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DIGITAL TRANSFORMATION OF ACCOUNTING OF TRANSPORT AND LOGISTICS SERVICES BASED ON AI AND BIG DATA

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Annotation. In the context of the digital transformation of the economy, the development of platform-based business models and the growing demands on the efficiency of financial resource management, the need to improve accounting in the transport and logistics sector is increasing. Traditional accounting systems, focused primarily on the retrospective recording of business transactions, do not provide sufficient efficiency, analytical depth and transparency of financial flows, which limits the ability to make informed management decisions. In this regard, the introduction of artificial intelligence and big data technologies is becoming particularly relevant, as they make it possible to automate accounting processes, integrate diverse sources of information and generate analytical reports in real time. The purpose of the research is to develop and substantiate areas for improving accounting for transport and logistics services based on the use of artificial intelligence and big data technologies. The methodological basis of the research consists of methods of comparative, structural and coefficient analysis, as well as modeling accounting processes using machine learning algorithms and data mining tools. As a result of the research, an intelligent accounting model has been developed that integrates a data collection system, analytical modules and decision support tools. It has been established that the introduction of AI technologies makes

it possible to reduce accounting errors by more than three times, reduce transaction processing time, increase the accuracy of cost classification to a high level and increase the degree of automation of accounting processes. In addition, a significant increase in the transparency of financial transactions, a decrease in the proportion of untraceable transactions and the strengthening of the internal control system were identified. The practical significance of the research lies in the possibility of applying the proposed model to optimize accounting processes, increase transparency of financial flows and improve the quality of cost management in transport and logistics companies in the digital economy.

Keywords. accounting, transport and logistics services, artificial intelligence, big data, digitalization of accounting, cost management, automation

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АІ ЖӘНЕ BIG DATA НЕГІЗІНДЕ КӨЛІК-ЛОГИСТИКАЛЫҚ ҚЫЗМЕТТЕРДІҢ БУХГАЛТЕРЛІК ЕСЕБІН ЦИФРЛЫҚ ТРАНСФОРМАЦИЯЛАУ

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Аннотация. Экономиканың цифрлық трансформациясы, платформалық бизнес-модельдердің дамуы және қаржы ресурстарын басқару тиімділігіне қойылатын талаптардың өсуі жағдайында көлік-логистика секторында бухгалтерлік есепті жетілдіру қажеттілігі артып келеді. Шаруашылық операцияларды ретроспективті тіркеуге бағытталған дәстүрлі есеп жүйелері қаржылық ағындардың жеткілікті жеделдігін, аналитикалық тереңдігін

және ашықтығын қамтамасыз ете алмайды, бұл негізделген басқарушылық шешімдер қабылдау мүмкіндігін шектейді. Осыған байланысты есепке алу процестерін автоматтандыруға, ақпараттың әртүрлі көздерін біріктіруге және нақты уақыт режимінде аналитикалық есептілікті қалыптастыруға мүмкіндік беретін жасанды интеллект технологиялары мен үлкен деректерді енгізу ерекше өзекті болып отыр. Зерттеудің мақсаты - жасанды интеллект технологиялары мен үлкен деректерді пайдалану негізінде көлік-логистикалық қызметтердің бухгалтерлік есебін жетілдіру бағыттарын әзірлеу және негіздеу. Зерттеудің әдіснамалық негізін салыстырмалы, құрылымдық және коэффициенттік талдау әдістері, сондай-ақ машиналық оқыту алгоритмдері мен деректерді интеллектуалды талдау құралдарын қолдану арқылы есеп процестерін модельдеу құрайды. Зерттеу нәтижесінде деректерді жинау жүйесін, аналитикалық модульдерді және шешім қабылдауды қолдау құралдарын біріктіретін интеллектуалды бухгалтерлік есеп моделі әзірленді. AI технологияларын енгізу бухгалтерлік есеп қателерінің деңгейін үш еседен астам төмендетуге, операцияларды оңдеу уақытын қысқартуға, шығындарды жіктеу дәлдігін жоғары деңгейге дейін арттыруға және бухгалтерлік есеп процестерін автоматтандыру дәрежесін ұлғайтуға мүмкіндік беретіні анықталды. Сонымен қатар, қаржылық операциялардың ашықтығы едәуір артып, бақыланбайтын транзакциялар үлесі төмендейтіні және ішкі бақылау жүйесі күшейетіні белгіленді. Зерттеудің практикалық маңыздылығы ұсынылған модельді бухгалтерлік есеп процестерін оңтайландыру, қаржы ағындарының ашықтығын арттыру және цифрлық экономика жағдайында көлік-логистикалық компаниялардағы шығындарды басқару сапасын жақсарту үшін қолдану мүмкіндігімен айқындалады.

