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## **Diagnosis of financial risks in the activities of agro-industrial enterprises within the enterprise risk management system as a tool of financial engineering**

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**Abstract.** Given the volatility of market conditions and the specific nature of the agro-industrial complex, timely diagnosis of financial risks not only enables loss minimisation but also ensures adaptability to external changes, optimises capital structure, and enhances solvency. This is particularly relevant for attracting investment and financing, as investors are guided by the enterprise's risk profile. The aim of the study was to improve methodological approaches to the diagnosis of financial risks as an important tool of financial engineering within the risk management system of agro-industrial enterprises. The study employed methods of scientific inquiry, namely: the systems approach, analysis, synthesis, scientific abstraction, and generalisation. To diagnose the level of financial risks using agro-industrial enterprises as examples, the method of calculating financial ratios and the method of taxonomic analysis were applied, along with tabular and graphical methods for presenting the research findings. The integral indicator (IFR) was constructed based on the main areas of risk assessment: liquidity, financial stability, solvency, profitability, and settlement efficiency. The study assessed the level of financial risk of agro-industrial enterprises during the period 2021-2023. The lowest risk was observed in EFI "Viterra Ukraine" (IFR = 0.114), while LLC "TAS Agro Center" demonstrated negative dynamics: the IFR increased from 0.022 to 0.572. Consistently high risk was identified in LLC "Agrotrade-Production" (IFR = 0.620 in 2023), with the highest level observed in LLC TC "Vitagro" (IFR = 0.688). The practical value of the study lies in the proposed approach to diagnosing the level of financial risks, which can be used to justify and make current and future management decisions in the risk management system of a business entity

**Keywords:** solvency; financial stability; profitability; financial performance; financial leverage

### **● INTRODUCTION**

The relevance of the research topic is driven by the need for comprehensive diagnosis of financial risks and the development of an effective risk management system in the agro-industrial sector. This will contribute not only to the financial security of individual enterprises but also to the overall stability of the agricultural sector. Under conditions

of globalisation and intensified competition, effective financial risk management has become a crucial element of the development strategy for agro-industrial enterprises. Insufficient attention to the identification and mitigation of risks may lead to loss of liquidity, increased credit burden, and even bankruptcy of enterprises. Financial

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engineering as a risk management tool enables agro-industrial enterprises to develop and implement modern financial strategies aimed at enhancing their resilience. The use of hedging, insurance, capital structure optimisation, and other financial mechanisms makes it possible to reduce the level of financial uncertainty and ensure stable development.

As financial risks faced by modern enterprises are among the most dangerous and destructive, there is an urgent need for their further study, analysis of their nature, classification, and the development of effective management methods. A significant number of scholars in the field of financial management and analysis have paid attention to the issue of diagnosing financial risks in the activities of enterprises. The authors N.S. Zgadova *et al.* (2025) paid attention to the theoretical aspects of financial risk management and studied their impact on the financial security of the enterprise. In the work by A. Nechiporenko (2023), approaches to defining the concept of “financial risk” were analysed, and the factors influencing financial risks of an enterprise are systematised. The necessity of financial risk management under transformational changes is substantiated, the specifics and main stages of the financial risk management process are examined, and conceptual foundations for financial risk management are proposed in the context of the enterprise’s financial security. The authors S. Zhukevych *et al.* (2023) emphasised the risk analysis system as an important component of the risk management mechanism. However, the issues related to the diagnosis of financial risks in enterprise activities were left unaddressed in the aforementioned works.

In the work by V.P. Ilchuk & O.V. Shishkina (2020), the necessity of using financial indicators as tools for identifying financial risks in industrial enterprises was substantiated. The authors V.M. Butenko & M.V. Baidatskiy (2023) emphasised that the risk management system must be holistic and identify the main stages of risk management, namely: risk identification, analysis, assessment, modification, and monitoring of key risk indicators. However, the authors did not address the issues related to organising a risk management system within the enterprise, nor did they substantiate the use of financial engineering as a means of creating competitive advantages through effective risk management. One example of a modern analytical approach is bibliometric analysis, which was conducted by J.R. Jena *et al.* (2023) as part of a study using data from the Scopus database covering the years 2007-2022. A total of 343 scientific publications were analysed using the tools VOSviewer and Biblioshiny (R Studio). A distinctive feature of this approach is the methodological generalisation of research in the field of financial engineering, which made it possible to identify potential directions for future studies.

The historical aspects of the essential characteristics of the stages in the evolution of financial engineering were explored by A. Panteleimonenko & A. Karnausenko (2024), where the authors demonstrated that at each stage of its development, financial engineering was associated with the creation of innovative financial instruments (approaches) tailored to the interests of specific market participants. The study by S.M. Khalatur (2024a) focused on examining the latest trends in financial engineering that

facilitate the transition to a digital economy. Particular attention is given to analysing the impact of digital financial instruments on global markets and the role of financial institutions in the new digital environment. However, the mentioned work lacks research on the use of financial engineering tools within enterprise-level risk management systems and does not sufficiently reveal how historical trends have influenced current financial engineering practices in the corporate sector.

The study by P. Fu *et al.* (2025) highlighted the importance of combining financial knowledge with quantitative methods, whereby financial engineering provides a deeper understanding of market mechanisms, contributing to improved risk management and decision-making through analytics and mathematical modelling. The use of financial engineering in conjunction with forecasting technologies confirms its effectiveness as a tool for enhancing the accuracy of financial predictions and fostering innovation in modern finance. In the work by O.M. Parubets & M.M. Zabashtanskiy (2021), financial engineering is considered a theoretical and practical foundation for developing and implementing strategies for the financial support of territorial community development, strengthening the financial autonomy of local self-government bodies, and ensuring the financial independence of local budgets. The article by S.M. Khalatur *et al.* (2024b) explored the essence of financial engineering and analyses its significance and role in the development and optimisation of the banking system, particularly in the context of managing the active operations of commercial banks. The study by V.A. Zamlinskiy (2018) is devoted to the development of an organisational and economic mechanism for implementing financial engineering and identifying key trends in the development of the banking market and the derivatives market in Ukraine. However, the reviewed works do not sufficiently address the application of financial engineering in the context of individual enterprises. Therefore, there is a need for further research focused on specific aspects of applying financial engineering at the enterprise level, taking into account its unique characteristics and needs. Financial engineering is a crucial process within the risk management system of agribusiness enterprises, as it enables effective financial risk management, enhances business resilience, and optimises financial flows.

Thus, in a competitive-oriented economy, financial engineering is an integral part of modern risk management in agribusiness enterprises, contributing to the reduction of financial threats, the preservation of market positions, and the assurance of long-term business resilience. Through modelling and analysis of financial risks, enterprises can develop more accurate financial strategies that support their stable growth. The analysis of literature on the implementation of financial engineering and the diagnosis of financial risks in enterprise activities has shown that, despite the high quality of current research, issues related to the improvement and integration of financial risk assessment tools into the risk management systems of business entities remain underexplored. The aim of this study was to improve the methodological foundations for diagnosing financial risks, which is considered a key instrument of financial engineering within the risk management system of agribusiness enterprises.

● **MATERIALS AND METHODS**

To achieve the stated objective, based on the analysis of scholarly contributions in the fields of financial engineering and financial management, the role of financial engineering within the business system and its areas of application was identified. The concept of “financial engineering of an economic entity” was clarified; the relevance of diagnosing financial risks within the risk management system of economic entities was substantiated; and the level of financial risks in the activities of agribusiness enterprises in Ukraine was diagnosed using the method of taxonomic analysis.

To explore the theoretical and methodological aspects of the nature and application of financial engineering in

the activities of business entities, methods of systems approach, analysis, synthesis, scientific abstraction, and generalisation were used. To test the developed methodological framework for diagnosing the level of financial risks in the activities of agribusiness enterprises, financial statements of agribusiness entities for the years 2021-2023 were used, as published on the official analytics and counterparty verification portal (Clarity Project, n.d.). The selection of enterprises for the study was justified by their affiliation with the agribusiness sector and their operations under NACE code 01 “Agriculture, hunting and related service activities” and NACE code 46.2 “Wholesale of agricultural raw materials and live animals” (Table 1).

**Table 1.** Indicators of the level of economic security of Ukraine by components (percentage of the optimum value)

Enterprise	NACE code	Primary activity
LLC “Agrotrade-Production” (n.d.)	01.61, 01.64, 01.63	Support activities in agriculture and post-harvest operations
PE “Zakhidnyi Buh” (n.d.)	01.11, 01.13, 01.30	Growing of cereals (excluding rice), leguminous crops, and oilseed crops
LLC AE “Nibulon” (n.d.)	46.21, 01.61, 01.63	Wholesale of grain, unprocessed tobacco, seeds, and animal feed
EFI “Viterra Ukraine” (n.d.)	46.21, 46.19, 46.33	Wholesale of grain, unprocessed tobacco, seeds, and animal feed
LLC “TAS Agro Center” (n.d.)	01.50, 01.61, 46.21	Mixed farming
LLC TC “Vitagro” (n.d.)	46.21, 46.19, 46.90	Wholesale of grain, unprocessed tobacco, seeds, and animal feed
LLC “Upi-Agro” (n.d.)	46.21, 46.36, 46.75	Wholesale of grain, unprocessed tobacco, seeds, and animal feed
LLC “Astarta-Kyiv” (n.d.)	01.11, 01.13, 46.21	Growing of cereals (excluding rice), leguminous crops, and oilseed crops
PE “Oliyar” (n.d.)	10.41, 46.21, 46.12	Production of oils and animal fats
LLC “Kernel-Trade” (n.d.)	10.41, 46.21, 46.12	Production of oils and animal fats

Source: compiled by the authors based on Clarity Project (n.d.)

To calculate partial indicators for assessing the financial risks of an enterprise, the coefficient analysis method was used, and the following indicators were calculated: the absolute liquidity ratio, which reflects the ratio of the most liquid assets (cash and current financial investments) to current liabilities. This ratio helps determine what portion of the enterprise’s short-term debt can be immediately repaid if necessary. An increase in this ratio over time indicates a reduction in the risk of losing solvency, and vice versa. It is calculated using the following formula:

$$\text{Absolute Liquidity Ratio} = \frac{\text{Cash and Cash Equivalents}}{\text{Current Liabilities}}. \tag{1}$$

The current liquidity ratio (coverage ratio) is calculated as the ratio of current assets to the enterprise’s short-term liabilities. It indicates how many monetary units of current assets correspond to each monetary unit of current liabilities and allows for assessing whether the total value of the enterprise’s current assets is sufficient for timely repayment of short-term debts. From a risk assessment perspective, a decline in this ratio below one signals a high risk of the enterprise losing its ability to meet its obligations. It is calculated using the following formula:

$$\text{Current Liquidity Ratio} = \frac{\text{Current Assets}}{\text{Current Liabilities}}. \tag{2}$$

The financial risk ratio reflects the relationship between borrowed funds and equity, indicating how many monetary units of liabilities correspond to one unit of own capital. An increase in this ratio over time signals a growing dependence of the enterprise on external sources of financing, which implies a higher risk of losing financial autonomy and, consequently, a decline in financial

stability – and vice versa. It is calculated using the following formula:

$$\text{Financial Risk Ratio} = \frac{\text{Borrowed Capital}}{\text{Equity}}. \tag{3}$$

The financial stability ratio determines the share of long-term liabilities within the total capital structure – that is, the sources of financing an enterprise can utilise over an extended period (at least more than one year). An increase in this ratio, under otherwise equal conditions, generally indicates a higher overall level of financial stability and, accordingly, a reduced risk of losing financial autonomy and independence. It is calculated using the following formula:

$$\text{Financial Stability Ratio} = \frac{\text{Equity} + \text{Long-Term Liabilities}}{\text{Total Liabilities}}. \tag{4}$$

The accounts receivable turnover ratio reflects the effectiveness of a company’s credit policy toward buyers in terms of receiving payments for goods sold on credit. It characterises the level of commercial risk associated with such financial relationships. The higher the value of this indicator, the faster the settlements with buyers occur, and the more efficiently the company manages these relationships, thereby minimising payment risk. It is calculated using the following formula:

$$\text{Accounts Receivable Turnover Ratio} = \frac{\text{Net Revenue for the Period}}{\text{Average Annual Accounts Receivable}}. \tag{5}$$

The accounts payable turnover ratio indicates the speed at which a company settles its obligations with creditors. Accordingly, it allows for assessing the risk of delayed payments and the potential for financial penalties from creditors. This indicator is calculated using the following formula:

Accounts Payable Turnover Ratio = Net Revenue for the Period / Average Annual Accounts Payable. (6)

The ratio of revenue growth rate to cost growth rate reflects the comparative dynamics of income and production expenses. It is calculated using the following formula:

Ratio of Revenue Growth to Cost Growth = Growth Rate of Net Revenue / Growth Rate of Cost of Goods Sold. (7)

The sales profitability ratio reflects the efficiency level of a company's core operations and indicates its ability to generate profit from the sale of products, goods, or services, showing the proportion of net profit within the structure of net sales revenue. A high value of the ratio signifies effective cost management and a sound commercial strategy, whereas a decline may signal the need to optimise production and distribution processes. The sales profitability ratio is calculated using the following formula:

Sales Profitability Ratio Based on Net Profit = Net Profit (Loss) / Net Revenue from Sales of Products. (8)

Return on Equity (ROE) characterises a company's profitability relative to the amount of equity invested and reflects the efficiency of its utilisation in generating net profit. The higher the value of this ratio, the more effectively the enterprise leverages its available resources to achieve financial results, which positively influences its investment appeal and market valuation. The ratio is calculated using the following formula:

ROE = Net Profit (Net Loss) / Average Annual Amount of the Company's Equity. (9)

To diagnose the level of financial risks in the activities of agribusiness enterprises, the use of economic and mathematical tools has been proposed. This approach enables the transformation of multidimensional data into a consolidated integral assessment, which, on the one hand, allows for the formation of a generalised profile of financial risk based on a system of criteria for each individual enterprise, and on the other hand, facilitates comparison across the sector and, if necessary, ranking of enterprises by risk level. The authors proposed the application of the taxonomic analysis method, which enables the calculation of taxonomic indicators of financial risk levels for each enterprise over time. The taxonomic indicator may vary within the interval [0; 1], and is interpreted as follows: the closer the calculated value is to one, the higher the overall level of financial risk in the activity of the enterprise under study.

To construct the taxonomic indicators, the algorithm described by W. Pluta (1986) has been adopted. It involves the following steps: formation of an observation matrix based on the calculated partial indicators of financial risk for agribusiness enterprises; construction of a standardised matrix applied to the initial data; formation of a reference vector, i.e. determination of benchmark values for all indicators. This required the classification of indicators into stimulators and destimulators, depending on how they reflect the dynamics of financial risk in the enterprise's activity. In this context, stimulators are indicators whose increase over time signals a rise in financial risk, while destimulators are those whose growth indicates a reduction in risk exposure for the enterprise. For stimulators, the

reference vector was defined as the maximum value among all standardised observations; for destimulators, it was the minimum. Subsequently, Euclidean distances were calculated between the indicators in the matrix and the reference vector, followed by the computation of the integral (taxonomic) indicator.

For further diagnostics and determination of the risk level in the activities of agribusiness enterprises, the use of the Harrington scale has been proposed. This scale enables effective measurement of the intensity of the criterial property of the phenomenon or process under investigation. The numerical boundary values of the Harrington scale were derived from the analysis and processing of a large dataset of statistical information, as presented in the work of O.G. Tyzhnenko (2021). Harrington scale application is justified by its universal nature and widespread use in the qualitative gradation of quantitative criteria when assessing economic processes, allowing for an adequate economic interpretation of the diagnostic results obtained.

## ● RESULTS

### **The essence and role of financial engineering in the business system and its areas of application**

In the current conditions of economic development, characterised by the globalisation of financial markets and the digitalisation of the economy, financial engineering plays a pivotal role in ensuring the competitiveness and resilience of economic entities. It encompasses the development and implementation of innovative financial instruments, methods, and strategies aimed at effective risk management, optimisation of financial flows, and capital mobilisation. Globalisation opens up new opportunities for enterprises, while simultaneously intensifying competition and increasing financial risks. Financial engineering enables businesses and financial institutions to devise new mechanisms for capital management, adapt to change, and maintain financial stability.

