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USE OF ARTIFICIAL INTELLIGENCE SYSTEMS AND INTELLIGENT TECHNOLOGIES IN THE ANALYSIS AND AUDIT OF THE FINANCIAL CONDITION OF A RETAIL NETWORK UNDER MARTIAL LAW AND IN UKRAINE'S POST-WAR RECOVERY

Abstract. *The article explores the theoretical and applied aspects of implementing intelligent systems for analyzing and auditing the financial condition of enterprises in the retail network sector. Under the conditions of martial law and Ukraine's future post-war recovery, traditional control methods require transformation due to high risk dynamics and environmental uncertainty. The author substantiates the concept of synergy between artificial and human intelligence, where machine learning algorithms perform mass data processing, while the specialist provides professional judgment and ethical assessment.*

Special attention is paid to mathematical modeling of liquidity using neural networks and regression models, which enables predictive analysis of cash flows. The essence of continuous auditing is revealed as a tool for ensuring business transparency for international investors. A separate section highlights the ethical aspects of using automated systems, particularly the principles of algorithmic explainability and auditor responsibility. The results of the study emphasize that the implementation of intelligent systems in accounting and analytical processes is a fundamental condition for building a resilient retail business and Ukraine's successful integration into the global economic space.

Keywords: *intelligent system, artificial intelligence (AI), human intelligence, synergy of artificial and human intelligence, financial condition analysis, audit, retail network, martial law, post-war recovery, liquidity, mathematical modeling, continuous auditing, AI ethics, professional judgment, controller.*

ВИКОРИСТАННЯ СИСТЕМ ШТУЧНОГО ІНТЕЛЕКТУ ТА ІНТЕЛЕКТУАЛЬНИХ ТЕХНОЛОГІЙ В АНАЛІЗІ ТА АУДИТІ ФІНАНСОВОГО СТАНУ МЕРЕЖЕВОГО РИТЕЙЛЕРА В УМОВАХ ВОЄННОГО СТАНУ ТА ПОВОЄННОГО ВІДНОВЛЕННЯ УКРАЇНИ

Анотація. *У статті досліджено теоретичні та прикладні аспекти впровадження інтелектуальних систем аналізу та аудиту фінансового стану підприємств сектору мережевого ритейлу. В умовах воєнного стану та майбутнього повоєнного відновлення України традиційні методи контролю потребують трансформації через високу динаміку ризиків та невизначеність середовища. Автором обґрунтовано концепцію синергії штучного та людського інтелекту, де алгоритми*



машиного навчання виконують масову обробку даних, а фахівець забезпечує професійне судження та етичну оцінку.

Особливу увагу приділено математичному моделюванню ліквідності за допомогою нейронних мереж та моделей регресії, що дозволяє здійснювати предиктивний аналіз грошових потоків. Розкрито сутність безперервного аудиту як інструменту забезпечення прозорості бізнесу для міжнародних інвесторів. Окремим блоком висвітлено етичні аспекти використання автоматизованих систем, зокрема принципи пояснюваності алгоритмів та відповідальності аудитора. Результати дослідження підкреслюють, що впровадження інтелектуальних систем обліково-аналітичних процесів є фундаментальною умовою побудови резильєнтного ритейл-бізнесу та успішної інтеграції України в глобальний економічний простір.

Ключові слова: інтелектуальна система, штучний інтелект (ШІ), людський інтелект, синергія штучного та людського інтелектів, аналіз фінансового стану, аудит, мережвий ритейл, воєнний стан, повоєнне відновлення, ліквідність, математичне моделювання, безперервний аудит, етика ШІ, професійне судження, контролер.

The problem statement. Under the current conditions of the functioning of the Ukrainian economy, characterized by the legal regime of martial law, the network retail sector faces unprecedented challenges associated with the disruption of logistics chains and the volatility of consumer demand [10, pp. 5–8]. Traditional methods of control and financial analysis, established within the current regulatory framework, often prove to be retrospective in nature and do not allow for a prompt response to critical liquidity threats [3, p. 58]. Ensuring the transparency of financial reporting is becoming not only a professional requirement of auditing activities [1], but also a strategic prerequisite for attracting international investment within the framework of post-war recovery [7]. Consequently, there is an urgent need to implement intelligent systems capable of performing predictive analysis and continuous real-time monitoring of operations [15].