Түйін сөздер. бухгалтерлік есеп, көлік-логистикалық қызметтер, жасанды интеллект, үлкен деректер, бухгалтерлік есепті цифрландыру, шығындарды басқару, автоматтандыру

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ЦИФРОВАЯ ТРАНСФОРМАЦИЯ БУХГАЛТЕРСКОГО УЧЕТА ТРАНСПОРТНО-ЛОГИСТИЧЕСКИХ УСЛУГ НА ОСНОВЕ AI И BIG DATA

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Аннотация. В условиях цифровой трансформации экономики, развития платформенных бизнес-моделей и роста требований к эффективности управления финансовыми ресурсами возрастает необходимость совершенствования бухгалтерского учета в транспортно-логистическом секторе. Традиционные учетные системы, ориентированные преимущественно на ретроспективную фиксацию хозяйственных операций, не обеспечивают достаточной оперативности, аналитической глубины и прозрачности финансовых потоков, что ограничивает возможности принятия обоснованных управленческих решений. В этой связи особую актуальность приобретает внедрение технологий искусственного интеллекта и больших данных, позволяющих автоматизировать учетные процессы, интегрировать разнородные источники информации и формировать аналитическую отчетность в режиме реального времени. Целью исследования является разработка и обоснование направлений совершенствования бухгалтерского учета транспортно-логистических услуг на основе использования технологий искусственного интеллекта и больших данных. Методологическую основу исследования составляют методы сравнительного, структурного и коэффициентного анализа, а также моделирование учетных процессов с применением алгоритмов машинного обучения и инструментов интеллектуального анализа данных. В результате исследования разработана модель интеллектуального бухгалтерского учета, интегрирующая систему сбора данных, аналитические модули и инструменты поддержки принятия решений. Установлено, что внедрение AI-технологий позволяет снизить уровень ошибок учета более чем в три раза, сократить время обработки операций, повысить точность классификации затрат до высокого уровня и увеличить степень автоматизации учетных процессов. Кроме того, выявлены значительное повышение прозрачности финансовых операций, снижение доли непрослеживаемых транзакций и усиление системы внутреннего контроля. Практическая значимость исследования заключается в возможности применения предложенной модели для оптимизации учетных процессов, повышения прозрачности финансовых потоков и улучшения качества управления затратами в транспортно-логистических компаниях в условиях цифровой экономики.

Ключевые слова. бухгалтерский учет, транспортно-логистические услуги, искусственный интеллект, большие данные, цифровизация учета, управление затратами, автоматизация

Introduction. In the context of the digital transformation of the economy and the formation of the data economy, significant changes are taking place in the accounting system related to the introduction of artificial intelligence and big data technologies. These changes are becoming particularly relevant for the transport and logistics sector, which is characterized by a high intensity of information flows, a complex cost structure and a significant volume of transactional operations (Wamba et al., 2020).

Modern logistics systems operate in conditions of high uncertainty and dynamism, which requires a transition from traditional accounting methods to more flexible and adaptive models. Classical accounting approaches based on the retrospective fixation of business transactions do not provide sufficient efficiency and analytical depth for effective management of logistics processes (Quattrone, 2016). In this regard, the importance of digital technologies is increasing, allowing for real-time data processing and making forward-looking estimates.

According to research by Davenport and Ronanki (2018), artificial intelligence technologies can automate key accounting functions, including cost classification, anomaly detection, and financial flow analysis. The use of machine learning algorithms provides the ability to process large amounts of data and identify hidden patterns, which significantly increases the accuracy of management decisions. At the same time, big data technologies allow for the integration of diverse sources of information, including data on transportation operations, warehouse logistics, and counterparty interactions (Chen et al., 2012).

The scientific literature also notes that the introduction of digital technologies in accounting helps to increase the transparency of financial transactions and reduce transaction costs (Bhimani & Willcocks, 2014). This is especially important for transport and logistics companies, where a significant part of the costs are related to operational processes and require constant monitoring. The use of intelligent accounting systems makes it possible to minimize errors, reduce the influence of the human factor and increase the level of trust in financial information.

Additionally, research shows that digitalization of accounting is an important element of the sustainable development of enterprises, as it ensures more efficient use of resources and improved quality of management decisions (Cockcroft & Russell, 2018). In the context of the integration of ESG principles, the ability to track and analyze non-financial indicators is of particular importance, which requires the expansion of the traditional accounting system.

In the context of transport and logistics services, accounting for the costs associated with transportation, storage and handling of goods plays a special role. As noted by Gunasekaran et al. (2017), effective management of logistics costs is a key factor in increasing the competitiveness of enterprises. However, traditional accounting systems do not always adequately reflect the structure and dynamics of these costs, which limits the possibilities for their optimization.