Financial engineering is a relatively young scientific discipline that emerged as a distinct field in the 1990s. A significant milestone in its development was the awarding of the Nobel Prize in 1997 to researchers F. Black and M. Scholes (1999) for their work in the field of financial instruments. The proposed option pricing model (Black-Scholes option pricing model) became a widely recognised standard for the analysis of derivatives in international financial markets. The emergence of financial engineering was driven by several key factors: the inefficiency of traditional financial risk management methods under conditions of high market volatility; the rapid development of information technologies and the growing financial awareness of society; the transformation of financial markets from fragmented segments into a unified global system; the liberalisation and deregulation of financial markets, which led to increased instability; and tax disparities and regulatory constraints that stimulated the search for new financial solutions.

Financial engineering emerged as a response to the challenges of the modern economy, fostering the development of innovative financial instruments and risk management strategies. Although numerous interpretations of the concept exist, as of 2025, no unified systemic approach has been established regarding its definition, core functions, or

areas of application. Based on the analysis of approaches by I.M. Chmutova *et al.* (2018) in the field of financial management and engineering, several key domains have been identified where financial engineering is most actively employed: the derivatives market, the stock market, corporate finance, and banking. In the banking sector, financial engineering is aimed at creating conditions for the efficient movement of financial capital – both for banks themselves and for their clients. It facilitates the development of innovative banking products that enable additional profit generation, risk diversification, and the application of speculative strategies to achieve income with minimal risk.

In the stock market sector, financial engineering plays a significant role by creating non-standard financial instruments and securities tailored to the specific needs of investors and issuers. The primary objective of such instruments is to ensure an optimal balance between profitability, risk, and asset liquidity for business entities. In the derivatives market, financial engineering is employed to develop new financial derivatives through the combination or modification of existing instruments. Within the corporate sector, financial engineering facilitates the creation of effective financial tools that contribute to increasing the market value of enterprises, optimising cash flow, and implementing robust risk management strategies. Financial engineering is a versatile tool that can be applied across various areas of finance to address complex challenges and generate innovative solutions.

Researchers offer various interpretations of the role and functions of financial engineering within the context of enterprise activity. A. Kucherenko (2018) proposed a systemic approach, defining financial engineering as a set of interrelated financial innovations, technologies, and instruments integrated into a company's financial management to optimise business processes and harness its innovative potential. The authors A. Nurpeisova *et al.* (2022) viewed financial engineering as an Internet of Things (IoT) technology and explored its application in the field of transport and logistics to address a range of complex challenges within the transportation sector.

Based on the definitions provided, financial engineering within an enterprise is understood as a commercial process involving the development and implementation of synergistically functioning combinations of financial innovations, technologies, and instruments. These are aimed at maximising profit, increasing enterprise value, resolving financial challenges (ranging from liquidity crises to capital acquisition), and optimising business processes by unlocking innovative resource potential. At the same time, financial engineering for economic entities is defined as a system of strategic financial management that entails the use of modern financial instruments, methods, and technologies to optimise financial flows, minimise risks, and enhance the market value of the business.

### **Justification of the relevance and directions of financial risk diagnostics in enterprise activity**

For financial engineering to function effectively, a clear understanding of the potential risks faced by an enterprise is essential. This is precisely where risk diagnostics gain critical relevance – as a systematic process of identifying, assessing, and analysing financial threats that may impact

the company's operations. According to the authors, the necessity and appropriateness of applying financial risk diagnostics as a tool of financial engineering are justified by the following considerations: for an individual business entity, diagnostics serve as a means of comprehensive assessment of financial risk levels, identifying the parameters of financial activity within which specific types of financial risks arise and materialise. This enables the detection of "weak points" in the enterprise's financial relations system and, on this basis, the development of effective managerial decisions in the field of risk management aimed at preventing and minimising adverse consequences. For entities interacting with the enterprise under diagnosis – such as counterparties, investors, banks, and financial institutions – the results of diagnostics provide a foundation for the use of financial engineering tools in their dealings with the enterprise, thereby reducing their own financial risk exposure.

Thus, financial risk diagnostics constitute an integral part of financial engineering, as they enable informed decision-making regarding the selection and application of financial instruments; minimise potential losses; and ensure the financial stability of the enterprise. They also enhance the overall effectiveness of financial engineering and contribute to the achievement of strategic objectives. When referring to financial risk diagnostics as a tool of financial engineering within an enterprise, the authors understand it as a structured process of identifying, assessing, and analysing indicators of the presence and potential manifestation of financial risks that may adversely affect the company's financial stability and profitability. The ultimate aim is to apply financial engineering instruments to manage these risks effectively. Moreover, the results of such diagnostics may be employed to develop hedging mechanisms within the enterprise's risk management system, thereby reinforcing its capacity to mitigate financial threats.

Agribusiness is a strategic sector of the economy, yet it is characterised by a high level of risk. Among these, financial risks hold particular significance, as they can substantially affect the stability and profitability of enterprises. Effective diagnostics of such risks is a prerequisite for successful risk management, providing businesses with the means to minimise exposure and ensure the stability of financial flows. Based on a comparative analysis of literature on financial diagnostics and risk management in economic entities (Zhuravlyova *et al.*, 2017; Berest & Sablina, 2022; Zhukevych *et al.*, 2023), the following types of financial risks and corresponding evaluation coefficients have been proposed for constructing an integral indicator to assess the financial risk level of agribusiness enterprises (Table 2).

Since financial risk within an enterprise is inherently complex, it is essential from a risk management perspective to account for the most critical types of financial risks, as outlined above. The risk of losing solvency and liquidity is associated with the enterprise's inability to meet its financial obligations fully and on time due to a shortage of cash or difficulties in converting assets into liquid funds. The materialisation of this risk may lead to temporary or chronic insolvency, the onset of a financial crisis, and even bankruptcy. To assess this type of risk, the calculation of the absolute liquidity ratio and the current liquidity ratio has been selected.

**Table 2.** Indicators of the level of economic security of Ukraine by components (percentage of the optimum value)

Type of financial risk	Risk of loss of solvency and liquidity		Risk of loss of financial stability		Settlement risk		Risk of decline in financial performance		
Risk indicators	Absolute Liquidity Ratio(ALR)	Current Liquidity Ratio (CLR)	Financial Risk Ratio (FRR)	Financial Stability Ratio (FSR)	Accounts Receivable Turnover Ratio (ART)	Accounts Payable Turnover Ratio (APT)	Ratio of Net Revenue Growth to Cost Growth(RRCG)	Return on Sales Ratio (ROS)	Return on Equity Ratio (ROE)

Source: compiled by the authors

The risk of losing financial stability is associated with a disruption in the balance between equity and borrowed funds, which may lead to excessive dependence on creditors, increased debt burden, and, consequently, financial instability and loss of the enterprise's financial autonomy. To diagnose this type of financial risk, the financial risk ratio and the financial stability ratio have been selected. Settlement risk arises from potential issues in counterparties fulfilling their financial obligations, delays in payments, or fraudulent activities. Such occurrences may cause desynchronization of cash flows within the enterprise, cash gaps, and, as a result, deterioration of its financial condition. To assess this type of risk, the accounts receivable turnover ratio and the accounts payable turnover ratio have been chosen.

The risk of declining financial performance is associated with reduced profitability, decreased revenues, or

increased expenses, which may occur due to unfavourable market conditions, ineffective management, or rising production costs caused by resource price increases, among other factors. The consequences of this type of risk may include reduced operational efficiency, lower financial results, losses, and a lack of funds to meet obligations. To diagnose this risk in the study, the following indicators have been proposed: the ratio of net revenue growth to cost growth, the return on sales ratio, and the ROE of the enterprise.

#### Analysis of the level of financial risks in the activities of agribusiness entities in Ukraine

The dynamics of the above-described partial indicators, calculated based on the financial reporting data of the analysed agribusiness companies for the period 2021-2023, are presented in Table 3.

**Table 3.** Calculation of partial indicators for assessing financial risks of agribusiness enterprises for 2021-2023

Enterprises / Indicators	Year	ALR	CLR	FRR	FSR	ART	APT	RRCG	ROS	ROE
LLC "Agrotrade-Production"	2021	0.000	1.068	12.607	0.074	0.858	2.094	0.917	0.075	0.697
	2022	0.023	1.059	14.989	0.063	0.647	3.185	1.041	-0.007	-0.050
	2023	0.006	1.038	19.748	0.048	0.765	12.158	1.007	0.001	0.016
PE "Zakhidnyi Buh"	2021	0.080	3.264	0.929	0.837	2.908	25.366	1.057	0.419	0.491
	2022	0.021	2.664	0.910	0.780	3.403	15.875	1.095	0.261	0.315
	2023	0.049	1.762	1.218	0.727	3.668	8.480	1.095	0.007	0.010
LLC AE "Nibulon"	2021	0.001	0.708	1.815	0.488	17.622	4.927	0.996	0.032	0.099
	2022	0.011	0.302	7.719	0.194	7.194	2.011	0.838	-0.616	-1.111
	2023	0.057	0.322	14.867	0.134	26.858	4.792	0.838	-0.053	-0.501
EFI "Viterra Ukraine"	2021	0.102	1.054	11.129	0.086	14.373	5.199	0.992	0.029	1.093
	2022	0.138	1.519	1.624	0.385	8.738	3.668	1.127	0.077	0.947
	2023	0.461	4.447	0.259	0.794	9.735	9.473	1.127	0.081	0.409
LLC "TAS Agro Center"	2021	0.678	2.998	1.535	0.691	4.164	8.849	1.480	0.331	1.165
	2022	0.001	1.933	5.200	0.535	3.664	4.173	0.732	-0.022	-0.064
	2023	0.001	2.114	2.114	0.580	2.869	2.954	0.732	-0.088	-0.243
LLC TC "Vitagro"	2021	0.000	1.078	50.939	0.073	2.070	2.894	0.951	0.003	0.120
	2022	0.000	1.165	18.642	0.142	1.459	3.965	1.025	0.010	0.310
	2023	0.000	1.125	16.040	0.111	1.357	4.339	1.025	-0.013	-0.268
LLC "Upi-Agro"	2021	0.000	1.001	0.078	0.928	0.027	0.000	0.966	-0.033	0.000
	2022	0.000	1.000	1.114	0.473	0.004	36.482	0.963	-0.070	0.000
	2023	0.000	0.997	1.494	0.401	0.002	46.404	0.963	-0.227	-0.001
LLC "Astarta-Kyiv"	2021	0.007	0.238	1.167	0.588	1.104	3.735	0.940	-1.087	-0.269
	2022	0.042	0.404	0.721	0.734	1.772	4.337	1.278	-0.495	-0.144
	2023	0.001	0.260	1.304	0.571	3.225	5.500	1.278	0.392	0.216
PE "Oliyar"	2021	0.020	1.121	1.921	0.416	7.360	15.307	1.069	0.039	0.122
	2022	0.108	1.783	1.300	0.610	7.881	17.455	1.108	0.050	0.167
	2023	0.002	5.295	0.665	0.871	5.306	16.334	1.108	0.068	0.141
LLC "Kernel-Trade"	2021	0.098	1.155	3.149	0.241	6.051	9.365	0.902	-0.020	-0.154
	2022	0.085	1.273	2.395	0.295	3.122	5.992	1.257	0.076	0.399
	2023	0.317	1.912	0.855	0.539	2.015	7.271	1.257	0.070	0.204

Source: calculated by the authors

The results of the calculated partial indicators for assessing financial risks of agribusiness enterprises served as the input data for the standardisation procedure, which

resulted in the construction of a standardised indicator matrix (Table 4). The results of constructing the reference vector for agribusiness enterprises are presented in Table 5.

**Table 4.** Standardised matrix of financial risk assessment indicators for the agribusiness enterprise over the period 2021-2023

Enterprises / Indicators	ALR	CLR	FRR	FSR	ART	APT	RRCG	ROS	ROE
<b>2021</b>									
LLC "Agrotrade-Production"	-0.472	-0.309	0.263	-1.154	-0.804	-0.749	-0.653	0.238	0.716
PE "Zakhidnyi Buh"	-0.091	1.953	-0.489	1.236	-0.460	2.320	0.178	1.088	0.307
LLC AE "Nibulon"	-0.469	-0.681	-0.432	0.144	2.006	-0.375	-0.186	0.131	-0.470
EFI "Viterra Ukraine"	0.014	-0.324	0.168	-1.116	1.462	-0.340	-0.208	0.125	1.502
LLC "TAS Agro Center"	2.786	1.679	-0.450	0.779	-0.250	0.142	2.693	0.871	1.646
LLC TC "Vitagro"	-0.473	-0.299	2.730	-1.158	-0.601	-0.644	-0.450	0.059	-0.430
LLC "Upi-Agro"	-0.474	-0.378	-0.544	1.522	-0.943	-1.025	-0.365	-0.028	-0.668
LLC "Astarta-Kyiv"	-0.441	-1.165	-0.474	0.456	-0.763	-0.533	-0.517	-2.635	-1.203
PE "Oliyar"	-0.380	-0.255	-0.425	-0.080	0.286	0.994	0.248	0.148	-0.426
LLC "Kernel-Trade"	-0.472	-0.309	0.263	-1.154	-0.804	-0.749	-0.653	0.238	0.716
<b>2022</b>									
LLC "Agrotrade-Production"	-0.394	-0.355	1.480	-1.445	-1.010	-0.602	-0.030	0.248	-0.242
PE "Zakhidnyi Buh"	-0.441	1.913	-0.707	1.446	-0.124	0.568	0.287	1.238	0.454
LLC AE "Nibulon"	-0.650	-1.424	0.351	-0.917	1.095	-0.710	-1.226	-2.006	-2.262
EFI "Viterra Ukraine"	1.898	0.294	-0.596	-0.145	1.591	-0.557	0.472	0.555	1.657
LLC "TAS Agro Center"	-0.836	0.880	-0.041	0.460	-0.040	-0.511	-1.849	0.191	-0.268
LLC TC "Vitagro"	-0.856	-0.205	2.047	-1.126	-0.749	-0.530	-0.125	0.309	0.444
LLC "Upi-Agro"	-0.863	-0.438	-0.675	0.210	-1.216	2.467	-0.489	0.012	-0.147
LLC "Astarta-Kyiv"	-0.023	-1.281	-0.736	1.264	-0.648	-0.496	1.359	-1.558	-0.420
PE "Oliyar"	1.313	0.668	-0.646	0.761	1.315	0.713	0.362	0.458	0.172
LLC "Kernel-Trade"	0.852	-0.052	-0.476	-0.508	-0.214	-0.343	1.240	0.552	0.613
<b>2023</b>									
LLC "Agrotrade-Production"	-0.510	-0.529	1.799	-1.457	-0.604	0.030	-0.215	-0.143	0.065
PE "Zakhidnyi Buh"	-0.251	-0.098	-0.601	0.845	-0.240	-0.257	0.306	-0.105	0.042
LLC AE "Nibulon"	-0.198	-0.955	1.167	-1.164	2.670	-0.545	-1.203	-0.485	-1.847
EFI "Viterra Ukraine"	2.282	1.500	-0.725	1.073	0.521	-0.179	0.491	0.361	1.520
LLC "TAS Agro Center"	-0.542	0.111	-0.485	0.346	-0.340	-0.688	-1.823	-0.707	-0.893
LLC TC "Vitagro"	-0.547	-0.477	1.319	-1.243	-0.530	-0.580	-0.104	-0.233	-0.985
LLC "Upi-Agro"	-0.549	-0.554	-0.565	-0.260	-0.700	2.703	-0.467	-1.581	0.004
LLC "Astarta-Kyiv"	-0.543	-0.992	-0.590	0.318	-0.296	-0.489	1.376	2.320	0.807
PE "Oliyar"	-0.537	2.004	-0.672	1.334	-0.034	0.356	0.382	0.280	0.527
LLC "Kernel-Trade"	1.397	-0.009	-0.648	0.209	-0.447	-0.351	1.257	0.293	0.760

Source: calculated by the authors

**Table 5.** Formation of the reference vector

Indicator	Stimulator / Destimulator	2021	2022	2023
Allocation Coefficient	Destimulator	-0.474	-0.863	-0.549
SR	Destimulator	-1.165	-1.424	-0.992
ROCE	Destimulator	2.730	2.047	1.799
Financial Stability	Destimulator	-1.158	-1.445	-1.457
ITR	Destimulator	-0.943	-1.216	-0.700
CTR	Destimulator	-1.025	-0.710	-0.688
NPM	Destimulator	-0.740	-1.849	-1.823
ROA	Destimulator	-2.635	-2.006	-1.581
ROE	Destimulator	-1.203	-2.262	-1.847
Allocation Coefficient	Destimulator	-0.474	-0.863	-0.549

Source: calculated by the authors

Based on the calculations performed, taxonomic indicators of the financial risk level in the activities of agribusiness enterprises (IFR) were constructed, and the

studied economic entities were ranked according to the level of risk in their operations on an annual basis for the period 2021-2023 (Table 6).