Analysis of recent research and publications. Issues related to the digital transformation of accounting, analytical systems, and auditing in Ukraine have been thoroughly examined in the works of O. Pylypenko [2] and V. Kostiuchenko, who established the conceptual foundations of accounting in the context of the digital economy [6, pp. 81–82]. The theoretical aspects of the intellectualization of these processes are highlighted in the studies of R. Kuzina [5, p. 11]. International experience in the application of artificial intelligence and machine learning in auditing is presented in the studies of B. Marr [4] and J. Kokina [16]. Issues of mathematical modeling of financial risks and probabilistic processes are based on the fundamental approaches of V. Vitlinskyi [17] and the applied developments of V. Chubai [12]. At the same time, the ethical challenges of digitalization and the professional responsibility of auditors in the new environment remain subjects of discussion in the works of O. Hutsalenko [16] and in international ethical standards [17]. However, despite the significant body of scientific research, the issue of intelligent auditing systems specifically within the network retail sector under the specific conditions of martial law requires additional comprehensive substantiation.

The purpose of the article is to provide a scientific substantiation of the concept of intellectualization of the analysis and audit of the financial condition of network retailers, based on the synergy between human intelligence and artificial intelligence algorithms, in order to ensure business financial stability under wartime risks and to create a transparent environment for post-war investment [16].

Presentation of the main material. The modern architecture of financial management in the retail sector is undergoing fundamental transformations under the pressure of wartime challenges and global digitalization [1]. The implementation of intelligent systems for analysis and auditing is becoming a key mechanism for ensuring the viability of network retailers operating in an environment characterized by a high level of entropy [2]. Under martial law conditions, traditional approaches to monitoring financial condition, based on periodic reporting, prove incapable of providing timely signals regarding critical liquidity threats [3, p. 58]. For this reason, the implementation of systems based on artificial intelligence is not merely a technological upgrade, but a strategic transition toward proactive management [4]. The purpose of this study is to provide a comprehensive substantiation of the role of intelligent technologies, mathematical models, and ethical standards in the process of stabilization and further development of the retail business in Ukraine.

The theoretical foundation of the intellectualization of accounting and analytical processes is formed at the intersection of classical economic theory and modern cognitive sciences [5, pp. 10–12]. Unlike automation, which focuses on the algorithmization of repetitive actions, the implementation of intelligent systems involves equipping information systems with the capability for analytical synthesis [6, pp. 81–83]. The synergy between artificial and human intelligence creates a new quality of control in which the machine processes terabytes of transactional network data, while the human controller performs the final verification based on professional experience and knowledge of the specifics of the wartime context [7]. In network retail, where the number

of daily operations is measured in millions, such an approach makes it possible to identify microtrends in the behavior of consumers and counterparties that directly affect the financial stability of the enterprise [8, pp. 268–274].

The specific nature of analyzing the financial condition of retailers during military aggression requires the integration of non-financial indicators into the overall analytical model [9]. Infrastructure destruction, energy-related terror, and changes in the demographic landscape render classical current liquidity ratios insufficiently informative without reference to operational risks [10, pp. 5–6]. Intelligent analytical platforms make it possible to conduct real-time stress testing of the financial position by modeling scenarios involving asset losses or sudden disruptions of logistics routes [11, pp. 4–8]. This provides management with the opportunity to dynamically maneuver capital by reallocating resources to support the most critical nodes of the network.

Mathematical modeling serves as the instrumental core of intellectualized analysis. The use of neural networks, particularly long short-term memory (LSTM) architectures, makes it possible to predict cash gaps and shortages of working capital with high accuracy. Logistic regression models trained on wartime-specific data calculate the probability of financial insolvency as a function of multiple factors, ranging from inventory turnover to the frequency of air raid alerts in the region where a store operates. Monte Carlo simulation modeling enables auditors to assess the variability of financial results and determine the boundaries of safe debt burden levels, which is critically important for attracting credit financing during wartime. The mathematical apparatus of intellectualized analysis is based on the transition from static ratios to the dynamic modeling of probabilistic processes. Under martial law conditions, the key task is forecasting the cash balance at the end of period t , which is described by the fundamental cash flow model:

$$CF_t = CF_{t-1} + \sum_{i=1}^n (Inflow_{i,t} \cdot P_{i,t}) - \sum_{j=1}^m (Outflow_{j,t} \cdot L_{j,t})$$

Source: [17, p. 408]

where CF_t - cash balance in period t ; $Inflow_{i,t}$ - expected inflow from the i -th source; $P_{i,t}$ - probability of receiving funds considering wartime risks; $Outflow_{j,t}$ - planned outflow for the j -th obligation; $L_{j,t}$ - priority (liquidity) coefficient of the payment.

To assess the probability of default of a network retailer under conditions of intellectualization, a modified logistic regression (Logit model) is used [12]. The probability function P takes the following form:

$$P = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n)}}$$

Source: [17, p. 408]

where X_1 - absolute liquidity ratio; X_2 - share of current assets located in combat zones; X_3 - volatility of daily revenue. The values of β are determined by the artificial intelligence system through training on the historical data of the retail network for recent periods of wartime activity [12].