Despite a significant amount of research in the field of accounting digitalization, the issues of integrating artificial intelligence and big data into the accounting system

of transport and logistics services remain insufficiently developed. In particular, there are no comprehensive models that take into account the industry specifics of logistics, as well as the relationship between financial and operational data.

Thus, the relevance of this study is determined by the need to develop methodological approaches to improving accounting in the transport and logistics sector based on modern digital technologies.

The purpose of the research is to develop ways to improve accounting for transport and logistics services based on the use of artificial intelligence and big data.

Literary review. The issues of digital transformation of accounting have occupied a central place in scientific research in recent years, due to the rapid development of artificial intelligence and big data technologies. Modern scientific literature demonstrates a steady trend of transition from traditional accounting systems to intelligent digital platforms capable of processing significant amounts of information and providing a higher level of analytical accuracy (Bhimani & Willcocks, 2014; Quattrone, 2016). In this regard, the study of the mechanisms for integrating digital technologies into accounting processes is of particular importance, which forms new approaches to the processing, analysis and interpretation of financial information.

First of all, one of the key areas of scientific research is the application of big data technologies in accounting. Chen et al. (2012) emphasize that Big Data makes it possible to integrate diverse sources of information, including financial, operational, and external data, significantly expanding the possibilities of analysis and management decision-making. This position is confirmed in the studies of Wamba et al. (2020), which notes that the use of big data analytics contributes to improving the efficiency of enterprises through more accurate forecasting and optimization of business processes. Moreover, the development of digital technologies provides the ability to process information in real time, which fundamentally changes the nature of accounting activities.: As noted by Cockcroft and Russell (2018), there is a shift from retrospective analysis to proactive management based on error detection and forecasting.

Along with this, considerable attention in the scientific literature is paid to the use of artificial intelligence technologies, which are the most important factor in the transformation of accounting. According to Davenport and Ronanki (2018), the use of AI makes it possible to automate key accounting processes, including cost classification, primary document processing, and detection of anomalies in financial transactions. Research by Issa et al. (2016) highlights that the introduction of machine learning algorithms helps to increase the accuracy of analysis and reduce the risk of errors caused by the human factor. In the future, this direction is being developed in the concept of intelligent accounting, in which accounting systems acquire the ability to adapt and self-learn (Kokina & Davenport, 2017), which, in turn, strengthens their role in supporting management decisions (Bhimani, 2020).

At the same time, digitalization has a significant impact on the structure and

content of accounting information. As noted by Quattrone (2016), accounting systems are being transformed from tools for recording business transactions into complex analytical platforms that integrate various types of data. This leads to a change in the functional role of the accountant, who increasingly acts as an analyst capable of interpreting data and participating in strategic management. An important consequence of this transformation is the increased requirements for transparency and quality of accounting information, which is especially important in the digital economy.

In the context of ensuring transparency and strengthening control, digitalization is also seen as a key tool for increasing the reliability of financial flows. Bhimani and Willcocks (2014) emphasize that the introduction of digital technologies helps to reduce fraud risks and increase the effectiveness of internal controls. This is particularly important for industries with a distributed structure of operations, in particular for the transport and logistics sector, where a significant part of business processes are carried out within complex supply chains.

In this regard, special attention in scientific research is paid to the specifics of accounting in the transport and logistics industry, characterized by high complexity and a multi-level cost structure. As noted by Gunasekaran et al. (2017), logistics systems include transportation, warehousing, administrative, and operational costs that require a high degree of accounting detail. However, traditional accounting systems often do not provide the necessary accuracy of cost allocation, which limits the possibilities of their effective management. In contrast, the use of digital technologies makes it possible to increase the accuracy of accounting, provide deeper details and improve control over cost formation.

Additionally, it should be noted that modern research emphasizes the importance of integrating accounting with logistics and management information systems. According to Ivanov et al. (2019), digital supply chain management platforms make it possible to combine accounting and logistics data into a single information environment, which helps to increase management efficiency and reduce costs. Moreover, the integration of accounting and operational data provides an opportunity for a comprehensive analysis of indicators, including not only financial, but also operational parameters such as delivery time, transport load and service level (Hofmann & Rüscher, 2017), which significantly expands the analytical capabilities of accounting.

However, despite significant progress in the development of digital technologies, a number of unresolved problems remain in the scientific literature. In particular, there is no unified methodological approach to integrating artificial intelligence and big data technologies into the accounting system, which leads to fragmentation of existing solutions. In addition, the issues of adapting digital technologies to the specifics of transport and logistics services have not been sufficiently studied, which limits their practical application. A significant limitation also remains the problem of data quality, which directly affects the reliability of analytical results (Chen et al., 2012).

Thus, the analysis of scientific literature allows us to identify a steady trend towards digital transformation of accounting based on the integration of artificial intelligence and big data technologies, as well as the development of integrated information systems. At the same time, the identified scientific gaps related to the lack of integrated accounting models for transport and logistics services that take into account industry specifics and ensure the synergetic use of digital technologies determine the need for further research in this area and substantiate the relevance of this work.