**Table 6.** Ranking results of agribusiness enterprises by financial risk level in their activities for the period 2021-2023

Rank	2021		2022		2023	
	Enterprise	IFR	Enterprise	IFR	Enterprise	IFR
1	LLC "TAS Agro Center"	0.022	EFI "Viterra Ukraine"	0.126	EFI "Viterra Ukraine"	0.114
2	PE "Zakhidnyi Buh"	0.117	PE "Zakhidnyi Buh"	0.141	LLC "Astarta-Kyiv"	0.186
3	LLC AE "Nibulon"	0.349	PE "Oliyar"	0.192	PE "Oliyar"	0.218
4	EFI "Viterra Ukraine"	0.355	LLC "Kernel-Trade"	0.274	LLC "Kernel-Trade"	0.269
5	PE "Oliyar"	0.379	LLC "Upi-Agro"	0.334	LLC "Upi-Agro"	0.382
6	LLC "Upi-Agro"	0.392	LLC "Astarta-Kyiv"	0.351	PE "Zakhidnyi Buh"	0.399
7	LLC "Kernel-Trade"	0.459	LLC "TAS Agro Center"	0.426	LLC AE "Nibulon"	0.535
8	LLC "Agrotrade-Production"	0.480	LLC TC "Vitagro"	0.505	LLC "TAS Agro Center"	0.572
9	LLC "Astarta-Kyiv"	0.565	LLC "Agrotrade-Production"	0.554	LLC "Agrotrade-Production"	0.620
10	LLC TC "Vitagro"	0.642	LLC AE "Nibulon"	0.646	LLC TC "Vitagro"	0.688

**Source:** calculated by the authors

Considering that the value of the taxonomic indicator used to assess the level of financial risks in the activities of agribusiness enterprises ranges from 0 to 1, and in

accordance with the gradation values of Harrington's verbal-numerical scale, a scale of risk level ranges has been constructed (Table 7).

**Table 7.** Scale of financial risk level ranges

Range of variation of the integral financial risk indicator (IFR)	Risk level description
$0.00 \leq \text{IFR} \leq 0.36$	Low
$0.36 \leq \text{IFR} \leq 0.64$	Medium
$0.64 \leq \text{IFR} \leq 1$	High

**Source:** developed by the authors based on O.G. Tyzhnenko (2021)

Thus, based on the results of the diagnosis of the financial risk level in the activities of agribusiness enterprises, the following can be established. In 2021, the lowest level of financial risk was observed in the activities of LLC "TAS Agro Center", as confirmed by the minimum value of the taxonomic indicator IFR of 0.022. This indicates a stable financial condition of the studied enterprise, a high level of liquidity, solvency, financial stability, a fairly high speed of settlements, and a high level of profitability. A low level of financial risk according to Harrington's scale was also identified in PE "Zakhidnyi Buh" (IFR 0.117). A medium level of financial risk was observed in the activities of the majority of enterprises (7 out of 10 studied business entities), where the taxonomic indicator of financial risk ranged from 0.349 for LLC AE "Nibulon" to 0.565 for LLC "Astarta-Kyiv". In contrast, the highest level of financial risk was characteristic of LLC TC "Vitagro", whose IFR amounted to 0.642, indicating an unstable financial condition of this entity and a high level of risk in interactions with it.

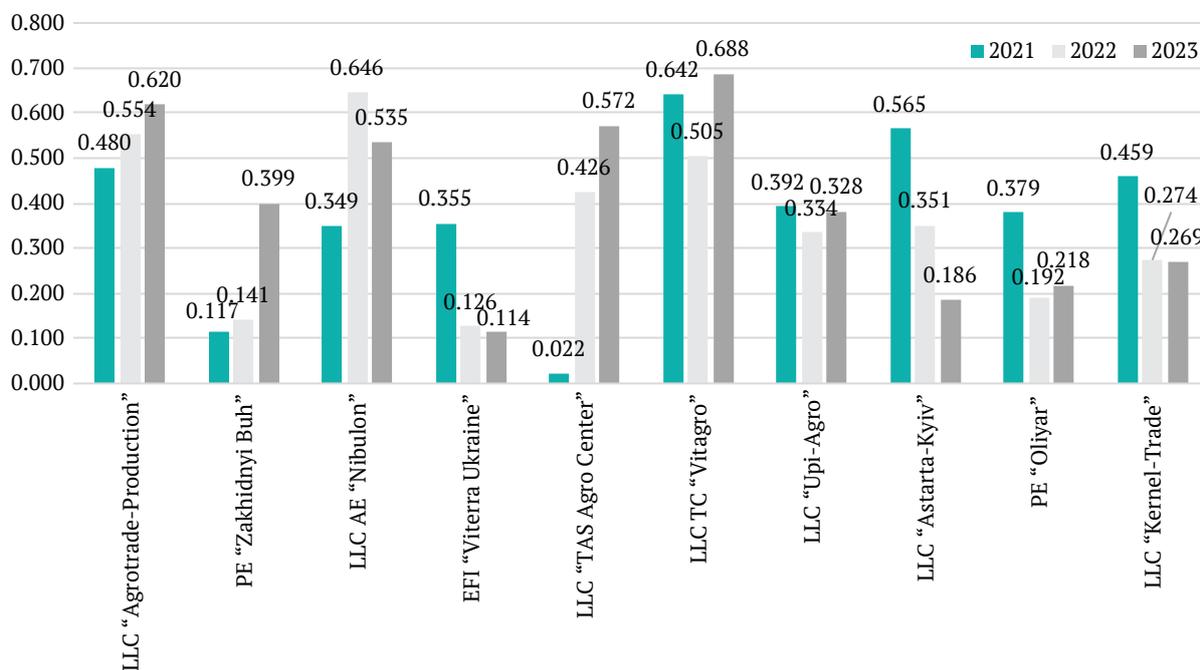
In 2022, the lowest level of financial risk was observed in the activities of EFI "Viterra Ukraine", where the taxonomic indicator IFR amounted to 0.126. A low level of financial risk according to Harrington's scale was also observed in the activities of PE "Zakhidnyi Buh", PE "Oliyar", LLC "Kernel-Trade", LLC "Upi-Agro", and LLC "Astarta-Kyiv" (IFR range from 0.141 to 0.351). This dynamic indicates that despite 2022 being the year of the start of the full-scale invasion of Ukraine and the conduct of

active hostilities, the mentioned enterprises managed to maintain a stable financial condition and improve their financial indicators. A medium level of financial risk was identified for LLC "TAS Agro Center" (IFR 0.426), LLC TC "Vitagro" (IFR 0.505), and LLC "Agrotrade-Production" (IFR 0.554). It can be seen that this dynamic is positive for LLC TC "Vitagro", which in the previous year was characterised by a high level of risk. Thus, the mentioned enterprise improved its financial condition and increased its reliability in interactions. In contrast, LLC "TAS Agro Center" demonstrated a negative dynamic in the level of risk, shifting from a low to a medium level, which indicates a deterioration in its financial condition. The highest level of financial risk, classified as high, was demonstrated by LLC AE "Nibulon", whose taxonomic indicator IFR significantly increased from 0.349 to 0.646. This dynamic is negative both for the enterprise itself and for its partners, counterparties, and creditors.

In 2023, the enterprise with the lowest level of financial risk remained EFI "Viterra Ukraine", with the taxonomic indicator IFR showing the minimum value among all studied entities at 0.114. The number of enterprises that also demonstrated a low level of financial risk decreased compared to 2022 from six to four, including LLC "Astarta-Kyiv", PE "Oliyar", and LLC "Kernel-Trade". The financial risk level increased from low to medium for LLC "Upi-Agro" (IFR 0.382) and PE "Zakhidnyi Buh" (IFR 0.399). LLC "TAS Agro Center" (IFR 0.572) and LLC

“Agrotrade-Production” (IFR 0.620) remained within the medium risk range. A positive trend towards a shift from high to medium financial risk was demonstrated by LLC AE “Nibulon” (IFR 0.535). In contrast, an increase in financial

risk to a high level was noted in the activities of LLC TC “Vitagro” (IFR 0.535). The dynamics of the taxonomic indicators of financial risk in the activities of the studied business entities are presented in Figure 1.



**Figure 1.** Dynamics of taxonomic indicators of the financial risk level of agribusiness enterprises

Source: compiled by the authors

Thus, by analysing the dynamics of financial risk levels according to the taxonomic indicator, it becomes evident that among the studied business entities, the most significant and consistent increase in risk levels was demonstrated by LLC “Agrotrade-Production” and LLC “TAS Agro Center”. This serves as a negative signal not only for investors and counterparties, but also directly for the owners and shareholders of the enterprise. A clear trend towards the deterioration of their financial condition is observed, which may hinder further cooperation with these enterprises from external stakeholders and leads to a decline in their investment attractiveness. A negative trend towards an increase in risk levels has also been identified in PE “Zakhidnyi Buh”; however, it is not as rapid, and the financial risk level of this enterprise is assessed as moderate. An unstable trend in risk levels is observed in LLC AE “Nibulon”, LLC TC “Vitagro”, and LLC “Upi-Agro”. At the same time, LLC TC “Vitagro” recorded the highest risk level among all analysed enterprises in both 2021 and 2023, indicating a high level of risk in engaging with it. A positive trend of consistent risk reduction was demonstrated by EFI “Viterra Ukraine”, PE “Oliyar”, LLC “Kernel-Trade”, and LLC “Astarta-Kyiv”, which serves as a favourable indicator for external stakeholders.

The results of the diagnostics may serve as a foundation for applying such financial engineering instruments as: development of a risk hedging strategy (currency, credit, price risks) through the use of derivatives (forwards, futures, options) or the conclusion of long-term contracts with fixed terms (e.g., for product supply or raw material

procurement); securitisation of risky assets: restructuring the asset portfolio by forming an asset pool and issuing securities, which will help reduce risk and attract additional financing; financial restructuring of companies with increasing risk (LLC “Agrotrade-Production”, LLC “TAS Agro Center”) through changes in capital structure (reducing the share of borrowed funds) or optimising the level of financial leverage (the ratio of liabilities to equity); development of individual financial products depending on the level of risk, for example, the introduction of structured financial products to attract capital at a lower cost or to protect against specific risks.

## ● DISCUSSION

The obtained results complement the work of researchers in the field of financial risk management and diagnostics in the activities of business entities. The research team led by A. Shibani *et al.* (2024) identified financial and economic risks as the most significant in a study dedicated to the risks facing Lebanon’s construction sector amid a prolonged economic crisis. Based on expert surveys, it was established that the main threats are linked to currency fluctuations, inflation, and lack of solvency. The study also emphasised the importance of implementing risk management in construction projects, despite existing organisational and economic barriers. However, it would be appropriate to further investigate the risk of losing financial stability and declining financial performance among construction enterprises.

In the study by Italian researchers F. Dainelli *et al.* (2024), an adaptive model for assessing default risk is

proposed, which accounts for the dynamic interaction of credit and market risk factors to evaluate the prospective probability of default (PD). This is achieved by establishing interest rate ranges based on the company's projected performance, changes in its financial structure, and anticipated trends in lending conditions. It can be agreed that such an approach holds potential for significantly enhancing financial intermediation and verifying forward-looking financial information in the process of default risk assessment. At the same time, the authors do not consider the complex nature of the financial risk system of business entities, which is particularly relevant in the context of transformational changes in the external environment and the evolving needs of external users of financial information.

The research team led by S. Zhukeyvych *et al.* (2023) examined a range of factors that comprehensively characterise the financial and economic activities of an enterprise, and developed a methodology for risk analysis and assessment that reflects the complexity of the concept of financial condition across the following dimensions: liquidity indicators, financial stability, business activity, and operational efficiency. It is worth noting that the primary objective of this study was to conduct a quantitative assessment of risk within the enterprise's financial security system. Acknowledging that the development of an effective risk management system and its universal functional component – risk analysis – are pressing issues of the present day, the study enables the formulation of a set of measures aimed at minimising threats and risks in the financial and economic activities of business entities. The outlined risk assessment dimensions were further expanded to include settlement risk, which arises from potential issues in counterparties fulfilling their financial obligations, payment delays, or fraud. This type of risk may lead to the desynchronisation of cash flows within the enterprise, cash gaps, and, consequently, a deterioration in the financial condition of the enterprise.

In the study by L. Ding *et al.* (2024), a sample of Chinese manufacturing companies listed on the A-shares market during the period 2012-2022 was analysed to explore the relationship between systemic risk, financial performance, and ESG indicators (environmental, social, and governance aspects). The findings revealed that a reduction in systemic risk contributes to the improvement of companies' ESG indicators with a lag of one to two reporting periods, with financial performance playing a key role in this process. However, the study did not devote sufficient attention to the detailed assessment of specific financial risks. In particular, it did not consider how individual types of financial risk – such as liquidity risk, financial stability risk, and settlement risk – respond to changes in financial performance in both the short and long term.

The study conducted by C.A. Wolf & J. Karszes (2023) analysed the financial risks and resilience of 105 dairy farms in New York State based on data from 2010 to 2019. Key financial indicators were examined, including solvency (equity-to-asset ratio), liquidity (current ratio), debt servicing capacity (debt coverage ratio), and efficiency (operating expenses and net income). Financial risk was defined as uncertainty related to interest rates, financing, cash flows, and collateral value. Financial resilience was understood as the enterprise's ability to withstand adverse external factors. The results indicated that over the observation

period, there were four average, two favourable, and four crisis financial years. During unfavourable years, the proportion of farms with critically low liquidity and debt servicing capacity increased significantly, while solvency remained relatively stable. The study leaves room for further exploration, particularly in examining the relationship between financial risks and investment activity. Specifically, it would be worthwhile to assess how the level of financial risk influences farmers' investment decisions.

The study conducted by I.V. Zhuravlyova *et al.* (2017) focused on identifying the components, factors, and consequences of financial risks at the macro-, meso-, and microeconomic levels in Ukraine, as well as methods for their assessment and analysis. The aim of the research was to develop an analytical toolkit for risk management based on an integrated system of financial risk indicators across different economic levels. The authors identified inflationary, credit, and investment risk components using statistical data. To assess the integral index of financial risks across all components, taxonomic analysis was applied. Financial risks at the micro level, which pose significant threats to the financial stability of enterprises, can be classified into two categories: those that lead to reduced profitability and operational efficiency of business entities, and those that negatively affect their financial condition. Based on the approach proposed by the authors, it is also advisable to expand and specify the list of such risks in the context of enterprise operations.

In the study by M. Fan *et al.* (2023), a financial risk assessment model tailored to the needs of the football industry was developed, based on a sample of 24 publicly listed clubs worldwide. The application of exploratory factor analysis enabled the identification and classification of key risk components. The results indicated that football clubs generally exhibit a high level of financial risk, reflected in low authorised capital, high levels of debt, low profitability, a significant number of loss-making clubs, and weak asset liquidity. The study also identified internal and external factors contributing to financial crises, highlighting the need to strengthen financial discipline and management practices to ensure the resilience of clubs. While the model may be applicable to entities in other industries, it would be advisable to supplement it with indicators of settlement risk, particularly turnover ratios of accounts receivable and accounts payable.

Thus, as a result of analysing contemporary developments in the research field, the need to improve the existing system of financial risk diagnostics has been identified, positioning it as a financial engineering tool within the risk management framework of business entities. The findings enable the formation of a system of financial ratios and the construction of taxonomic indicators for risk level assessment based on the financial statements of agribusiness enterprises. This provides an opportunity to apply these indicators in substantiating managerial decisions aimed at optimising the capital structure of business entities, enhancing solvency, and attracting investment.

## ● CONCLUSIONS

It has been established that in a competition-oriented economy, financial engineering plays a pivotal role in the modern risk management of agribusiness enterprises. It

contributes to the minimisation of financial threats, the preservation of market positions, and the long-term stability of business operations. In this context, the study clarifies the role of financial engineering within the business system and its areas of application, while also detailing the concept of “financial engineering of a business entity”. The research substantiates the relevance of financial risk diagnostics within the risk management system of business entities, both from the perspective of the individual enterprise and from that of external counterparties interacting with it. A comprehensive list of financial risk types in business activities has been justified, and a system of ratios for their assessment has been developed.

