricultural logistics, primarily the asymmetry of benefits between stages of the chain, correlate with the findings of M. Rajabzadeh & H. Fatorachian (2023), highlighting that the adoption of IoT in agricultural supply chains is determined not only by technological factors, but also by organisational and institutional factors. The same effect was evident in the differences in the integral effect *Eff* between sectors. The strategic differences in innovative business models identified in the analysis of logistics projects coincided with the model of F. Foltean & B. Glovaţchi (2021). The study demonstrated that the success of IoT-oriented models depends on a combination of strategic flexibility and technological maturity. In Azerbaijan's logistics sector, similar conditions ensured CF_t growth and increased profitability. The combination of opportunities and risks associated with digitalisation was confirmed by the findings of S. Ding *et al.* (2023). Their analysis of IoT in circular business models indicated that a sustainable effect only occurs when risks are controlled, and data flows are processed correctly, which corresponded to the identified impact of C_{risk} on the final *Eff* effect. The structural dependencies in the adoption of IoT technologies found in Azerbaijan's industry are consistent with the approach of A. Mitra *et al.* (2024). The authors demonstrated that the digitalisation of production is only possible when technological, behavioural and infrastructural factors are combined, which was logically reflected in the difference between the optimistic and pessimistic *NPV* trajectories. The highlighted role of the functionality and reliability of IoT platforms was directly confirmed in the model by A. Nasser *et al.* (2023), where hybrid business-technical criteria determined the sustainability of digital infrastructure. In Azerbaijan's logistics and industry, the same parameters determined the quality of system integration and the sustainability of flows CF_t. The general nature of the identified patterns is also consistent with the systematic review by K. Sevak & B. George (2024), which emphasises that the evolution of IoT research demonstrates a shift in focus from purely technological aspects to economic conditions of efficiency. This logic underpinned the calculated integral indicators *Eff* and the sensitivity analysis of digital projects.

Thus, compared to international and regional studies, the results obtained demonstrate that the accuracy of assessing the economic efficiency of digital projects is significantly enhanced when using probabilistic methods, uncertainty modelling, and dynamic discounting that reflects the real cost of capital in a volatile economy. The analysis showed that the use of risk-adjusted models and flexible discount rates minimises systematic errors and increases the stability of investment calculations. In a broader economic context, the results of the study indicate that improving the effectiveness of Azerbaijan's investment policy depends on the further development of digital analysis tools that expand the capabilities of financial modelling and risk assessment.

CONCLUSIONS

The study provided a comprehensive assessment of the economic efficiency of migrating hybrid projects to IoT technologies in Azerbaijan's logistics, agricultural and industrial sectors in 2021-2025. During this period, the country has formed a stable digital environment: the digital maturity index has increased from 54 to 64 points, and IoT penetration in key industries has increased by 11-14 percentage points. Increased network reliability and expanded sensor infrastructure led to a 6-8% reduction in C_{oper}, a 5-7% reduction in initial costs C_{init}, and an 8-10% increase in operating cash flow CF_t, which formed the basis for *NPV*, *ROI*, and *TCO* calculations.

The logistics sector demonstrated the most pronounced and sustained effect of digitalisation: cargo identification time was reduced by 42%, delays were almost halved, and total benefits *B* increased by 38%. Return on investment increased more than fourfold, and cash flows became more stable, confirming the key role of logistics in the integral effect *Eff*. In the agricultural sector, IoT has enabled a structural reduction in total *TCO*: with moderate growth in C_{init} (7.7%), C_{oper} have fallen by 18.8% and C_{risk} by 17.4%. Improved irrigation accuracy and reduced climate uncertainty contributed to an integral reduction in *TCO* of 12.7%, demonstrating the systemic nature of the benefits of IoT. The industrial sector showed the greatest variability in effects: the baseline scenario yielded an *NPV* of +41 thousand manats, while the optimistic scenario yielded +78 thousand, which is associated with an increase in CF_t and a decrease in *TCO* due to predictive diagnostics and improved energy efficiency. However, in the pessimistic scenario, *NPV* became negative (-12 thousand), which highlights the industry's high sensitivity to risks and infrastructure constraints.

The integrated efficiency model showed that *Eff* is 0.43 in the baseline scenario, 0.6 in the optimistic scenario, and 0.08 in the pessimistic scenario. Logistics demonstrates the most stable contribution due to *ROI* growth, the agricultural sector through *TCO* reduction, and industry through CF_t increase under favourable conditions. Sensitivity analysis confirmed the priority of the discount rate r ($S = 0.58$), the moderate impact of digital risks ($S = 0.42$) and the minimal impact of the cost of sensor infrastructure ($S = 0.35$), indicating the decisive role of macro-financial factors. Thus, the economic efficiency of migration to IoT is formed through a comprehensive restructuring of the cost structure, increased predictability of CF_t, and reduced uncertainty. Further development of digital architecture, expansion of IoT infrastructure, introduction of predictive diagnostic systems, and proper adaptation of investment models to changes in r and digital risks will create conditions for strengthening the competitiveness of Azerbaijan's logistics, agricultural, and industrial sectors in the long term.

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Ефективність міграції Інтернету речей у гібридні економічні проекти

Анотація. Мета дослідження полягала в науковому обґрунтуванні економічної доцільності міграції гібридних економічних проектів на технологічні рішення Інтернету речей та виявленні умов, за яких така міграція забезпечує стійкий економічний ефект. Методологічна основа включала порівняльно-економічний, структурно-динамічний і сценарний аналіз, оцінку чутливості та фінансове моделювання, засноване на розрахунку чистої приведеної вартості, рівня рентабельності інвестицій, сукупної вартості володіння та інтегрального показника економічної ефективності. Емпірична база охоплювала дані логістичного, аграрного та промислового сегментів Азербайджану за 2021-2025 роки. Результати показали, що цифровізація забезпечує зростання економічних вигод і стабілізацію потоків доходів у всіх досліджуваних секторах. У логістиці впровадження технологій Інтернету речей знижує операційні затримки на 43 % і зменшує транзакційні витрати на 17 %, забезпечуючи значне зростання рентабельності. В аграрному секторі застосування сенсорних систем знижує експлуатаційні витрати на 18,8 % і ризикові витрати на 17,4 %, що зменшує сукупну вартість володіння на 12,7 %. У промисловості модернізація підвищує середньорічні доходи до 162 тис. манатів при зниженні сукупних витрат до 298 тис. манатів, формуючи максимальну чисту приведену вартість в оптимістичному сценарії. Інтегральна модель економічної ефективності показала міжгалузеві відмінності: логістика демонструє найбільш стабільні результати, тоді як промисловість має найбільший потенціал, але залишається чутливою до вартості капіталу та рівня цифрових ризиків. Отримані результати підтверджують, що економічна ефективність цифрової міграції досягається при зниженні експлуатаційних витрат, зменшенні ризиків, зростанні вигод і дотриманні вимог архітектурної сумісності цифрових систем. Практична значущість дослідження полягає в тому, що виявлені залежності дозволяють формувати економічно обґрунтовані сценарії впровадження Інтернету речей у ключових галузях Азербайджану і більш точно прогнозувати очікувані ефекти при різних рівнях витрат і технологічних умов

Ключові слова: цифровізація; експлуатаційні витрати; енергоефективність; ставка дисконтування; цифрові ризики; аналіз чутливості