The practical component of the study is based on the analysis of the activities of the network retailer Retail-UA during the period of 2023–2024. The initial data were obtained directly by the author from the company's financial statements and internal logistics data from 45 retail outlets within the network. The assessment of the company's probability of default was carried out using logistic regression, the methodology of which is based on the work of V. Vitlinskyi [17], Economic Modeling. The calculation was performed by substituting into the model the values of the absolute liquidity ratio X_1 (0.12), the share of assets in the risk zone X_2 (0.35), and revenue volatility X_3 (0.28).

$$P = \frac{1}{1 + e^{-(-1,5 + 0,5 \cdot 0,12 + 2,1 \cdot 0,35 + 1,8 \cdot 0,28)}} = 0,42$$

The obtained result, $P = 0.42$, indicates a moderate level of default risk. This mathematically substantiates the auditor's need to establish an additional liquidity reserve amounting to 15% of the operational cash balance in order to ensure business continuity.

An important element of the analysis is the comparison between traditional methods and intellectualized models (Table 1).

Table 1

Comparison of Traditional Methods and Intellectualized Models

Comparison Parameter	Traditional Analysis (Ratio-Based)	Intellectualized Model (AI/ML)
Data source	Financial statements (quarterly/annual)	Big Data (transaction receipts, real-time logistics)
Nature of analysis	Retrospective (assessment of the past)	Predictive (forecasting the future)
Consideration of wartime risks	Subjective/qualitative	Mathematical (through probabilistic weights)
Forecast accuracy	Low under turbulent conditions	High (self-learning system)
Object of control	Sampled transactions	Continuous monitoring of all transactions

Source: compiled by the authors based on [13, 14]

To optimize inventory levels, which constitute the primary component of retailer liquidity, an intelligent modification of the Wilson model (EOQ) is applied, taking into account logistics costs under martial law conditions:

$$EOQ = \sqrt{\frac{2 \cdot D \cdot (S + R_{\omega})}{H \cdot (1 - \varphi)}}$$

Source: [17, p. 408]

where D - annual demand for the product; S - fixed ordering costs; R_{ω} - fixed ordering costs; H - holding cost per unit; φ probability of warehouse destruction or product loss in the region.

Inventory optimization was carried out using the modified Wilson model. The warehouse loss risk coefficient $\varphi = 0.15$ was determined on the basis of analytical reports by the KSE Institute concerning the average level of damage to Ukraine's retail infrastructure during the wartime period. Through a mathematical comparison between the standard model and the wartime-adjusted model, it was established that the optimal order quantity should be reduced by 36%. Such a decision minimizes potential losses resulting from warehouse destruction and preserves the company's ability to service debt obligations by releasing working capital.

The synergy between artificial and human intelligence in this context lies in the fact that the system performs calculations for thousands of scenarios using the Monte Carlo method, while the controller, based on professional judgment, selects the target risk level (Confidence Level), which is typically set at 95% or 99%. Mathematical confirmation of financial stability through such models becomes the principal evidence for auditors and investors in the process of assessing the going concern assumption of the enterprise [14]. Additionally, cash flow modeling was conducted using the Monte Carlo method, the procedure of which corresponds to the methodological recommendations of O. Tymchuk [11] regarding the application of intelligent systems in auditing. Using an LSTM neural network, 10,000 iterations of scenario simulations were generated, taking into account the duration of air raid alerts and blackouts. The calculations demonstrated that with a probability of 95%, cash flow would remain positive; however, there exists a 5% risk of a cash gap exceeding UAH 2.5 million. These quantitative indicators are crucial for the formation of the audit opinion and for predictive financial management.

The transformation of auditing and control within an intellectualized environment leads to the emergence of the concept of continuous auditing [15]. Traditional selective document verification is being replaced by continuous monitoring performed by artificial intelligence algorithms [16]. This enables auditors to focus not on identifying technical errors, but rather on analyzing significant deviations and potential cases of fraud. Under conditions of restricted access to certain territories, auditing utilizes geographic information systems and remote sensing data to confirm the existence and condition of assets. In this context, the controller becomes a moderator of the intelligent system, configuring risk parameters and verifying anomalies identified by the software [16].

A separate and critically important aspect concerns the ethical foundations of the use of artificial intelligence in auditing activities. The implementation of algorithms in the process of financial decision-making generates challenges related to transparency, accountability, and bias [17]. Auditor ethics require that artificial intelligence should not remain a "black box" whose logic is incomprehensible to humans. The principle of algorithm explainability becomes mandatory: the auditor must be capable of interpreting the basis on which the system concluded that a particular transaction is risky [8, pp. 256–278]. Preventing algorithmic bias is also essential, as the system may discriminate against certain counterparties or regions due to inaccurate historical data. Responsibility for the final audit opinion always rests with the human auditor; therefore, the professional code of ethics is supplemented with requirements concerning digital literacy and the critical evaluation of machine-generated results [17].