Within the scope of the study, a comprehensive diagnosis of financial risk levels among agribusiness enterprises was conducted using the method of taxonomic analysis. Based on financial reporting data from 2021 to 2023, a system of nine financial ratios was developed, covering key areas of risk assessment: liquidity, financial stability, solvency, profitability, and settlement efficiency. The application of the integrated taxonomic indicator (IFR) enabled the ranking of enterprises by risk level and revealed both positive and negative trends in their dynamics. The lowest risk level over the three-year period was demonstrated by EFI “Viterra Ukraine”, with an IFR of 0.114 in 2023, which corresponds to a low risk level according to the Harrington scale. In contrast, LLC “TAS Agro Center” showed a deterioration in its financial position, with its IFR rising from 0.022 in 2021 to 0.572 in 2023, indicating a shift from low to medium risk. LLC “Agrotrade-Production” maintained a consistently high risk level, with its IFR increasing from 0.480 (2021) to 0.620 (2023). The highest risk in 2023 was

observed in LLC TC “Vitagro”, with an IFR of 0.688, corresponding to a high risk level.

A steady increase in financial risk was observed in the operations of LLC “Agrotrade-Production” and LLC “TAS Agro Center”. This trend serves as a negative signal for investors, counterparties, and directly for the owners or shareholders of the respective companies. A moderate rise in risk levels was recorded for PE “Zakhidnyi Buh”; however, its financial risk remains within the bounds of a medium level. An unstable risk dynamic was noted in LLC AE “Nibulon”, LLC TC “Vitagro”, and LLC “Upi-Agro”. A consistent decline in financial risk levels was recorded for EFI “Viterra Ukraine”, PE “Oliyar”, LLC “Kernel-Trade”, and LLC “Astarta-Kyiv”, which is regarded as a favourable signal for investors and counterparties. The proposed approach enables the timely identification of threats to the financial stability of agribusiness enterprises, substantiation of managerial decisions, and determination of the need for implementing instruments such as hedging, restructuring, or financial planning. Further research should focus on improving the risk management system of agribusiness enterprises based on the application of financial engineering tools integrated with digital technologies.

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None.

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## Діагностика фінансових ризиків у діяльності підприємств агропромислового комплексу в системі ризик-менеджменту підприємства як інструмент фінансового інжинірингу

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**Анотація.** Зважаючи на мінливість ринкових умов та специфіку агропромислового комплексу, своєчасна діагностика фінансових ризиків дозволяє не тільки мінімізувати втрати, а й забезпечити адаптивність до зовнішніх змін, оптимізувати структуру капіталу та підвищити платоспроможність. Це особливо актуально для залучення інвестицій і фінансування, оскільки інвестори орієнтуються на ризик-профіль підприємства. Метою дослідження було удосконалити методичні підходи до діагностики фінансових ризиків як важливого інструменту фінансового інжинірингу в системі ризик-менеджменту підприємств агропромислового комплексу. У роботі використано методи наукового пізнання, а саме: системного підходу, аналізу, синтезу, наукової абстракції, узагальнення. Для проведення діагностики рівня фінансових ризиків на прикладі підприємств агропромислового комплексу було застосовано метод розрахунку фінансових коефіцієнтів та метод таксономічного аналізу, а також табличний і графічний методи представлення результатів дослідження. Інтегральний показник (ІФР) побудовано за основними напрямками оцінки ризиків: ліквідність, фінансова стійкість, платоспроможність, прибутковість та ефективність розрахунків. У дослідженні оцінено рівень фінансового ризику підприємств агропромислового комплексу у 2021-2023 рр. Найнижчий ризик спостерігався у ПП «Вайтерра Україна» (ІФР = 0,114), ТОВ «ТАС Агро Центр» показало негативну динаміку: ІФР зріс із 0,022 до 0,572. Стабільно високий ризик виявлено в ТОВ «Агротрейд-Виробництво» (ІФР = 0,620 у 2023 р.), найвищий – у ТОВ ТК «Вітагро» (ІФР = 0,688). Практична цінність дослідження полягає у запропонованому підході до діагностики рівня фінансових ризиків, який може бути використано для обґрунтування та прийняття поточних та перспективних управлінських рішень у системі ризик-менеджменту суб'єкта підприємництва

**Ключові слова:** платоспроможність; фінансова стійкість; рентабельність; фінансові результати; фінансовий леверидж

## **Management challenges of labour market transformation in the context of migration crisis**

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**Abstract.** The migration crisis caused by the war significantly transforms the labour market of Ukraine and requires a rethinking of approaches to its restoration. The purpose of the study was to substantiate the typology of managerial challenges of transforming the labour market in the context of the migration crisis and to form a system of strategic management decisions to overcome them. To achieve the goal, content analysis of scientific sources, statistical analysis of data of the State Employment Service of Ukraine and international organisations, comparative analysis of Ukrainian and foreign approaches to labour market regulation, as well as a method of generalisation to systematise the results obtained were used. As a result, the generalised typology of managerial challenges by management levels has been formed: at the macro level, the institutional imbalance of the employment system and the shortage of strategic vision have been identified; at the meso level, the gap between the local needs of the labour market and the tools of regional management; at the micro level, the personnel instability, the lack of qualifications and the challenges of adaptation of personnel to new conditions have been identified. Based on the results obtained, a multi-level system of managerial actions, coordinated at the macro-, meso- and micro levels, has been proposed. It is based on the principles of synchronisation of institutional efforts, regional adaptability and internal flexibility of organisations. The target vision of the future labour market was defined – adaptive, digital-orientated, resistant to challenges and capable of preserving and reproducing human capital. The results of the study can be used by public authorities, regional management structures and business to develop

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strategies for responding to crisis challenges, as well as the basis for further scientific developments in the field of labour market management in the context of migration processes

**Keywords:** labour migration; structural imbalances; strategic management; human capital; digitalisation; employment policy; management action system

## ● INTRODUCTION

The transformation of the labour market under the influence of forced migration has become global, exacerbating challenges in the sphere of employment, mobility of population and preservation of human capital. These processes have become especially acute in the context of a full-scale war in Ukraine, which caused a massive outflow of able-bodied people abroad and the formation of a significant number of internally displaced persons. As a result, imbalances between demand and labour supply increased, problems of regional distribution of labour resources increased, shadow employment increased and the destruction of the professional qualification structure occurred. In these circumstances, traditional employment policies were ineffective. The need for operational management response to new realities comes to the fore: development of strategies for the preservation and return of human capital, stimulating the reintegration of displaced persons, adapting the professional structure of employees to changed demand and revision of models of interaction between the state, business and employees. The migration crisis creates unique management challenges: on the one hand – the loss of experienced staff, on the other – a growing demand for flexible, innovative and adaptive approaches to managing labour resources. This requires a rethinking of established practices and the formation of a strategic vision that can take into account both demographic and socio-psychological factors. Preservation of the economic potential of the country, support of the working population, development of motivational mechanisms for the return of migrants are key tasks for management structures in modern conditions.

In modern scientific literature, the issue of the impact of the migration crisis on the labour market is considered in several main analytical areas. The first relates to the effects of intellectual and forced migration for human capital. In particular, according to O. Baeva (2023), significant losses of skilled personnel create an imbalance in the structure of labour resources and inhibit the restoration of the economy in the post-crisis period. M. Kopytko *et al.* (2024) noted that the outflow of highly skilled workers weakens the competitiveness of the national economy. Scientists N. Komarnytska *et al.* (2022) concluded in their work that the decline in job availability for vulnerable categories of the population violates the socio-economic rights of workers. According to A. Karimi & Y. Belikova (2024), migration adversely affects the stability of enterprises and public institutions. In this context, the issues of socio-economic rights of workers, reduction of job availability for vulnerable categories of the population and the destructive impact of migration on enterprises and state institutions are also raised. The second analytical direction focused on macroeconomic effects of changing the labour market structure in the conditions of war and forced displacement. Ye.Ye. Ionin & V.M. Zahorodnyi (2025) stressed that regional imbalances and shortages of skilled labour strengthen the need to adapt state employment policies. S. Lykholat *et al.* (2020) emphasised the

role of institutional coordination between the authorities and international partners for the stable functioning of the labour market. Ye. Pashkevych (2024) has proven that an effective labour market recovery is possible only if regional and state policies are harmonised.

Particular attention in the literature is paid to the transformation of human capital management strategies in the context of global migration and digitalisation. Y. Petrushenko & A. Vorontsova (2021) emphasised that improving the adaptability of management decisions and using digital platforms for retraining employees are key factors in the formation of a new employment model. According to K. Nemashkalo *et al.* (2024), the introduction of innovative HR practices provides flexibility of personnel policy and strategic focus on long-term stability. O. Stryzhak (2025) noted that effective personnel planning requires the integration of crisis factors into the overall management system. In these works the importance of strategic orientation of managerial decisions on long-term stability and integration of crisis factors in personnel planning is emphasised. Another direction is estimation of efficiency of state regulation of demand and supply in the labour market through tools of educational and economic policy. L. Bilorusets *et al.* (2025) stressed the importance of the state order and the formation of personnel reserve as the basis for the restoration of labour potential. V. Ponomarenko & O. Pysarchuk (2024) drew attention to the need to coordinate the content of educational programmes with the needs of the economy to improve the efficiency of human capital.

Thus, the available research outlined a wide range of problems related to the transformation of the labour market in the context of the migration crisis, but mostly focused on certain aspects – social, demographic or human resources. While the issues of strategic management of transformational processes in the labour market, in particular at the interlevel (state, regional, corporate) levels, needed further generalisation, systematisation and conceptualisation. The purpose of the study was to identify managerial challenges of transforming the labour market in the context of the migration crisis and justify strategic guidelines for overcoming them. To achieve this goal, the article solved a number of tasks, in particular: to analyse structural changes in the labour market in conditions of forced migration; to systematise managerial risks and barriers in the context of crisis; to determine priorities for the formation of a sustainable employment system. The scientific novelty of the study is to conceptualise the managerial challenges of transforming the labour market caused by the migration crisis, as well as to propose an adaptive framework for strategic management of employment. In contrast to the existing research, the article focuses on the interlevel interaction of state, regional and corporate structures in the formation of a new model of the labour market in crisis conditions.

## ● MATERIALS AND METHODS

Within the study of managerial challenges of transformation of the labour market in the context of the migration crisis, a complex of general scientific and special methods was applied, which provided a comprehensive study of the problem at macro-, meso- and micro-levels of management. The methodological basis was the system paradigm, which allowed to consider the labour market as a complex dynamic system, where the changes caused by migration processes have multidimensional consequences and require coordinated management decisions. The use of a systematic approach provided analytical integration of environmental factors, institutional limitations, demographic situation, behaviour of economic agents and political decisions. The method of structural and functional analysis was involved to isolate the key functions of different levels of labour market management, identify their role in the process of adaptation to the migration crisis, as well as to identify structural imbalances between demand and supply of labour. This method defines the logic of interaction between the elements of the management system in response to external challenges. To justify the typology of managerial challenges, the classification method was used, which made it possible to highlight the generalised categories of challenges by control levels and spheres of influence.

The methodology pays special attention to content analysis of statistical and analytical materials, including State Employment Service of Ukraine (n.d.) data, International Organization for Migration reports (n.d.), Eurofound (2024) and Robot.ua (2024). This method allowed to distinguish quantitative and qualitative changes in the parameters of employment, mobility of population, structure of professional employment, age and gender structure of labour force, etc. To determine the management actions relevant to each type of challenges, methods of analytical generalisation and project approach were applied, which provided for a consistent processing of empirical and theoretical data to form a holistic concept of management of the labour market in a crisis. On the basis of the conducted analysis, a multi-level system of managerial actions, coordinated in the vertical of macro-, meso- and micro-level, taking into account the specifics of the functioning of state, regional and corporate institutions, was proposed.

This methodology is also supplemented by a reference analysis of scientific publications of international researchers covering the impact of forced migration on the labour market, the inclusion of displaced persons in local economies, digitalisation of employment management, the introduction of flexible models of employment, and long-term planning in the field of human capital. The choice of modern scientific literature allowed to compare the results with international approaches to overcoming such crisis challenges. The chosen combination of methods allowed to conduct a multi-level analysis of the situation in the labour market, formulate a typology of managerial challenges and develop an agreed system of strategic response to the migration crisis in the context of the transformation of social and labour relations.

## ● RESULTS AND DISCUSSION

The migratory crisis caused by the full-scale war in Ukraine has become an unprecedented challenge for the stability

and functioning of the national labour market. In the short period from the beginning of the armed aggression there was a massive and rapid outflow of people, especially women, children and people of working age, mainly from the most economically active regions of the country. According to the International Organisation for Migration, more than 5.6 million Ukrainian citizens have left the state as temporarily displaced persons abroad, while about 3.7 million remain internally displaced persons within the country (International Organization for Migration, n.d.), which led to large-scale destruction of established mechanisms for distributing labour resources.

These processes have led to a deep imbalance between supply and demand for labour at both the national and regional levels. In some regions, there was a shortage of labour, especially in areas with high levels of physical activity or specific qualifications. In others, the excessive burden on social services has been concentrated due to the high level of internal migration and the lack of new jobs adapted to the needs of the displaced population. Despite the gradual adaptation of the economy to military conditions, the situation in the labour market of Ukraine remains tense. Existing structural imbalances in the labour market only exacerbate difficulties with the effective use of labour potential. As of January 1, 2024, 96,100 unemployed people were registered with the State Employment Service, with more than 40% of them having higher education. At the same time, the number of vacancies available for employment was only 40.2 thousand units.

In 2023, the status of unemployed was 483.2 thousand people, which is significantly less than in 2022 (867.6 thousand people). Of them, 160.1 thousand people were employed, and 32.9 thousand were trained in vocational training. For comparison, in 2022, the corresponding figures were 248.8 thousand and 46.6 thousand people respectively (State Employment Service of Ukraine, n.d.). At the same time, the official unemployment figures in Ukraine do not fully reflect the real state of affairs in the labour market, since the statistical accounting does not cover the population located in the temporarily occupied territories, and does not take into account those persons who have lost their jobs, but have not registered with the state employment service. This is especially true for young people: about 25% of all registered unemployed persons are able to work under 35 years of age. During the war, their number in the official reporting declined, which is partly due to the mass departure abroad – among forced migrants, about 78% are persons aged 18-40 years – and the mobilisation of young men into the ranks of the Armed Forces of Ukraine. The highest number of unemployed youth is kept in the Dnipropetrovsk Region (12.2 thousand people), as well as in Lviv (7.5 thousand) and Kyiv (7.4 thousand) regions, which indicates the concentration of youth unemployment in regions with traditionally active labour markets (State Employment Service of Ukraine, n.d.).

In addition to this, the sectoral structure of the labour market has been significantly affected. Many enterprises have stopped production or been forced to relocate, which has led to job losses and disruption of production chains. In particular, in agrarian, construction and logistics sectors, there is a shortage of qualified workers. The official statistics of State Employment Service of Ukraine (n.d.)

shows that the discrepancy between the quantitative and qualitative characteristics of demand and supply of labour in Ukraine is preserved. The analysis of the structure of the labour market of Ukraine as of June 2025 shows the presence of critical structural gaps between demand and supply of labour, manifested mainly in the form of a complete absence of vacancies or their significant deficit in a number of industries. In particular, in such industries as “Activities of extraterritorial organisations”, “Production of sheet glass”, “Precious metals”, “Life insurance”, “Financial markets” and some types of office activities, during the reporting period, no vacancies were recorded, despite the presence of 3 to 19 registered applicants in each of them. For example, in “Production of sheet glass” – 19 applicants and no free space, the unemployment rate – 89%; in “Life insurance” – 8 applicants, of which 6 are officially unemployed. A similar situation is observed in highly specialised industries, such as the production of electrical insulators, ceramic sanitary ware, precious metals, and the financial sector. In sectors with a minimum number of vacancies, demand is also significantly inferior to supply. For example, in the “Sphere of culture” – 4 vacancies for 108 people, in the “Financial leasing” – 1 to 10, in the “Construction” – 2 to 29. Such a shortage of demand is also fixed in light industry, where production capacity is limited, and competition for places remains high (State Employment Service of Ukraine, n.d.).

As of June 2025, the Ukrainian labour market has the opposite in nature, but not less threatening situation in a number of sectors, the demand for labour significantly exceeds the supply (State Employment Service of Ukraine, n.d.). Such an excess indicates the formation of personnel shortages, which is a consequence of both military migration and economic transformation, in particular – relocation of production, growth in demand for logistics, security, maintenance and construction. It is worth emphasising the critical shortage of staff in the field of public catering. For example, in the category “Mobile food service” 265 vacancies are available with only 41 people looking for a job, which means almost 6.5 vacancies per applicant. In the construction sector, especially in the categories “Construction of residential and non-residential buildings”, the situation remains similar: 2,516 vacancies with 1,423 applicants. This is a ratio of almost 1.8 to one. In logistics, particularly in the “Support activities in transport”, demand also exceeds supply – 1,997 vacancies with 1,393 persons in search (State Employment Service of Ukraine, n.d.).