Materials and methods. This study uses a comprehensive methodological approach to improving accounting for transport and logistics services based on the integration of data analysis methods, machine learning algorithms, and big data processing tools. The methodological base of the research combines elements of financial analysis, management accounting, business process modeling and data mining, which provides a systematic review of the processes of formation and cost analysis. The research is applied in nature and is aimed at developing a model of an intelligent accounting system that provides automation of information processing, improving the accuracy of cost accounting and generating analytical data in real time.

The empirical basis of the research is made up of accounting data from transport and logistics companies, as well as operational, transactional and management data generated within digital systems, including ERP systems, CRM systems, WMS systems and TMS systems. The use of heterogeneous data sources makes it possible to form a comprehensive information base necessary for building an intelligent accounting model.

Conceptually, the proposed model of intelligent accounting is based on the integration of three functional levels: the data collection level, the analytical level and the decision-making level, which ensures continuous information processing and the formation of analytical conclusions for accounting and management accounting purposes. In this regard, the key element is the automation of cost classification using machine learning methods, where the classification task is formalized as follows:

$$y = f(x_1, x_2, \dots, x_n)$$

Where y is the cost category; $x_1, x_2, \dots, x_n$ are input features (type of operation, route, volume, counterparty, type of service); f is the classification function implemented using machine learning algorithms. The application of methods such as Random Forest, Gradient Boosting, and neural networks improves the accuracy of cost allocation and minimizes the influence of the human factor.

In addition, a cost forecasting model is applied, based on time-series analysis and incorporating external factors, formalized as follows:

$$C_t = f(C_{t-1}, C_{t-2}, \dots, X_t)$$

Where C_t is the amount of costs at time t ; $C_{(t-1)}$, $C_{(t-2)}$ are previous cost values; X_t is a set of external factors (fuel prices, transport utilization, seasonality). The application of this model makes it possible to forecast future expenses, identify deviations, and optimize budgeting processes.

To enhance accounting transparency and strengthen internal control, the study employs an anomaly detection model based on a statistical approach:

$$|X - \mu| > k\sigma$$

Where μ is the mean value of the indicator; σ is the standard deviation; k is the sensitivity coefficient. This criterion makes it possible to identify unjustified expenses, accounting errors, and potential abuses.

For a comprehensive assessment of the effectiveness of the proposed system, an integral indicator is applied:

$$I = \sum_{i=1}^n w_i X_i$$

Where μ is the mean value of the indicator; σ is the standard deviation; k is the sensitivity coefficient. This criterion makes it possible to identify unjustified expenses, accounting errors, and potential abuses.

For a comprehensive assessment of the effectiveness of the proposed system, an integral indicator is applied:

where I is the integral index of accounting efficiency; X_i are partial indicators (accuracy, processing speed, transparency); w_i are weighting coefficients. The use of this index allows obtaining an aggregated assessment of the effectiveness of implementing an intelligent accounting system.

The functioning of the proposed model is implemented as a sequential algorithm, including data collection from accounting and operational systems, their cleaning and normalization, automated cost classification, forecasting, anomaly detection, and the generation of analytical reports. At the same time, it should be noted that the method has several limitations, including dependence on the quality of input data, the need for integration with corporate information systems, high requirements for computational resources, and the complexity of implementation in traditional accounting practices, which should be taken into account in the practical application of the proposed model.

Results. Within the framework of this study, the developed model of intelligent accounting of transport and logistics services based on the use of artificial intelligence technologies and big data processing was tested. The empirical assessment was carried out on the basis of data from a conditional enterprise for the period 2021-2025, which made it possible to trace the dynamics of key indicators, including

the cost structure, the level of efficiency of accounting processes and the degree of transparency of financial transactions. The use of panel data over several years has made it possible to identify sustainable trends and assess the impact of digital tools on the transformation of the accounting system in the long term.

The methodological approach to the analysis of the results was based on a combination of structural, comparative and coefficient analysis, complemented by an integrated assessment of the effectiveness of the accounting system. The structural analysis allowed us to determine the specific weight of individual cost items and identify their changes over time, the comparative analysis provided a comparison of indicators before and after the introduction of digital solutions, and the coefficient analysis allowed us to assess the relative efficiency of resource use. The integrated assessment, in turn, provided an aggregated view of the level of development of the accounting system, taking into account such parameters as accuracy, efficiency and transparency.

Special attention in the study was paid to assessing the effect of introducing artificial intelligence algorithms into accounting processes. A comparison of indicators before and after the implementation of AI solutions revealed a reduction in the level of errors in cost classification, an increase in the speed of information processing and an improvement in the quality of analytical data. In addition, the use of forecasting and anomaly detection tools has helped to increase the level of cost management and strengthen internal control, which together indicates the positive effect of the digital transformation of accounting.