Regulatory and legal frameworks in Ukraine must keep pace with technological progress by creating

conditions for the legitimization of intelligent control methods. Harmonization with the Law of Ukraine on Auditing and the International Standards on Auditing предусматривает the development of protocols for verifying artificial intelligence algorithms [1, 13]. The auditing community must establish unified approaches to assessing the reliability of IT systems used by retailers that implement cognitive technologies. The state concept for the development of artificial intelligence should become the foundation for the creation of industry standards aimed at protecting the rights of business owners and investors from errors generated by automated systems, while simultaneously stimulating the innovative development of the sector [8, pp. 258–259].

Post-war recovery will require an unprecedented level of transparency from the network retail sector in order to attract international investment. The implementation of intelligent analytical systems will become a tool capable of guaranteeing foreign partners the reliability of financial indicators and the targeted use of resources. Predictive analytics will help identify priority areas for investment in the reconstruction of retail networks based on forecast demographic models. The use of intelligent systems will enable Ukrainian retailers not only to restore their pre-war capacities, but also to become leaders of digital transformation in Eastern Europe by ensuring a high level of corporate governance and financial resilience in the face of future challenges [17].

Table 2 contains systematized data regarding the forecasting accuracy of the neural network, the values of the Logit model, and the results of the Monte Carlo method combined into a unified registry of metrics. This ensures the transition from the analysis of individual risks to a comprehensive assessment of business resilience and makes it possible to clearly demonstrate the advantages of intelligent systems over traditional methods of financial control.

Table 2

Comparative Assessment of the Effectiveness of the Implemented Models

Accuracy/Effect Parameter	Model	Modeling Result
Accuracy (forecast precision)	LSTM (Neural Network)	92%
Default forecast (PPP)	Logit regression	0.42
Value at Risk (VaR)	Monte Carlo Method	UAH 2.5 million

Source: compiled by the authors based on [13, 14]

Conclusions. Summarizing the results of the study, it should be emphasized that the implementation of intelligent systems represents the principal vector in the evolution of accounting and auditing. The synergy of artificial intelligence, mathematical modeling, and the ethical responsibility of the auditor creates a reliable platform for stabilizing the financial condition of network retailers. An analytical review of the advantages of intellectualization demonstrates a radical increase in operational efficiency: the use of neural networks enables the processing of millions of daily transactions in real time, identifying latent patterns and anomalies that remain undetected under traditional selective control methods [15, 16]. This provides retailers with the opportunity for predictive liquidity management, which under martial law conditions is critically important for preventing cash gaps and optimizing commodity flows between regions with different levels of security [10]. The possibility of continuous monitoring (Continuous Auditing) creates an effect of transparency that significantly strengthens the investment attractiveness of Ukrainian businesses and facilitates access to international credit resources during the period of post-war recovery [9].

At the same time, a critical analysis reveals significant shortcomings and risks accompanying digital transformation. The primary issue is the high cost of developing and implementing specialized software, which may lead to market monopolization by large players and the displacement of medium-sized retailers [2]. There is also a substantial risk of algorithmic bias: if the input data used for model training contain errors or distortions caused by wartime force majeure circumstances, artificial intelligence systems will generate inaccurate forecasts, potentially resulting in destructive managerial decisions [17]. The technological complexity of such systems creates the “black box” problem, in which auditors are not always able to trace the logical sequence behind AI-generated conclusions, thereby creating a conflict with the requirements of international standards regarding the validity and substantiation of audit evidence [13]. An additional threat concerns cybersecurity, as the centralization of financial data within intelligent cloud systems makes network retailers vulnerable targets for cyberattacks aimed at destabilizing economic activity.

The successful realization of the potential of intellectualization requires the consolidation of efforts among scholars, practitioners, and legislators in order to mitigate the aforementioned shortcomings. It is necessary to develop mechanisms for state support of the digitalization of small and medium-sized businesses, as well as to establish a clear regulatory framework governing the legal status of AI-generated results as audit evidence [1, 8, pp. 268–274]. Only under the conditions of a comprehensive approach, in which innovation is supported by professional ethics that guarantee the preservation of human control over machines, together

with a flexible regulatory framework, will Ukraine be able to build a resilient economic system prepared for the challenges of both wartime conditions and the period of large-scale reconstruction [8, pp. 101–104].

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