According to Ye.Ye. Ionin & V.M. Zahorodnyi (2025), a particularly acute imbalance between supply and demand for labour is manifested in regions that have adopted a significant number of displaced persons, but do not have sufficient economic and institutional resources for their effective integration. However, this need could not always be met because of the inconsistency of the qualifications of the displaced persons with the requirements of employers. This creates additional pressure on the infrastructure of local labour markets, increases competition for jobs and deepens regional imbalances. The imbalance between demand and supply of labour in the Ukrainian labour market has double consequences. In particular, some sectors of the economy, which are relatively stabilised or adapted to the conditions of war, actively need a new workforce, but do not get it in the proper amount. This also indicates a

potential deepening of structural imbalances, because in conditions where there is an excess of personnel in non-demand sectors and a parallel shortage in sectors with active growth, the state employment system does not perform a coordinating function. In other words, the labour market is divided between “stagnant” industries with over-saturated supply and “dynamic” sectors with acute deficit. Without rapid response in the form of overfitting, regional staff mobility and official employment stimulation, these distortions can slow the recovery of the national economy and increase social risks in the regions.

The migration crisis is also accompanied by an increase in shadow employment, since a significant part of internally displaced persons do not have the opportunity to officially find employment due to lack of documents, difficulties with registration of residence or lack of suitable vacancies. According to the International Organization for Migration (n.d.), the unemployment rate among internally displaced persons is 15%, which exceeds the national average, and among those who recently moved – reaches 24%. This indicates the weak integration capacity of regional labour markets and the limited impact of existing employment programmes. It also creates additional risks of social exclusion and loss of access to basic labour guarantees, pension insurance and medical services. According to N. Komarnytska *et al.* (2022), forced displacement causes a decline in legal employment, deterioration of working conditions and violations of labour rights in host communities.

In addition to the current situation with the demand and supply of labour in the labour market of Ukraine, it should be noted the growing risk of long-term loss of highly qualified specialists who left abroad, in particular against the background of growing demand for Ukrainian workers in Europe. This increases the phenomenon of intellectual migration and threatens with the depletion of national human capital, which makes it impossible for the country to recover quickly after the end of hostilities. As O. Baeva (2023) pointed out, the loss of intellectual resource through emigration creates the risks of a long-term slowdown in the pace of innovation development and a decrease in the global competitiveness of the economy due to the degradation of the professional and qualification structure. Many of those who have left have a high level of education, but in countries of temporary residence most of them work on unskilled or low-skilled jobs that do not correspond to their education and professional experience. According to A. Karimi & Y. Byelikova (2024) researchers, more than 70% of Ukrainian refugees have higher education, but a significant proportion of them are involved in low-paid sectors. This imbalance contributes to both the degradation of human capital and the reduction of motivation to return to the country of origin.

According to A. Karimi & Y. Byelikova (2024), an important characteristic of the migration crisis is changing motivational patterns of labour behaviour. If at the initial stages of the war a significant part of the displaced persons declared their intention to return to Ukraine after the end of hostilities, then in 2024 the share of those who plan to return decreased to 20%. This trend shows the risks of long-term loss of highly skilled human resources and sharpens the need to implement effective management strategies aimed at preserving, returning and mobilising

human capital. In this context, the integration of internally displaced persons into the formal sector of the economy is of particular importance. However, current programmes of retraining, employment and social adaptation are fragmentary, not coordinated enough and do not take into account the real profile of demand in the regional labour markets. As noted by H.O. Komarnytska *et al.* (2022), in a crisis, the effectiveness of such programmes depends on inter-level coordination of actions between public authorities, local administrations and employers.

The transformation of the labour market is influenced not only by internal movements, but also by the state policy of employment support. As noted in the work of L. Yatsenko (2024), in 2023, employers were compensated for the employment costs of 14 thousand internally displaced persons, and almost 10 thousand micro-grants were given to create 20.6 thousand new jobs. At the same time, grant support is aimed at integrating veterans, persons with disabilities and their families into the production processes. Despite these efforts, the number of officially registered unemployed under the age of 35 remains significant, with concentrations in the Dnipropetrovsk, Lviv and Kyiv regions. A separate problem is the uneven growth of wages. In 2023, the average wage in vacancies was 11,559 UAH, but regional differentiation was significant. Kyiv, Dnipropetrovsk, Lviv and Kherson regions remain the most attractive in terms of salaries, while the lowest level of payment is observed in Luhansk, Vinnytsia and Sumy regions. At the same time, the demand for certain professions, such as builders, drivers, and electricians, has led to a certain increase in wages in the relevant market segments.

One of the characteristic features of the modern labour market in Ukraine is the growing competition for jobs with the possibility of remote work. The Remote Employment format, which was actively used during the COVID-19 pandemic, continued to play an important role in a full-scale war, ensuring the continuity of many economic processes. According to June 2024, as stated in L. Yatsenko (2024), more than 14% of the candidates were looking for an online job, while the proportion of the relevant vacancies was less than 7%, which indicates a significant imbalance between supply and demand in this area. Flexible forms of employment are increasingly attracting workers. According to the results of a study of the Work.ua platform, 31% of respondents stated that the most important criterion for choosing a job is the ability to work remotely with a flexible schedule (Kuzenkova, 2024). Traditional corporate incentives, such as a social package, insurance, training compensation or participation in internal activities of the company, are of secondary importance to them. Overall, the number of jobs in Ukraine with remote work has increased by 40% since the start of a full-scale invasion. In particular, in Kyiv in March 2024, 96% more such vacancies were registered than in February 2022. In Kharkiv, the growth was 68%, in Lviv – 35%, in Odesa – 34%, and in Dnipro – 16%.

Remote work is viewed by employees as an effective strategy for personal security, saving time on the way to the office, optimising the work regime and expanding employment opportunities not only at the national, but also at the international level. For employers, this solution reduces the cost of office rent, technical support and maintenance of staff, and also facilitates the involvement of specialists with

higher qualification regardless of their geographical location. In the context of the structural transformation of the labour market, flexible forms of employment are becoming increasingly important as a means of adaptation to external challenges. At the same time, the widespread introduction of remote work requires the improvement of national labour legislation – in particular in the aspects of labour relations regulation, social protection and minimisation of risks associated with non-standard forms of employment.

Thus, the migration crisis in the war not only complicated the functioning of the labour market, but also brought to the fore the need to adapt management strategies to the realities of the crisis period. This requires the formation of a new employment model that is capable of combining flexibility, inclusiveness and resilience, as well as ensuring effective inter-level interaction between the state, regions and business. Particular attention should be paid to vulnerable groups – women, youth, persons with disabilities, who often face multiple barriers to employment. Limited access to flexible forms of employment, discriminatory practices and weak support infrastructure only deepen their marginalisation in the labour market.

Finally, the migration crisis requires a reconsideration of traditional approaches to managing employment. According to N. Yurchuk *et al.* (2021), there is a need for complex labour market reforms aimed at increasing the flexibility and adaptability of the economy, which is consistent with the approaches to strategic response to the challenges of the migration crisis. V. Riabchenko (2024) emphasised the need to implement flexible, adaptive management solutions that allow you to quickly respond to external challenges and maintain the competitiveness of enterprises. The standardised approaches, based on employment policies in previous decades, proved ineffective in situations of extremely high demand variability and fragmentation of labour supply. The migration crisis creates a need for integrated governance solutions that take into account both the security and demographic context. An important condition for the formation of a new architecture of the labour market is the development of strategies for the preservation of human capital, the adaptation of displaced workers and the reintegration of labour migrants. In this process, management structures must act in close interaction at the interlevel – from public policy to regional employment programmes and corporate HR strategies.

To effectively adapt the labour market to the large-scale challenges posed by the migration crisis, it is necessary to systematically allocate key management functions at three interrelated levels: macro-, meso- and micro-levels. This approach helps to identify structural imbalances between demand and supply of labour and coordinate management actions to overcome them. At the macro level, management is carried out through the formation of state employment policy, the development of legislative and regulatory acts, coordination between central authorities, international organisations and key stakeholders. This level is responsible for strategic planning, resource base and creating favourable conditions for the integration of internally displaced persons and labour migrants into the national economy. Of particular importance is the monitoring and forecasting of national labour market trends, which allows to quickly identify industries with surplus or shortage of staff.

At the meso level, management functions are implemented through regional authorities, employment services, industry associations and local institutions. Here is the adaptation of national strategies, taking into account the specifics of regional labour markets, the organisation of vocational training and retraining, coordination of programmes to support displaced persons and local residents. The regional level provides a bridge between politics and specific enterprises, regulating the balance of demand and supply of labour and minimising the negative social consequences of migration processes. At the micro level, management is concentrated within individual enterprises and organisations that directly implement personnel policy, implement internal training and development programmes, and adapt working conditions in accordance with new market requirements. It is here that there is an

operational reaction to personnel challenges, such as the shortage of skilled workers, changing employment forms (for example, remote work) and the introduction of flexible management models.

Enterprises play a key role in maintaining and mobilising labour potential in crisis conditions. Interaction and coordination of functions at macro-, meso- and micro-levels of labour market management create a holistic system that can respond to the challenges of the migration crisis, reduce structural imbalances and ensure the stability of the national economy. The lack of synergy between these levels significantly reduces the effectiveness of management strategies and is fraught with deepening of socio-economic problems. The analysis of the key functions of different levels of labour market management, distributed at the macro-, meso- and micro-levels, is given in Table 1.

**Table 1.** Key functions of different levels of labour market management

Level of management	Key features	Role in adaptation to the migration crisis	Impact on structural imbalances between supply and demand
Macro Level	<ul style="list-style-type: none"> <li>• Formation of state policy and legislation</li> <li>• Provision of resources and regulatory conditions</li> <li>• Cooperation with international organisations</li> </ul>	<ul style="list-style-type: none"> <li>• Strategic planning and coordination of national action</li> <li>• Creating conditions for the integration of internally displaced persons and migrants</li> </ul>	<ul style="list-style-type: none"> <li>• Monitoring and forecasting of national trends</li> <li>• Identify industries with personnel shortage or surplus</li> </ul>
Meso Level	<ul style="list-style-type: none"> <li>• Implementation of state policy taking into account regional peculiarities</li> <li>• Coordination of support programmes for IDPs and local people</li> <li>• Interaction with industry associations and local institutions</li> </ul>	<ul style="list-style-type: none"> <li>• Organisation of professional training and retraining</li> <li>• Adaptation of national strategies to regional needs</li> </ul>	<ul style="list-style-type: none"> <li>• Balancing demand and supply at the regional level</li> <li>• Minimisation of social consequences of migration</li> </ul>
Micro Level	<ul style="list-style-type: none"> <li>• Implementation of personnel policy of enterprises</li> <li>• Organisation of internal training and staff development</li> <li>• Managing forms of employment (remote, flexible employment)</li> </ul>	<ul style="list-style-type: none"> <li>• Rapid response to personnel challenges</li> <li>• Adaptation of working conditions, introduction of flexible models of work</li> </ul>	<ul style="list-style-type: none"> <li>• Preservation and mobilisation of labour potential</li> <li>• Reduction of personnel shortages within individual enterprises</li> </ul>

**Source:** compiled by the authors

A key problem that requires in-depth understanding is that most of the existing management decisions remain reactive, that is, aimed at eliminating certain manifestations of the crisis, and not at its systemic prerequisites. In particular, the existing organisational model of the State Employment Service showed a low adaptability to spatial changes in the labour market structure. Limited access to relevant information, uneven distribution of administrative resources and weak coordination with other institutions – all this slows down the formation of effective management responses. This is especially critical in a situation where traditional instruments have lost relevance in new conditions, and alternative forms of regulation have not yet acquired a systemic nature.

Against this background, the lag in the formation of medium- and long-term human capital management strategies is increasing, in particular in the area of forecasting labor market needs, updating educational programs in accordance with new professional demands, and developing vocational training infrastructure. Management decisions in certain regions remain fragmented and do not take into account the peculiarities of the local labour market, which increases the stress in the social sphere. An additional dimension of the problem is related to the unwillingness of

the state system to large-scale digital transformation of the employment sphere. The lack of a unified digital ecosystem that would combine educational services, employment mediation and market analytics, deprives the system of opportunities for personalised management decisions. This makes it difficult to quickly respond to situations of staff shortage or exceeding them in individual sectors. At the same time, the emigration of highly qualified specialists and the reduction of motivation to return labour migrants pose long-term threats to restore the human potential of the country. In this context, it is important not only to maintain the balance of available resources, but also to strategically shape the conditions for reproduction and preservation of intellectual capital.

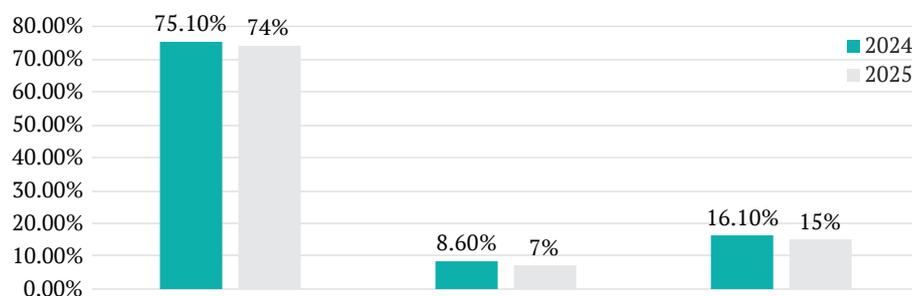
While strategic disintegration, regulatory inertia and institutional disunity are observed at macro and meso levels, Ukrainian enterprises directly experience the consequences of the crisis in the form of tactical and human resources management challenges. Changing the structure of the workforce, reducing its availability, high staff turnover, as well as increasing uncertainty in the labour market form the need to adapt internal management strategies. Among the main managerial challenges faced by enterprises in the conditions of military turbulence, it

is worth highlighting the shortage of personnel of critical specialties. According to a study conducted by the online platform Robota.ua (2024), the shortage of staff was considered critical by 75.1% of the employers surveyed. In case of evacuation, mobilisation, emigration of employees and structural shift of the employment market, ensuring continuity of operational processes turns into a constant challenge. Only 8.6% of companies do not experience a shortage of staff, while the rest are actively looking for ways to overcome it.

In addition, enterprises are faced with the discrepancy of expectations of employees to working conditions, which leads to a decrease in motivation, difficulties with the involvement of staff and a general drop in organisational loyalty. High competition for specialists forces employers to revise approaches to personnel management, implement flexible schedules, remote formats, additional intangible incentives that require resources and new competencies in HR departments. The average salary expectations on the part of applicants in March 2024 reached 22,653 UAH, while the average employer offer was only 19,603 UAH, which forms a gap of 3,050 UAH. For comparison, in January 2022, this gap was 7 times smaller and amounted to 445 UAH, which indicates a significant increase in wages expectations against the background of limited resources of companies (Robota.ua, 2024). The average salary expectations of Ukrainian employees in 2025 significantly exceed the proposals of employers. 30% of the respondents consider the optimal salary in the range of 30,000-50,000 UAH, another 25% are trying to earn more than 50,000 UAH. While only 13% are ready to work for 10,000-20,000 UAH

(Ukrainians' salary expectations..., 2025). This shows a significant gap between employee expectations and real job offers in the labour market.

In the structure of the reasons for personnel difficulties, 16.1% of employers note inflated salary expectations of candidates, 4.1% point out difficulties caused by geographical conditions of doing business, 2.3% point out the unwillingness of candidates to work in low-profile companies. In response to these challenges, 53.5% of enterprises introduce internal staff retraining or redistribution of responsibilities, 32.6% implement programmes for young professionals, 23.9% – automate individual processes, 16% – attract external resources through outsourcing, and 8.8% are orientated towards older workers (Robota.ua, 2024). In 2025, staffing difficulties and strategies of employers in Ukraine have undergone some changes compared to the previous year. 15% of the surveyed employers noted inflated salary expectations of candidates as one of the main reasons for difficulties in recruitment (75% of employers..., 2025). This indicates the preservation of the tendency to high demands on the part of job seekers. In response to these challenges, 75% of businesses plan to wage increases in 2025, particularly in agriculture, mining, and manufacturing. This shows the desire of employers to retain and attract qualified personnel. As for HR strategies, 52% of employers have indicated the preservation of the full team as the main priority for 2025. In general, in 2025, employers keep focused on increasing wages and staff stability as the main strategies to overcome personnel difficulties. Dynamics of key indicators of personnel situation in 2024-2025 is shown in Figure 1.