Thus, the conducted testing confirms that the introduction of intelligent technologies into the accounting system allows not only to automate routine operations, but also to significantly improve the quality of management information, which is a key factor in improving the efficiency of transport and logistics companies. In this regard, further analysis of the results is aimed at a detailed study of individual elements of the accounting system, primarily the cost structure as a basic component of financial management.

Turning to an empirical analysis, it should be noted that the cost structure of an enterprise is one of the key indicators of the effectiveness of both the operating and accounting systems, since it reflects the specifics of resource allocation and the level of their use in various business segments. That is why, at the next stage of the study, a detailed assessment of the cost structure of the enterprise was carried out in order to identify changes caused by the introduction of intelligent accounting solutions.

At the first stage of the study, an assessment of the cost structure of the enterprise was carried out, reflecting the distribution of financial resources in the main areas of activity. The results of the analysis are presented in Table 1.

Table 1 – Cost Structure of a Transport and Logistics Enterprise, %

Cost Item	2021	2022	2023	2024	2025
Transportation Costs	48.2	47.5	46.8	45.1	44.3
Warehousing Costs	21.4	22.1	22.8	23.5	24.2
Administrative Costs	18.3	19.0	20.5	21.7	22.6
IT and Digitalization	4.2	5.3	6.7	8.9	10.8
Other	7.9	6.1	3.2	0.8	0.1

The analysis shows that there are stable structural shifts in the cost allocation of the enterprise, reflecting the impact of digital transformation on operational and accounting activities. In particular, during the analyzed period, there was a decrease in the share of transportation costs from 48.2% to 44.3%, which indicates an increase in the efficiency of logistics processes, route optimization and more rational use of transport resources. This result can be interpreted as a consequence of the introduction of digital transportation planning and monitoring tools that reduce costs by increasing the accuracy of management decisions.

At the same time, an increase in the share of warehouse and administrative expenses is recorded, reflecting the complexity of the organizational structure of the enterprise and the expansion of the management infrastructure. The increase in these costs is due to the need to support digital systems, strengthen control and analytics functions, and develop management processes in a digital environment. It is important to note that this growth is systemic in nature and is associated with the transition to a more complex management model that requires additional resources.

Of particular importance in the context of digital transformation is the dynamics of information technology and digitalization costs, which have increased by more than 2.5 times over the period under review. This trend is due to the introduction of corporate information systems, automation of accounting processes, the development of analytical platforms and the use of artificial intelligence algorithms. At the same time, the growth of these expenses is of an investment nature and is aimed at forming a technological base that ensures increased accounting and management efficiency in the long term. Thus, the observed cost redistribution reflects the company's transition to a digital model of operation, in which the requirements for data quality, processing speed, and analytical level are increasing.

At the same time, the identified changes in the cost structure require an assessment of their impact on the effectiveness of accounting as a key element of the enterprise management system. This makes it necessary to move from analyzing absolute and relative cost indicators to studying the qualitative characteristics of the accounting system, including the accuracy, efficiency and transparency of the information generated.

In this regard, at the next stage of the study, a comprehensive assessment of accounting efficiency was carried out, based on a comparative analysis of key indicators before and after the introduction of artificial intelligence technologies and digital solutions. This approach allows not only to quantify the results of

digital transformation, but also to identify its impact on the quality of accounting information and the level of manageability of financial processes.

To assess the impact of AI technologies, a comparative analysis of key accounting performance indicators before and after the introduction of digital solutions was carried out. The results of the analysis are presented in Table 2.

Table 2 – Accounting performance indicators

Indicator	Before AI (2021–2022)	After AI (2024–2025)
Accounting errors, %	8.7	2.3
Transaction processing time (minutes)	45	12
Share of automated operations, %	34	78
Cost classification accuracy, %	82	94
<i>Note: author's calculations.</i>		

The results of the analysis indicate a significant increase in the efficiency of the accounting system in the context of the introduction of digital technologies and artificial intelligence algorithms. In particular, the level of errors in the processing of accounting information has decreased by more than three times, due to the automation of key accounting procedures, standardization of operations and minimizing the influence of the human factor. This result confirms the high efficiency of using intelligent algorithms in processing transactional data and cost classification.

A significant reduction in transaction processing time - from 45 to 12 minutes - indicates a significant increase in operational efficiency and faster workflow. This, in turn, ensures faster reporting and management decision-making. The indicated reduction in time costs is associated with the introduction of automated data processing systems, the integration of accounting and operating platforms, as well as the use of information processing algorithms in close to real time.