**Figure 1.** Key indicators of personnel situation: staff shortage and salary expectations (2024-2025)

**Note:** share of employers who recognised a staff shortage; share of companies without staff shortages; inflated salary expectations of candidates

**Source:** compiled by the authors

An equally important challenge is to increase the risks of personnel exhaustion and emotional burnout of staff, associated with chronic tension, danger and increased workload on those employees who remain on the ground. The lack of systematic support from the state, instability of the environment, limited access to professional development create an additional burden on management, which is forced to perform the functions of crisis management. Finally, a common problem is the loss of personnel reserve and the complexity of staff development planning, which demotivates the management corps and makes it impossible for strategic personnel forecasting. All this is reinforced by the instability of demand, interruptions in logistics and the constant need to respond to situational threats.

The crisis nature of the current situation requires a generalisation of typical configurations of managerial problems, which are manifested at different levels – strategic, regional and operational. The complex of identified imbalances, crisis effects and transformations in the labour market shows that the modern employment management system was facing a multi-level and multi-vector crisis of managerial compliance. This is not only about the gap between the capabilities of institutions and the dynamics of the market, but also about the profound discrepancy between the traditional logic of managing the conditions of military instability, the hybrid functioning of the economy and the changed models of behaviour of employees and employers. Changing the structure of la-

hour resources, mass labour migration, growth of shadow employment, critical overload of certain regional labour markets, reduction of the effectiveness of institutional regulation, weakening of personnel reserves of enterprises and increasing competition for specialists – all this forms a new managerial reality, in which the crisis response should be transformed into a systemic transformation management. Before moving to the search for answers, it is advisable to outline the typical structure of managerial challenges faced by the employment

management system in the context of the migration crisis. This typology will identify not only the most critical problem areas, but also differentiate responsibility and response tools between different levels of governance – public, regional and corporate. The analysis presented in the article gives grounds to form a generalised typology of managerial challenges of transformation of the labour market in the conditions of the migration crisis, covering all levels of management – from national to individual enterprises (Table 2).

**Table 1.** Typology of management challenges of labour market transformation in conditions of migration crisis

Level of management	Challenge category	The essence of the challenge	Characteristics of manifestation/ consequences
Macro Level	Institutional inconsistency	Insufficient interagency coordination between state institutions	Disintegration of the state employment policy, duplication of functions, fragmentation of programmes
	Asymmetry of supply and demand	Structural discontinuities between sectors with redundancy and human resources deficits	Inefficient use of labour potential, reducing economic productivity
	Migration human capital outflow	Mass emigration of highly qualified specialists	Loss of intellectual potential, slowdown of innovative development
	Limited digitalisation of the labour market	Lack of a single digital employment ecosystem	Slow response to imbalances, weak analytics, low policy personalisation
Meso Level	Regional imbalances	Uneven load on labour markets in different areas	Infrastructure overload, lack of resources in host communities
	Low efficiency of IDP integration	IDPs do not meet the requirements of local labour markets	Rising unemployment, shadow employment, social exclusion
	Educational discrepancy	Lagging professional education from market needs	Reducing the competitiveness of the regional labour market
	Lack of resources for retraining	Limited funding of training programmes	Impossibility of adaptation of labour resources to the changed structure of demand
Micro Level	Staff shortage	High staff turnover, mobilisation, evacuation	Disruption of operational processes, increased load on residual personnel
	High expectations of candidates	The gap between the expected and real wages	Complications of recruiting, reduction of organisational loyalty
	Staff exhaustion	Chronic tension, emotional burnout	Reduced productivity, health risks for staff
	Lack of internal strategic decisions	Lack of personnel development planning, weak HR forecasting	Personnel reserve degradation, loss of managerial flexibility
	Lack of internal adaptation programmes	Lack of integration mechanisms for new employees and young professionals	Complexity of integration of new employees, loss of loyalty, increased level of adaptation risks

Source: compiled by the authors

Overcoming the identified management challenges in the transformation of the labour market in the conditions of the migration crisis requires not fragmentary, but complex, coordinated management actions integrated into the vertical of the state, regional and corporate policy. The response to the existing challenges should be aimed at adapting the labour potential, minimising structural imbalances, preserving human capital and stabilising social and labour relations in the face of uncertainty. At the level of public administration, the priority is the rethinking of the system of regulation of employment. It is about the need to introduce new models of interaction between the actors of the labour market, to increase the flexibility of institutions, to revise traditional approaches to professional orientation, to predict personnel needs and to quickly reconfigure the policy of supporting the unemployed. The formation of a digital employment ecosystem with the function of monitoring and analytics will ensure a real-time managerial

response. At the same time, it is strategically important to update the model of attracting and returning labour migrants by creating economic, social and professional incentives for their integration into the national economy.

At the regional level, the policy should be aimed at supporting the territorial adaptability and social integration of internally displaced persons, developing partnerships between local authorities, business and educational institutions, and providing targeted training programmes that take into account the specifics of the local labour market. In this regard, it is important to strengthen the institutional capacity of regional employment centres by transforming them from administrative tools into active agents of human capital management. At the enterprise level, the transformation processes in the labour market need to adapt personnel policy to the conditions of high staff turnover, shortage of qualified workers and changing motivation models.

In response to new challenges, employers are forced to apply internal vocational training mechanisms, implement flexible forms of employment, adapt remuneration systems and create conditions for stabilising labour collectives. At the same time, the crisis increases the need for the formation of internal personnel reserves, personnel development planning and implementation of stress management practices and mental well-being of employees. All this requires not only financial resources, but also a new management culture, which is able to integrate strategic

personnel management tools in conditions of uncertainty. Thus, in response to the identified challenges of transforming the labour market in the conditions of the migration crisis, a three-level model of management actions, covering macro-, meso- and micro-level of management, has been formed. It is based on the principles of synchronisation of institutional efforts, regional adaptability and internal flexibility of organisations. A generalised system of actions, structured according to the levels of control, is given in Table 3.

**Table 3.** The system of management actions in response to the challenges of the transformation of the labour market in the context of the migration crisis

Level of management	Management actions
Macro Level (public policy)	Creating a single digital employment ecosystem
	Modernisation of demand forecasting in the labour market
	Enhanced coordination between government, business and education
Meso Level (regional policy)	Implementation of return strategies for migrant workers
	Integration programmes for IDPs according to regional demand
	Professional clusters of retraining based on partnerships
	Monitoring and rapid response to local challenges
Micro Level (enterprises)	Expanding the functions of local employment centres
	Internal training, mentoring and adaptation programmes
	Flexible employment models: remote work, part-time employment
	Intangible motivation: social packages, leadership development
	Personnel development planning and personnel reserve formation
	Mental health support and burnout prevention

**Source:** compiled by the authors

Within the framework of the proposed system of managerial actions, it is extremely important not only to implement individual tactical response measures, but also to gradually move on to a long-term strategy for managing transformational processes in the labour market. This transition involves the formation of a targeted vision image of the future, based on institutional adaptability, digital integration, social orientation and sustainability of human capital. The definition of this strategic direction allows to coordinate current management actions with a promising model of the labour market, which is able not only to overcome crises, but also to form the basis for sustainable development and social cohesion in conditions of an uncertain future. In this context, the key factor of modernisation should be the development of adaptive institutions capable of acting in a high-uncertainty environment. It is about creating a system of managerial decision-making based on data, forecast models, algorithms of artificial intelligence and processing of large amounts of information. The move to data as a source of management logic reduces the time lag between problem detection and decision making, providing a rapid update of employment strategies based on real changes in demand and supply structure. The formation of a digital infrastructure, which includes platforms for career guidance, monitoring, microlearning, analytics and interaction between employers and job seekers, is a condition for creating an effective, transparent and flexible employment system.

At the centre of such a vision there should be a constancy of human capital, provided through access to continuous education, a safe working environment, preservation of the psycho-emotional well-being of employees and

integration of the principles of social justice. This includes reorientation of the employment policy to support individual professional development paths, stimulation of mobility, development of future competences and overcoming barriers to participation in the economic life of vulnerable groups. At the same time, flexible forms of employment should be regulated and institutionally enshrined as equal models, which allows to include in formal market relations new groups of employees and to reduce the level of latent unemployment.

In the future, intersectoral partnership as a tool for coordinating actions in the field of labour potential formation is of particular importance. Interaction between the education system, employers, state institutions and civil society should ensure training of personnel that meet the new technological and socio-economic needs. Thus, the visionary model of the labour market should be based on a combination of institutional flexibility, digital maturity and human capital orientation as a driver of change, which allows not only to overcome the consequences of crises, but also to form a qualitatively new employment paradigm in conditions of uncertainty and global transformations. The generalisation of the results of the study shows the need to develop a comprehensive system of management actions differentiated by the levels of state, regional and corporate policy, which corresponds to the complexity of labour market transformations in the context of the migration crisis. Comparison of the obtained results with the positions of foreign researchers shows the relevance of the topic at the international level and allows to identify both the points of intersection and the differences in approaches to assessing the challenges and response strategies.

The results obtained are consistent with the conclusions of M. Al-Dalahmeh & K. Dajnoki (2021), who systematically analysed the impact of migration processes on the labour market of developed countries. As in this study, the authors emphasised the need for institutional renewal and flexible mechanisms for state regulation of employment, which should be based on digital infrastructure, real-time analytics and intersectoral interaction. This position is completely correlated with the conclusions on the creation of a single digital employment ecosystem in Ukraine. Similar ideas are traced in M. Dias-Abeu (2021), where the role of legal institutions in mediating between migration challenges and the state of the labour market is emphasised. The author proved that the effectiveness of employment regulation directly depends on the ability of institutions to adapt to the changed socio-economic dynamics, which is also confirmed by the conclusions of this study on the example of Ukrainian realities.

At the level of regional administration, the findings are confirmed in the works of L. HadjAbdou *et al.* (2024) and A. Postepska & A. Voloshyna (2025), who analysed the impact of forced migration on local labour markets in the Czech Republic and Austria respectively. As in this study, the authors emphasised the need for territorial adaptation, the development of local clusters of professional retraining and strengthening the role of local employment services as active subjects of management. These authors have reached methodological and meaningful proximity in understanding the importance of regional adaptability as a condition for the effective integration of internally displaced persons into the labour market. Research by J. Wachs (2023) and M. Berte *et al.* (2023) deserve special attention as examples of using digital footprints to monitor migration mobility of highly qualified staff. In both cases, the scale of human capital losses in the IT industry has been confirmed, which is consistent with analytical observations within this study on the need to maintain key competencies, plan personnel reserves and implement flexible employment models.

In general, the analysis of foreign sources reveals several key conceptual approaches to this issue that correlate with the conclusions of the study, while supplementing them or pointing out the potential vectors of further scientific research. The first group consists of works that dominate the macro-approach to the study of the impact of migration on the labour market, with a focus on institutional reform and adaptation of state policy. The studies by M. Al-Dalahmeh & K. Dajnoki (2021), M. Dias-Abeu (2021), M. Dahlberg *et al.* (2022) and Eurofound (2024) substantiate the importance of revising models of state regulation of employment in response to changing migration flows. The focus of these studies is the need to improve legal mechanisms, increase the flexibility of state institutions, digitalise infrastructure and strengthen interaction between sectors. The focus of these studies is the need to improve legal mechanisms, increase the flexibility of state institutions, digitalisation of infrastructure and enhance interaction between sectors. This confirms and complements the conclusions about the strategic expediency of building a single digital employment ecosystem that can respond to changes in real time, and the introduction of cross-sectoral partnerships to preserve and return labour resources.

The second group consists of empirical studies covering transformations at the regional level under the influence of population movement. In particular, in works by K. Huk & A. Zeynalov (2022), L. HadjAbdou *et al.* (2024), A. Postepska & A. Voloshyna (2025), demonstrated that territorial imbalances due to forced migration strengthen regional development unevenness, actualising the need for flexible localised strategies for managing the labour market. The idea of developing regional clusters of retraining and strengthening the institutional capacity of local employment services, proposed in the study, is in logical connection with similar approaches.

A separate group of sources focuses on the micro level and highlights the organisational aspects of adaptation to crisis changes, in particular in the employment of highly qualified personnel. M. Berte *et al.* (2023) and J. Wachs (2023) investigated the professional mobility of Ukrainians using digital footprints, stating the loss of a significant part of human capital in the IT industry. The necessity of formation of internal personnel reserves, maintenance of organisational knowledge and development of mechanisms of professional growth, which is quite consistent with the proposals for strengthening the personnel policy of enterprises in the study, has been specified. Similar accents are found in A. Giacomo *et al.* (2023) reports, where the emphasis is placed on the restoration of the labour market by activating internal resources and managing knowledge at the enterprise level.

Another important analytical area concerns the humanitarian and legal dimension of forced migration. K. Sandvig & A. Garnier (2022) and Eurofound (2024) stressed the importance of long-term strategies for integrating displaced people beyond crisis response and provide for systematic work with professional adaptation, mental health and decent working conditions. Such considerations echo the need to form a new management culture, which in Ukrainian conditions should integrate social sensitivity into strategic personnel management models. It should be emphasised that most foreign studies offer either fragmented solutions at certain levels of government or are concentrated on specific industries or territories. In contrast, the results of the study allowed to formulate a three-level model of systemic managerial response, which combines institutional modernisation, regional adaptation and organisational flexibility. The integration of these approaches is a decisive factor in ensuring the stability of the labour market in the context of migration turbulence.

## ● CONCLUSIONS

The study allowed to draw detailed conclusions regarding the impact of the war-induced migration crisis on the labor market. The study allowed to form detailed conclusions regarding the impact of the the war-induced migration crisis on the labor market of Ukraine and to develop specific recommendations for its stabilisation. It was found that the transformation of the labour market has a multifaceted nature, which manifests itself at all levels of management and requires a comprehensive response. At the macro level, an institutional imbalance was identified, which is expressed in a significant quantitative discrepancy between the demand and the supply of labour. This is confirmed by the fact that as of the beginning of 2024, the number of registered

unemployed is almost 2.5 times higher than the number of available vacancies. At the same time, there was a shortage of strategic vision in management, which leads to incoordinated actions in the field of state employment policy.

At the meso-level, the gap between local labour market needs and regional governance efficiency is recognised as a key problem. In some areas, such as construction or mobile food, there is an acute shortage of staff, while in others, such as financial markets or insurance, the number of applicants is significantly higher than the number of vacancies. This imbalance shows the low adaptability of regional governance instruments to dynamic changes. At the micro level, the main challenges are personnel instability and qualification shortages. The study found that much of the economically active population, temporarily displaced, cannot find formal employment that contributes to the growth of shadow employment. In addition, there is a significant risk of intellectual migration, since more than 70% of Ukrainian refugees have higher education, but often have to work on low-skilled jobs, which reduces their motivation to return. An additional problem is the need to adapt staff to new conditions, which requires the introduction of flexible forms of employment, such as remote work, which is sought by more than 14% of potential employees.

Based on these results, a multi-level system of management actions has been proposed, which provides for the synchronisation of institutional efforts at the state

level, increasing regional adaptability to local challenges and increasing internal flexibility of organisations. This approach allowed to create a target image of the future labour market – adaptive, digital-orientated and resistant to crisis phenomena. Analysis of relevant sources confirmed the scientific and practical significance of the chosen problems. The relevance of the research results from the standpoint of modern scientific thought in the field of migration policy, labour market, digital governance and institutional economics has been confirmed. The proposed solutions are practically orientated and based on the principles of adaptability, digital integration, intersectoral coordination and preservation of human capital. In the future, further research should be focused on the empirical measurement of the effectiveness of the proposed management decisions, the expansion of digital analytics methods and the analysis of the relationship between labour migration and the innovative potential of regions.