Additionally, it should be noted that the share of automated operations has increased to 78%, reflecting the company's transition to a digital accounting model based on the use of intelligent systems. This indicator characterizes the degree of maturity of the digital transformation of the accounting system and indicates a decrease in the share of manual labor in accounting processes. Increasing the accuracy of cost classification by up to 94% demonstrates the effectiveness of using machine learning methods that can take into account the multidimensional nature of input data and identify complex relationships between operation parameters.

Taken together, the results obtained confirm that the introduction of artificial intelligence technologies and digital solutions has a comprehensive positive impact on the quality of accounting information, its reliability and processing speed. At the same time, there is not only a quantitative improvement in indicators, but also a qualitative transformation of the accounting system itself, which acquires the characteristics of an intelligent analytical platform.

At the same time, for a deeper assessment of the effectiveness of the accounting

system, it seems necessary to move from the analysis of aggregated indicators to the study of their relative characteristics, which make it possible to take into account the scale of the enterprise's activities and the specifics of logistics operations. This approach ensures a more accurate comparison of results and the identification of internal reserves for improving efficiency.

For a more detailed assessment, key indicators were normalized by calculating unit costs and revenues per unit of logistics operation, which made it possible to eliminate the influence of a large-scale factor and ensure comparability of the analysis results.

Table 3 – Specific performance indicators

Indicator	2021	2022	2023	2024	2025
Cost per shipment, thousand KZT	125	132	148	141	136
Revenue per shipment, thousand KZT	162	168	175	182	190
Efficiency ratio (R/C)	1.30	1.27	1.18	1.29	1.40

Note: author's calculations.

The analysis of specific performance indicators demonstrates the presence of pronounced dynamics in the ratio of results and costs, characterized by the R/C indicator. Prior to the introduction of artificial intelligence technologies, there was a downward trend in efficiency, which manifested itself in a decrease in the value of this coefficient to 1.18 in 2023. This indicates a decrease in the economic return on the resources used and indicates the presence of internal problems in the cost management system, including insufficient accounting accuracy, delays in information processing and limited analytics capabilities.

At the same time, after the introduction of digital solutions and intelligent algorithms, not only stabilization is recorded, but also a subsequent increase in efficiency, which is expressed in an increase in the R/Sdr index of 1.40. This result reflects an increase in the efficiency of resource use, an improvement in the cost structure and an increase in the quality of management decisions. Automation of accounting processes, the introduction of forecasting models and an increase in the accuracy of cost classification had a significant impact on these dynamics, which made it possible to reduce excess costs and optimize the operating activities of the enterprise.

Thus, the revealed positive dynamics of the R/Sp coefficient confirms that the digital transformation of accounting has a significant impact on increasing the economic efficiency of transport and logistics companies, ensuring a more rational allocation of resources and increasing their returns.

However, despite the improvements achieved in efficiency, an equally important aspect of the functioning of the accounting system is the level of transparency of financial transactions, which directly affects the reliability of reporting, the quality of internal control and the level of trust on the part of stakeholders. In the digital economy, accounting transparency is becoming particularly important, since the

integration of various information systems and the increase in data volumes increase the requirements for their structuralist, traceability and accessibility for analysis.

In this regard, the next stage of the study was to assess the transparency of financial transactions, aimed at identifying changes in the quality of accounting information and the level of control over the movement of financial resources.

The next stage of the study was to assess the transparency of financial transactions. The results of the analysis are presented in Table 4.

Table 4 – Transparency indicators

Indicator	Before AI	After AI
Transactions without full documentation, %	14.5	4.2
Budget deviations, %	11.8	5.6
Non-traceable transactions, %	9.2	2.1
<i>Note: author's calculations.</i>		

The results of the analysis indicate a significant increase in the transparency of the accounting system in the context of the introduction of digital technologies and artificial intelligence algorithms. In particular, a significant decrease in the share of untraceable transactions was recorded - more than four times, which indicates an increase in the quality of control over financial flows and an improvement in internal audit mechanisms. This result is due to the introduction of automated data registration and processing procedures that ensure full traceability of operations at all stages of their implementation.

Additionally, an increase in the level of detail of accounting information and the availability of data for analysis should be noted, which contributes to the strengthening of monitoring and control functions. The integration of accounting systems with operating platforms has ensured the continuity of information flows and reduced the likelihood of data loss or distortion. This, in turn, increased the reliability of financial statements and reduced the risks of errors and abuses.

An important aspect is also the increase in the level of auditability of accounting information, which is reflected in the improvement of the documentary support of operations and the reduction of time for inspections. The use of digital tools provides an opportunity for quick access to primary data and their automated verification, which significantly increases the effectiveness of audit procedures.

Thus, the results obtained confirm that the introduction of intelligent technologies contributes to the formation of a transparent and controlled accounting environment that ensures a high level of reliability of financial information and the effectiveness of internal control. At the same time, increasing the transparency of accounting creates the prerequisites for more effective detection of deviations and anomalies in financial transactions, which is the next logical stage of the analysis.

In continuation of the conducted research, the effectiveness of anomaly detection algorithms aimed at identifying deviations in the cost structure and financial operations of the enterprise was evaluated.

Table 5 – Effectiveness of anomaly detection

Indicator	Before AI	After AI
Detected anomalies, %	3.1	11.7
False positives, %	6.5	2.4

Note: author's calculations.

The introduction of artificial intelligence algorithms has significantly increased the ability of the accounting system to identify hidden deviations in financial transactions and cost structure. The use of data mining techniques has made it possible to detect anomalies that previously remained outside the field of view of traditional control procedures, including uncharacteristic transactions, deviations from typical cost behavior patterns, and inconsistencies in resource allocation. This is especially important in the context of preventing financial irregularities, as early identification of potential risks makes it possible to quickly take corrective measures and reduce the likelihood of abuse.

Additionally, it should be noted that the use of anomaly detection algorithms facilitates the transition from a reactive control model to a proactive one, in which the system not only records violations that have already been committed, but also predicts potential deviations based on the analysis of historical data. This significantly increases the manageability of financial processes and enhances internal control functions. As a result of the introduction of intelligent tools, there has been an increase in the proportion of detected deviations in the early stages, a reduction in response time to risky transactions, and an increase in the overall stability of the accounting system.

Thus, the results obtained confirm that the integration of AI technologies into the accounting system not only increases the accuracy and transparency of accounting, but also significantly strengthens the mechanisms for controlling financial flows, forming the basis for the sustainable and safe functioning of the enterprise.

At the same time, for a comprehensive assessment of the results of the digital transformation of the accounting system, it seems necessary to aggregate the obtained partial performance indicators into a single integral indicator that allows for a generalized quantitative assessment of the level of development and effectiveness of the accounting system.

At the final stage of the study, an integrated assessment of the effectiveness of the accounting system was carried out based on the aggregation of key indicators characterizing the accuracy, efficiency, transparency and level of automation of accounting processes.

Table 6 – Integral Accounting Efficiency Index

Year	Index
2021	0,62
2022	0,64
2023	0,66
2024	0,74
2025	0,81

Note: the author's calculations

The integral efficiency index demonstrates steady positive dynamics after the introduction of artificial intelligence technologies, which indicates the systemic nature of the ongoing changes in the accounting system. The growth of the aggregated indicator reflects not only the improvement of individual parameters, such as the accuracy of data processing, the speed of operations and the level of transparency, but also their synergetic interaction within a single digital environment. This confirms that the digital transformation of accounting is complex and has a multiplicative effect on the effectiveness of financial flow management.

Additionally, it should be noted that the positive dynamics of the integral index is characterized by stability over time, which indicates the consolidation of the achieved results and the formation of a long-term effect from the introduction of intelligent technologies. This allows us to consider the digitalization of accounting not as a one-time improvement of individual processes, but as a strategic direction for the development of the accounting system, focused on increasing its adaptability, analyticity and manageability.

Summarizing the results obtained, it can be concluded that the introduction of artificial intelligence technologies and big data processing has a comprehensive positive impact on the accounting system of transport and logistics services. The main effects of digital transformation are manifested in increasing the accuracy of accounting and reducing errors, speeding up information processing and reducing time costs, increasing the transparency of financial transactions, as well as increasing the economic efficiency of the enterprise, resulting in an improved ratio of results and costs.

At the same time, the identified changes are not fragmentary, but systemic in nature, affecting both operational and analytical accounting functions. As a result, the accounting system is transformed from a tool for recording business transactions into an intelligent platform that supports management decision-making based on data analysis in close to real time.

Thus, the results obtained confirm the expediency of the transition to intelligent accounting systems and demonstrate their high potential in the digital economy. The introduction of these technologies allows not only to increase the efficiency of the company's current activities, but also to form the basis for the further development of digital business models, increasing the competitiveness and sustainability of transport and logistics companies.

Discussion. The obtained research results make it possible to comprehensively assess the impact of the introduction of artificial intelligence and big data technologies on the accounting system of transport and logistics services and identify key patterns of digital transformation of accounting processes.

First of all, the revealed trend of increasing accounting efficiency confirms the hypothesis of a transition from traditional accounting systems to intelligent data processing models. A significant reduction in the error rate (from 8.7% to 2.3%) and a reduction in transaction processing time by more than 3 times indicate a qualitative change in accounting functions - from registration and control to

analytical and predictive. This result is consistent with the conclusions of Quattrone (2016), according to which digitalization transforms accounting into a tool to support managerial decision-making.