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## Управлінські виклики трансформації ринку праці в умовах міграційної кризи

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**Анотація.** Міграційна криза, спричинена війною, суттєво трансформувє ринок праці України та вимагає переосмислення підходів до його відновлення. Метою дослідження було обґрунтувати типологію управлінських викликів трансформації ринку праці в умовах міграційної кризи та сформувати систему стратегічних управлінських рішень для їх подолання. Для досягнення мети застосовано контент-аналіз наукових джерел, статистичний аналіз даних Державної служби зайнятості України та міжнародних організацій, порівняльний аналіз українських і зарубіжних підходів до регулювання ринку праці, а також метод узагальнення для систематизації отриманих результатів. У результаті сформовано узагальнену типологію управлінських викликів за рівнями управління: на макрорівні виявлено інституційний дисбаланс системи зайнятості та дефіцит стратегічного бачення; на мезорівні – розрив між локальними потребами ринку праці та інструментами регіонального управління; на мікрорівні – кадрову нестабільність, дефіцит кваліфікацій і виклики адаптації персоналу до нових умов. На основі отриманих результатів запропоновано багаторівневу систему управлінських дій, скоординованих на макро-, мезо- та мікрорівні. Вона ґрунтується на принципах синхронізації інституційних зусиль, регіональної адаптивності та внутрішньої гнучкості організацій. Визначено цільовий візійний образ ринку праці майбутнього – адаптивного, цифрово орієнтованого, стійкого до викликів та здатного до збереження і відтворення людського капіталу. Результати дослідження можуть бути використані органами державної влади, регіональними управлінськими структурами та бізнесом для розробки стратегій реагування на кризові виклики, а також як основа для подальших наукових розробок у сфері управління ринком праці в умовах міграційних процесів

**Ключові слова:** трудова міграція; структурні дисбаланси; стратегічне управління; людський капітал; цифровізація; політика зайнятості; система управлінських дій

## **Lifelong learning in the digital era: How the approach to human capital development is changing**

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**Abstract.** In the context of digital transformation and changes in the labour market, traditional approaches to human capital development are becoming inefficient, meanwhile, continuous updating of knowledge and skills is becoming more relevant as a prerequisite for the competitiveness of employees and organisations. The goal of this study was to identify trends in changes of educational paradigms, analyse the impact of digital technologies on the formation of requirements for employee competencies, as well as to explore best practices for implementing lifelong learning at the individual, organisational, and state levels. To achieve this goal, a comprehensive interdisciplinary approach has been applied, integrating theoretical foundations of lifelong learning, human capital theory and learning psychology with empirical methods, including content analysis, comparative, and systematic analysis of educational strategies and policies. The results of the study suggest a significant impact of digital transformation on the requirements for employee competencies. It has been discovered that nowadays the traditional professional knowledge of an employee is as important as digital literacy, meta-competencies and continuous learning. The study has also revealed significant changes in educational paradigms, with the transition from traditional forms of learning to flexible models focused on individualisation and the use of digital technologies. Online courses, corporate training, micro-qualifications are becoming important components of educational ecosystems. Based on content analysis, it has been found that organisations are currently playing an active role in the development of human capital by investing in training and retraining of their employees. A comparative analysis of the experience of implementing lifelong learning systems in different countries has revealed a number of problems,

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including the digital divide, insufficient motivation for learning and a failure of educational programmes to meet the needs of the labour market. Based on the carried-out study, recommendations for further implementation of lifelong learning to ensure the development of human capital have been made. The practical value of the study is determined by the creation of a theoretical basis for improving educational programmes, corporate training and state policy aimed at supporting lifelong learning in the digital economy

**Keywords:** competencies; digital literacy; digital transformation; meta-competencies; online learning

## ● INTRODUCTION

Technological changes, such as automation, artificial intelligence and digitalisation, have radically transformed the labour market. These changes have increased the requirements for flexibility and adaptability of employees, requiring them to constantly update their knowledge and skills. In such conditions, traditional educational models are gradually losing their effectiveness and are currently unable to provide a rapid response to the dynamic needs of the economy, which led to the development of the concept of lifelong learning. This concept has become important for the development of human capital, since continuous learning allows an employee to remain competitive in the labour market, constantly developing new competencies that meet current challenges. For organisations, implementing such a concept means maintaining innovation and productivity, since their employees always have the knowledge in demand and for the economy, lifelong learning is a guarantee of sustainable development and the ability to adapt to global changes, ensuring competitiveness in the global market.

As E. Ostmeier & M. Strobel (2022) and B. Audrin *et al.* (2024) have pointed out, Industry 4.0, characterised by the total implementation of digital technologies, automation and the use of the Internet of Things (IoT), has radically transformed the requirements for employee competencies. In this new industrial landscape, where the physical and digital worlds are closely integrated, traditional skill sets become insufficient. At the same time, a special emphasis should be placed on the development of such competencies as flexibility and critical thinking of an employee, since Industry 4.0 requires not just performers, but thinking specialists capable of innovation and continuous self-improvement. It corresponds to the concept of lifelong learning, which, according to A. Ivashura *et al.* (2022), S. Webb *et al.* (2022) and A. Sandblad (2023), is a key tool for adapting to the rapidly changing social and professional environment. This means that an employee must be prepared for the fact that their profession or skills may change and need to be supplemented throughout the life and not only at the initial stage of their career. This approach ensures personal flexibility and the ability to function successfully in conditions of uncertainty and innovation.

According to the World Economic Forum, more than 50% of employees worldwide will need to be retrained or upskilled by 2027 to meet the demands of new professions that did not exist even ten years ago (Future of jobs report, 2023). Given this, researchers C. Romero & S. Ventura (2020) and L.M. Håkansson *et al.* (2023) emphasised in their works that in the conditions of dynamic changes in the labour market, it has become extremely important to develop in employees the so-called “learning agility”, which is not just the ability to absorb information but a complex characteristic that encompasses the ability to quickly and effectively acquire new knowledge and, most importantly,

transform it into practical application. Thus, “learning agility” goes beyond the traditional understanding of learning, as it involves both the ability of cognitive assimilation and a high level of self-reflection, openness to new experience and willingness to experiment. A highly “learned” employee is not afraid to face unfamiliar tasks, quickly analyses the situation, studies the necessary information and implements the acquired knowledge to achieve certain results. This allows companies to quickly respond to the challenges of the digital age and maintain their competitiveness.

In addition, scientific research in the field of psychology, in particular J. Sweller (2020) emphasised the importance of developing metacognitive skills. This is not just the employee’s ability to learn, but the ability to be aware of and manage learning process. Developed metacognitive skills contribute to effective learning planning, monitoring its progress, evaluating results and adjusting strategies, which is directly related to the successful implementation of self-education models and individual educational trajectories. In this context, the concept of lifelong learning becomes a key element of human capital development strategies, as it ensures constant updating of knowledge and skills, which is the foundation for adapting to rapid changes in the labour market and in society as a whole. Moreover, lifelong learning is the basis for the formation of an inclusive and sustainable knowledge society, where everyone, regardless of age or primary education, has the opportunity to develop their potential throughout their lives.

Thus, the relevance of the chosen topic is stipulated by the challenges faced by modern society, in particular: processes automation, changing requirements for qualifications, the growth of the number of new professions and the disappearance of old ones. All these aspects stipulate the necessity of a systematic study of the digital transformation impact on educational practices and the development of human capital. The goal of this study was to analyse the transformation of the approach to the development of human capital in the context of digitalisation and the spread of continuing education practices. This goal was achieved through the following objectives: to analyse the content of the “human capital” concept and the concept of lifelong learning; to identify key aspects of the digital transformation impact on educational models; to analyse the practice of developing and applying lifelong learning in different countries; to make recommendations for improving approaches to the implementation of lifelong learning in order to develop human capital in the digital era.

## ● LITERATURE REVIEW

### The concept and evolution of lifelong learning

The concept of “lifelong learning” emerged in the second half of the 20<sup>th</sup> century as a response to the growing need for continuous updating of knowledge and skills.

International organisations such as the Council of Europe, the European Commission and the Organization for Economic Cooperation and Development (the OECD) played a significant role in the development of this concept. The publication of the report on “Education: The hidden treasure” edited by J. Delors *et al.* (1996) was a key milestone. This report laid the foundation for reconsidering the role of education as a continuous process covering all stages of a person’s life. In the following decades, the concept of lifelong learning was further developed in the strategic documents of the European Union and the OECD. According to the OECD (2023) report, lifelong learning is considered as a key to sustainable economic growth, innovation and social inclusion. Within the framework of the modern discourse, the emphasis is shifting from formal education to the integration of non-formal and informal learning, the recognition of the results of individual educational experience and the personalisation of educational trajectories. Thus, as O. Protasenko (2024) pointed out, the evolution of the concept of lifelong learning reflects the transition from a linear model of education to a dynamic, continuous and multi-level system that meets the challenges of the digital economy and the knowledge society.

Human capital theory emerged in economics in the mid-twentieth century as an attempt to explain the contribution of education and professional skills to economic growth. According to K.G. Abraham & J. Mallatt (2022), S. Leoni (2023) and P. Auerbach & F. Green (2024), approaches to the interpretation of human capital have expanded significantly in the context of digitalisation and automation. Modern research emphasises the need to develop soft skills, digital literacy, creativity and the ability to interdisciplinary interaction. Attention is also focused on the concept of learning agility – the ability to quickly adapt and master new things in conditions of uncertainty. Complementing classical economic models, A. Aman-Ullah *et al.* (2022) and L. Arokiasamy *et al.* (2023) considered human capital from the perspective of modern theories as a set of knowledge, skills, abilities, attitudes and motivations that are formed throughout life, rather than within the framework of formal education. This makes lifelong learning not just an element of professional growth, but a strategic resource for sustainable economic development.

### **The relationship between learning and human capital**

Lifelong learning affects directly the development of human capital, providing for a constant updating and expansion of competencies required in the conditions of digital transformation of the labour market. Studies by S. He & H. Yao (2022) and S. Sidenko (2024) proved that a significant part of employees (regardless of their field of activity) needs retraining and advanced training. Moreover, the connection between continuous learning and human capital productivity is confirmed by empirical data. E.S. Knudsen & L.B. Lien (2023) and the OECD (2023) pointed out that countries with a high share of employees involved in continuous learning demonstrate a higher level of employment, innovative activity and social mobility. In the long term, this leads to an increase in the competitiveness of the national economy.

From the perspective of the sociocultural approach developed by F.B. Mecocci *et al.* (2022) and I. Shavkun &

Y. Dybchinska (2022), lifelong learning allows a person to remain an active participant in social interaction and contributes to the development of cognitive and metacognitive skills. Thus, lifelong learning is both an economic category and a mechanism for individual development and social inclusion. Therefore, the concept of lifelong learning is a key paradigm of modern educational discourse, which reflects the transition from a linear model of knowledge acquisition to a continuous, integrative and personalised process of their assimilation throughout life. At the same time, considering lifelong learning from the perspective of human capital theories suggests its fundamental role in the formation and reproduction of a set of knowledge, skills and attitudes that are crucial for both individual and socio-economic development. All these aspects necessitate the study of the lifelong learning impact on approaches to human capital development.

### **● MATERIALS AND METHODS**

A comprehensive interdisciplinary approach, developed in the works of L. Nowell *et al.* (2022) and M.L. Rethlefsen *et al.* (2022), served as a methodological basis of the study, which provided a comprehensive analysis of the studied problem. The content analysis was used to identify key concepts, trends and discursive strategies in the scientific and analytical literature on the issues of lifelong learning and human capital development. The analytical search and review of scientific articles over the past ten years presented in well-known international databases (Scopus, Web of Science, Google Scholar, etc.), as well as books and their chapters, reports and presentations of international organisations (e.g., the OECD, the European Commission,) and large consulting companies, such as McKinsey & Company) were carried out with the help of content analysis. In addition, state strategies for the development of education and human capital were studied within the framework of content analysis. During the content analysis, special attention was paid to looking for information on: new competencies needed in the labour market (e.g., flexibility, critical thinking, digital literacy); existing approaches to organising lifelong learning (online courses, corporate training, etc.); the role of a state, business and each person in lifelong learning; difficulties that arise when implementing lifelong learning. Conclusions on the main trends and differences in views on the studied problem were drawn on the basis of the study results.

The comparative analysis allowed for a comparison of different strategies in the field of education and digital transformation, identification of common features and differences in approaches to the implementation of lifelong learning and human capital development. The comparative analysis included the following: a comparison of national educational strategies in countries with different levels of economic development and digital maturity; a comparison of models of financing and state support for lifelong learning; identification of common features and differences in approaches to the implementation of lifelong learning programmes and human capital development; effectiveness evaluation of specific initiatives and pilot projects.

The system analysis was used to identify the relationships between educational policy, economic transformations and human capital development, as well as to

develop recommendations for the implementation of lifelong learning for the growth of human capital. The analysis was carried out in the following order: identification and assessment of problems in existing education and human capital development systems, hindering the effective implementation of lifelong learning; analysis of hierarchies to determine the levels of management and decision-making in educational systems, as well as their impact on flexibility and adaptability to new requirements. This approach contributed to both understanding the current state and developing comprehensive and substantiated recommendations for the development and implementation of lifelong learning to develop human capital in the digital economy.

Various scientific sources, which provided an in-depth analysis of the problem, served as the empirical basis of the study. Modern scientific publications were used in the course of the empirical study, covering research in the field of lifelong learning, human capital development and the impact of digital transformations, analytical reports of leading international organisations, such as the OECD, which provides comprehensive data and recommendations on education and employment policies, as well as the European Commission, which develops strategies for skills development and support for lifelong learning in the European Union countries. A special attention was paid to current statistical data, in particular Human development reports (2024). The use of these sources made it possible to analyse the current state of the studied problem, as well as to identify key development trends and outline promising areas for further research and practical implementation. Such a comprehensive approach to data collection and analysis ensured the objectivity and validity of the drawn conclusions.

## ● RESULTS

### The impact of digital transformation on competency requirements

Digital transformation, covering all areas of economic and social life, has become a key factor in structural changes in the labour market and in the vocational training system. As G. Nazarova *et al.* (2022) point out, the development of technologies such as artificial intelligence, machine learning and business process automation have created new working conditions and put forward qualitatively different requirements for employee competencies. The modern labour market is under constant transformation, driven by the rapid development of digital technologies. More and more processes in production, logistics, media, education and even healthcare are being automated. As a result, a number of professions have lost their relevance. According to the World Economic Forum forecasts (Future of jobs report, 2023), about 800 million jobs in the world may be

replaced by automated systems by 2030. At the same time, new professions and fields of activity related to data analysis, digital platform management, development and support of AI systems, cybersecurity and digital marketing are being created.

Moreover, as far as the impact of digital transformation on employee competence is concerned, the OECD (2023) report states that lifelong skills are a key to adapting to global trends (digitalisation, population aging, technological change, pandemics) and also emphasises that essential “transversal” skills (critical thinking, teamwork, analytics) are in high demand and significantly increase labour productivity. The recommendations of the EU Council on the need to implement continuous training of employees highlight key competencies, including digital literacy, social communication, flexibility, entrepreneurial skills, etc., which are essential for employees throughout their lives (Council of the European Union, 2018). At the same time, the consulting company McKinsey & Company (2024) in its annual report emphasised the importance of digital transformation of education through the use of microcredits, personalised learning, the use of big data, artificial intelligence for the adaptive transition of employees to new work requirements. The company predicted that digital education could increase global GDP by \$2.7 trillion per year over the next five years. The company also believes that continuing education helps improve a person’s digital, social and cognitive skills, increasing employee competitiveness.

At the same time, flexibility is becoming a new standard in the employment structure. Non-standard forms of work are spreading, e.g. freelance, project employment, remote work and flexitime. These changes require quick adaptation, retraining and effective self-organisation in conditions of uncertainty and constant change. The skills of traditional “hard” professionalism are becoming insufficient, as the abilities for self-renewal, interdisciplinarity and digital mobility come to the forefront. Meanwhile, new realities of work involve the development of a wide range of digital and meta-competencies rather than just the knowledge of specific tools and technologies. These digital competencies are understood as the ability to effectively use digital resources, technologies and data to solve professional tasks. It includes working with information, digital communication, creating digital content, understanding ethical and legal aspects of the digital environment. However, digital skills alone are not enough. Modern employers expect specialists to have meta-competencies, i.e. universal, supra-professional qualities that provide the ability for self-development. Based on the results of content analysis of scientific and analytical literature, the most significant current meta-competencies of an employee have been identified (Table 1).

**Table 1.** Employee meta-competencies

Meta-competencies	Definition
Critical thinking	Ability to analyse and evaluate information, make informed decisions, resistance to manipulation
Communication skills	Ability to interact in interdisciplinary and intercultural teams, including a digital environment
Adaptability	Flexibility of thinking, readiness for change, stress resistance
Self-organisation skills	Time management, priorities, personal effectiveness in different working conditions
Ability for continuous learning (lifelong learning)	Openness to new knowledge and technologies, ability to learn independently and collaboratively

**Source:** developed by the authors based on M. Gaşior *et al.* (2021), H.B.-G. Chalutz & Y. Cohen (2022)

Thus, the modern model of a competent specialist includes technical qualification, as well as developed personal and social maturity, which contributes to a successful performance in a rapidly changing digital environment. The education system is transforming in accordance with the changing requirements for competencies. Traditional forms of education no longer provide the necessary flexibility and speed of knowledge updating. Instead, new educational formats focused on the digital environment and

individualisation of educational trajectories are actively developing. Digital transformation changes the sphere of employment and the profile of competencies, as well as creates new approaches to learning. The readiness for constant knowledge updating, digital literacy and developed meta-competencies are becoming an integral part of professional success in the 21<sup>st</sup> century. Key trends in educational formats, identified on the basis of content analysis of relevant literature, are presented in Table 2.