The increase in the share of automated operations to 78% confirms the trend described by Davenport and Ronanki (2018), about the gradual replacement of routine accounting procedures with intelligent systems. In the framework of this study, it was found that the introduction of AI not only reduces labor costs, but also improves the accuracy of cost classification (up to 94%), which is of fundamental importance for the transport and logistics industry, characterized by a complex cost structure.

An analysis of the cost structure showed a redistribution of financial resources towards digital technologies, which is consistent with the results of research by Bhimani and Willcocks (2014), emphasizing the investment nature of digitalization costs. Increasing the share of IT costs to 10.8% should be considered as a strategic investment aimed at improving the efficiency of the entire accounting and management system. At the same time, the decrease in the share of transportation costs indicates the indirect effect of digitalization, expressed in the optimization of logistics processes.

The results of the accounting transparency analysis are of particular importance. A significant decrease in the proportion of transactions without full documentation and untraceable transactions confirms the conclusions of Cockcroft and Russell (2018) that the use of big data contributes to increased transparency of financial flows. The study found that the introduction of AI technologies has reduced the level of opaque transactions by more than 3 times, which significantly increases the reliability of financial information and the effectiveness of internal control.

The anomaly detection results demonstrate a significant improvement in the quality of audit procedures. An increase in the proportion of detected deviations from 3.1% to 11.7%, while reducing false positives, confirms the effectiveness of using machine learning algorithms, which corresponds to the conclusions of Issa et al. (2016). This indicates a shift from a reactive control model to a proactive one based on data analysis.

The integrated efficiency assessment showed a steady increase in the index from 0.62 to 0.81, which confirms the systemic nature of the changes and indicates a comprehensive improvement in all elements of the accounting system. This result allows us to consider the proposed model as an effective tool for modernizing accounting in the transport and logistics sector.

From a theoretical point of view, the conducted research expands existing approaches to digitalization of accounting, offering integration of artificial intelligence and big data as the basis for formation of intelligent accounting systems. Unlike traditional models, the proposed approach provides not only accounting automation, but also its analytical development.

From a practical point of view, the results of the study have the following implications:

- improving the accuracy and efficiency of accounting;
- reduction of transaction and administrative costs;
- improving the transparency of financial flows;
- strengthening the internal control and audit system;
- optimization of the cost structure of transport and logistics enterprises.

However, a number of limitations of the study should be noted. Firstly, the analysis is based on simulated data, which requires further empirical verification in real enterprises. Secondly, the effectiveness of the proposed model depends on the quality of the source data and the level of digital maturity of the organization. Thirdly, the introduction of AI technologies is associated with additional costs and the need for staff training.

Despite these limitations, the results obtained confirm the significant potential of using artificial intelligence and big data to improve accounting for transport and logistics services. Further research may be aimed at developing industry standards for digital accounting, as well as integrating ESG metrics into intelligent accounting systems.

Conclusion. In the context of the digital transformation of the economy and the growing demands on the efficiency of financial resource management, the improvement of accounting for transport and logistics services is gaining strategic importance. The conducted research made it possible to substantiate the need for a transition from traditional accounting systems to intelligent models based on the use of artificial intelligence and big data technologies.

In the course of the work, a conceptual model of intelligent accounting was developed and tested, integrating machine learning algorithms and big data processing tools. The results showed that the introduction of AI technologies provides a significant increase in accounting accuracy, a reduction in errors, a reduction in information processing time and an increase in the degree of automation of accounting processes.

An analysis of the cost structure revealed a tendency to redistribute resources towards digitalization, which is accompanied by a decrease in the share of operating costs and an increase in the efficiency of logistics processes. The assessment of accounting transparency showed a significant reduction in untraceable transactions and deviations from budget targets, which indicates the strengthening of the internal control system.

The calculation of the integral efficiency index confirmed a steady improvement in the quality of the accounting system, which indicates the systemic nature of the positive changes. An important result is also an increase in the efficiency of anomaly detection, which minimizes financial risks and increases the reliability of accounting information.

The scientific novelty of the research lies in the development of an integrated approach to the integration of artificial intelligence and big data technologies into the accounting system of transport and logistics services, taking into account industry specifics. Unlike existing studies, the proposed model provides not only accounting automation, but also the formation of analytical and predictive information.

The practical significance of the work lies in the possibility of applying the proposed solutions to increase the efficiency of accounting processes, optimize costs and improve the quality of management decisions in transport and logistics companies.

At the same time, it is necessary to take into account the limitations associated with the need to ensure high-quality data, the significant costs of implementing digital technologies and the need to train qualified specialists.

The prospects for further research are related to the development of adaptive models of intelligent accounting, the integration of ESG indicators into the accounting analysis system, as well as the development of industry standards for digital accounting in logistics.

Thus, the results of the study confirm that the use of artificial intelligence and big data is a key area for improving accounting for transport and logistics services and forming an effective management system in the digital economy.

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