**Table 2.** New educational formats

Educational formats	Characteristics of the educational format
Online learning	Platforms such as Coursera (n.d.), Udemy (n.d.), edX (n.d.), Stepik (n.d.) and others offer a wide range of courses on relevant topics, ranging from programming to leadership. Online formats provide accessibility to education and the ability to choose the pace and depth of learning independently
Corporate training	Companies are creating internal learning platforms and academies that enable employees to master necessary skills in the context of specific business tasks. It contributes to the continuous development of human capital and adaptation to change
Microcredits and modular learning	Leading universities and platforms offer short-term certificate programmes (nano-degrees, microcredentials), contributing to quick mastering of necessary skills and confirming the qualification
Using artificial intelligence (AI) in education	AI provides for creating personalised learning trajectories, analysing progress, recommending learning materials and accompanying the learner
Gamification and engagement	The introduction of game mechanisms (scores, levels, challenges, competitions) into the educational process, contributes increasing motivation, maintaining attention and improving memorisation

**Source:** developed by the authors based on N.C. Burbules *et al.* (2020), H.B.-G. Chalutz & Y. Cohen (2022)

Platforms such as Coursera, Udemy, edX, Stepik and others offer a wide range of courses on relevant topics. They provide the possibility of flexible access to knowledge at a time convenient for employees, allowing them to combine learning with work responsibilities. Employee progress can be tracked through built-in assessment systems (tests, assignments, projects) available on these platforms. Based on this data, knowledge gaps can be identified and additional courses or materials can be recommended, adapting training to individual needs. Corporate learning systems can be designed with functionality for tracking progress, including the percentage of course completion, assessment results and feedback from supervisors. Based on the analysis of this data, individual development plans can be created for each employee, offering courses that meet their career goals and business needs. Microcredits and modular learning are ideal for quickly filling specific skill gaps or for obtaining highly specialised knowledge. The progress can be tracked through the skills assessment provided within each module. It makes it possible to accurately determine, which competencies have already been mastered and which require further development, and automatically offer subsequent modules according to individual educational needs.

AI can collect and analyse large amounts of data about an employee's interaction with training content (time spent on tasks, correct answers, typical errors). Based on this analysis, AI can dynamically adapt training materials, change the complexity of tasks, offer additional explanations or exercises and identify employees, requiring additional support, and provide them with automated tips or recommendations. Gamified platforms can automatically track employee progress through a system of scores, achievements and rankings. This creates a sense of competition and encouragement, which motivates further learning. The system can identify "weak spots" in knowledge,

offering additional "challenges" or "missions" aimed at deepening understanding of certain topics and thus tailor training to individual educational needs through interactive game scenarios.

These new educational formats, especially with the integration of AI and analytical tools, provide flexibility in tracking employee progress and individualising their learning, which allows for constant adaptation of educational programmes to labour market requirements and specific company needs, contributing to the continuous development of personnel. Thus, digital transformation changes the employment landscape and competence profile, as well as shapes new approaches to learning. Readiness for constant knowledge updating, digital literacy and developed meta-competencies are becoming an integral part of professional success in the 21<sup>st</sup> century.

**Changing approaches to human capital development in the digital environment**

Digital transformation is profoundly affecting the paradigm of human capital development. In the condition of a rapid technological change, accelerated knowledge obsolescence and labour market instability, the classic model of competency formation – through formal education followed by a long period of professional implementation – is losing its effectiveness. It is being replaced by the concept of continuous, flexible and adaptive learning, where apart from educational institutions, employees and organisations are becoming key actors.

One of the main trends is the decrease in the dependence of professional development exclusively on formal educational trajectories. The traditional education system, despite its continuing importance, is not always quick enough to adapt to the rapidly changing requirements of the digital economy. Curriculums are often updated late and a

diploma fails to be a guarantee of compliance with modern labour market challenges. Against this background, the importance of flexible forms of learning, focused on the practical application of knowledge, individual needs and rapid adaptation to changes, is growing. Self-directed learning, informal educational practices (webinars, podcasts, educational channels, online courses, professional communities, etc.) are becoming increasingly popular. Employees independently form and adjust their educational trajectories, based on the tasks, goals and conditions of a specific professional activity. This approach allows them to respond to changes in the professional environment more accurately and promptly and master necessary skills “here and now”.

The digital environment is becoming a catalyst for these processes, providing access to global educational resources, self-diagnostic tools and personalised learning. Mobility, interactivity and accessibility make informal learning an effective alternative to traditional forms of advanced training. In the digital economy, responsibility for the development of human capital is increasingly shifting to the level of organisations. Companies are beginning to play an active role in the formation and maintenance of their employees’ competence, becoming educational agents rather than just employers.

Corporate learning, which is implemented in various formats, has become one of the key tools of this process, ranging from internal trainings and webinars to the creation of full-fledged internal academies and universities. Such structures contribute to quick and flexible adaptation of educational content to the specifics of the organisation’s activities, strategic objectives and requirements of specific roles, contributing to the formation of a single corporate culture and talent retention. The practice of mentoring plays a special role, which strengthens horizontal ties within the organisation, promotes the transfer

of knowledge from experienced specialists to beginners and supports the culture of continuous development of human capital. Mentoring also creates emotional and professional involvement, which is particularly important during hybrid and remote work. Moreover, the strategies of Upskilling (upskilling within the current profession) and Reskilling (complete retraining to transition to a new professional field) are becoming widespread. These approaches are becoming a response to the need for constant updating of competencies caused by technological shifts and changes in business processes. Organisations invest in employee training not only to improve efficiency, but also considering it as a strategic measure to reduce costs connected with hiring new professionals and adapting to technological changes.

Thus, the development of human capital in the digital environment involves abandoning a linear and static model of education in favour of a flexible, multi-level and distributed system in which anyone can become a student, and any environment, including the work environment, can become a learning environment. A comprehensive approach, combining self-directed learning, organisational support and the use of digital technologies, is becoming the basis for sustainable professional growth of human capital in the context of digital transformation.

**Experience of different countries in the development and implementation of lifelong learning**

Lifelong learning has acquired strategic importance in the context of digital transformation and accelerated obsolescence of professional knowledge. In many countries of the world, this concept has become an integral part of public policy, corporate strategies and educational initiatives. Table 3 provides a comparative analysis of the experience of different countries in the application of lifelong learning.

**Table 3.** A comparative analysis of lifelong learning in different countries

Country	General characteristics of lifelong learning	The main focus of lifelong learning	Examples of successful lifelong learning models
Azerbaijan	Lifelong learning is a key element of the education system modernisation and the adaptation of the population to digitalisation, changes in the labour market and globalisation. To implement lifelong learning, both formal (universities, technical schools, centres for advanced training) and informal educational platforms (courses, trainings, online programmes) are used for different age and professional groups	Developing formal and informal education, advanced training and digital literacy	<p><b>Agency for quality assurance in education (TKTA) (n.d.):</b> established to raise educational standards, ensure quality and transparency in the educational environment. One of the agency’s most successful programmes is the teacher professional certification programme</p> <p><b>Advantage:</b> the programme allows teachers to undergo regular certification and advanced training, which contributes to improving the quality of education and the professional level of personnel</p> <p><b>Disadvantage:</b> the regions of the country are covered unevenly, which creates inequality in access to learning opportunities, particularly in rural and remote areas</p>
Britain	Continuing education as an integral part of personal development, economy and social mobility. Lifelong learning includes a wide range of opportunities for adult learning: vocational courses, evening and online programmes, as well as on-the-job training	Developing practical and professional skills in demand in the labour market	<p><b>The open university (n.d.):</b> a state distance learning university founded in 1969. It allows people of all ages and levels of training to: study remotely and at a convenient time; obtain academic degrees or professional certificates; combine studies with work and personal life</p> <p><b>Advantage:</b> maximum flexibility and accessibility</p> <p><b>Disadvantage:</b> lack of live interaction and practice</p>

Table 3, Continued

Country	General characteristics of lifelong learning	The main focus of lifelong learning	Examples of successful lifelong learning models
Germany	Dual training system, which includes theoretical education and practical onsite training directly at enterprises. Advanced training and professional retraining programmes, financed by the Federal Employment Agency, are available for the adult population	Supporting the mobility of professionals and preventing professional burnout	<b>Weiterbildungsprogramm (WBS Training, n.d.):</b> a set of public and private vocational training and advanced training programmes focused on the specific needs of regional and industry labour markets <b>Advantage:</b> close connection with the labour market <b>Disadvantage:</b> unequal access (e.g. workers with low level of education, migrants or workers in precarious employment are less likely to participate in training)
USA	The concept of lifelong learning is implemented mainly through the educational services market and private initiatives. A developed network of community colleges, online universities and corporate academies provides for acquiring professional skills in a short time	Investing in employee Upskilling and Reskilling programmes	<b>Community colleges in the United States (n.d.):</b> the programme provides opportunities for adults to gain practical knowledge, change careers or upgrade skills; programmes are tailored to busy people (evening/online classes); often provides practice-oriented programmes <b>Advantage:</b> accessibility and practical orientation <b>Disadvantage:</b> limited academic and career prospects
Ukraine	The initial stage of the lifelong learning development. Along with supporting the traditional higher education system, the state is developing digital educational platforms and implementing projects to train adults, including temporarily displaced persons and people with limited access to the labour market	Developing digital literacy and self-employment skills	<b>Diia. Education (n.d.):</b> aims to increase the digital literacy of the population; provides access to free online courses on the basics of digital security, the use of e-government services, digital hygiene and other issues <b>Advantage:</b> accessibility of digital learning to a wide audience <b>Disadvantage:</b> limited depth and academic content
Finland	The most integrated approach to building a lifelong learning ecosystem. The country has a modular education system, which allows adults to increase their qualifications flexibly at a convenient pace. State educational institutions cooperate closely with employers and programmes are funded from budgetary and private sources	Making digital skills training available to all age groups	<b>Digivisio 2030 programme (n.d.):</b> a national project that aims to create a digital platform, uniting all educational institutions; provides access to courses from any university or college in Finland; makes learning flexible and personalised <b>Advantage:</b> personalised and flexible learning <b>Disadvantage:</b> digital divide and technological barriers
France	Ensuring professional mobility, advanced training and adaptation of citizens to changes in the labour market. Educational trajectories are created individually, taking into account the employee's needs. Lifelong learning is supported by the state, employers and social partners, which ensures accessibility and effectiveness	Developing professional competencies and ensuring equal access to educational opportunities for all citizens throughout their lives	<b>Compte Personnel de Formation (n.d.) system:</b> allows every employee and job applicant to accumulate training hours upon entering the workforce and use them to complete certified educational programmes <b>Advantage:</b> flexibility and personalisation (employees choose independently the direction, format and training provider, based on their own professional goals) <b>Disadvantage:</b> limited awareness of employees about the opportunities provided by CPF, which reduces the reach of the target audience and the efficiency of resource use
South Korea	Introduction of digital technologies into educational processes. The state invests in the development of online platforms and encourages learning via smartphones, which makes education more accessible to the population	Priority for technological specialties and IT competencies, including training middle-aged professionals for the transition to the digital economy	<b>National online platform K-MOOC (National Institute for Lifelong Education, n.d.):</b> covers a wide range of disciplines and is aimed at adult learners. Its feature is the adaptation of courses to mobile devices and the use of personalisation technologies <b>Advantage:</b> broad and equal access to high-quality education <b>Disadvantage:</b> low course completion rate

**Source:** developed by the authors based on S. Benasso *et al.* (2022), H. Hinzen *et al.* (2022), A. Kuzior *et al.* (2023), Future of jobs report (2023), Human development reports (2024), I. Spivak *et al.* (2024)

The presented results of the comparative analysis made it possible to conclude that, despite successful practices, lifelong learning faces a number of barriers. In particular, the development of lifelong learning is hindered by the low level of digital literacy among employees over the age of fifty and in rural areas, which limits access to modern learning formats and requires basic digital training. There is also unequal access to educational resources due to social, economic and territorial factors, and in some countries there is a lack of infrastructure for large-scale online learning; in addition, some employees do not have a sufficient motivation to learn due to a lack of time, resources or incentives, and educational programmes often fail to meet the labour market requirements, do not provide the appropriate level of practical training and are not accompanied by certification recognised by employers. However, despite the existing barriers, there is a sufficient number of positive results of implementing lifelong learning systems in the company activities.

One example is Siemens, a global technology conglomerate known for its investment in employee development (Siemens UA, n.d.). The company actively uses dual education programmes and its own internal academies to upgrade the skills of engineers, technicians and managers. Siemens supports lifelong learning through various formats, including online courses, seminars and practical training to ensure employees' skills compliance with the latest technological advances. Another example is Google, a leader in implementing innovative approaches to learning, offering a wide range of internal programmes known as "Googler-to-Googler" (g2g), where employees share their knowledge and skills. Moreover, Google actively uses online platforms such as Coursera (n.d.) to provide microcredits that allow people to quickly acquire in-demand skills in the areas of IT support, data analysis, project management and UX design. It allows the company to constantly update the competencies of its employees and attract new talent.

Another example is the French telecommunications company Orange (n.d.), which implements the development of digital skills of its employees. The company actively uses the *Compte Personnel de Formation* (n.d.) system and has its own system, offering a wide range of training programmes adapted to the needs of the company and the individual career trajectories of employees. The company uses various formats, including blended learning, virtual reality and gamification to make training more interactive and effective. Another example is the Swedish company Spotify (n.d.), which encourages a culture of continuous learning and development. The company supports its employees in taking external courses (Coursera, Udemy, edX, etc.), attending conferences and participating in internal hackathons and workshops. Spotify also provides access to online resources and encourages knowledge sharing between teams, which contributes to rapid adaptation to changes in technology and market conditions.

### **Recommendations for implementing lifelong learning for the growth and improvement of human capital**

Companies are actively integrating lifelong learning into their HR development strategies, realising that traditional approaches to learning are losing their effectiveness. Companies are focusing on flexible learning models that focus

on individualisation and the use of digital technologies. Thus, companies are taking an active role in the formation of human capital by investing in training and retraining of their employees. The introduction of continuous education systems is causing changes in the leadership style of companies. In the context of digital transformation, leadership is transforming from directive to coaching, where managers become mentors, helping employees identify their educational needs and directing them to appropriate training programmes. The development of "learnability" has become a top priority. In addition, leadership is focused on encouraging employees to self-reflection, openness to new experiences and willingness to experiment, being the key aspects of "learnability".

To support employees' digital transformation, management approaches are also needed to effectively overcome barriers such as the digital divide, low motivation and the incompatibility of educational programmes with labour market needs. It includes personalising learning through the use of AI to adapt learning trajectories to the individual needs of every employee, as well as analysing knowledge gaps and recommending relevant courses. It is important to stimulate motivation through the implementation of effective mechanisms, such as gamification, incentive systems and achievements recognition, which increase employee engagement in learning. In addition, it is necessary to ensure a close connection of educational programmes with current labour market requirements for employees to receive in-demand skills. The formation of a culture of continuous learning is vital, where learning becomes an integral part of the work process and career growth rather than an additional burden.

Thus, the successful implementation of lifelong learning requires a comprehensive approach that combines state policy, employer engagement and personal responsibility of employees. The experience of applying lifelong learning systems in different countries, as well as examples of its successful application in the world's leading companies, suggest that effective improvement of the human capital quality through the application of lifelong learning models is achieved by coordinating the efforts of all parties involved, investing in digital infrastructure and creating a culture of permanent development of human capital. Modern socio-economic challenges, including digital transformation and accelerated aging of professions, emphasise the need for active development of lifelong learning in order to develop human capital. Based on the results of the content analysis of literary sources presented in the paper, as well as a comparative analysis of lifelong learning in different countries of the world, the conclusion was made that a comprehensive approach, covering technological, institutional and personal aspects, is needed for its effective development and implementation.

Based on the systematic analysis of the obtained results, technological methods were proposed to contribute to the further development and implementation of lifelong learning. They include the development of a flexible educational infrastructure for adapting training to the needs of specific groups of workers and the labour market, providing access to online courses, modular programmes and micro-qualification opportunities. It is also important to ensure the recognition of non-formal and informal learning,

including experience acquired outside formal educational institutions. The increase in digital inclusion is an essential aspect, suggesting the availability of digital technologies and skills necessary for full participation in learning for all segments of the population.

It is worth mentioning that the development and implementation of lifelong learning requires institutional participation. The systematic analysis of the obtained results made it possible to identify the main participants of this process. The state, as a key participant, must provide a regulatory framework, stable financing and the creation of a holistic educational ecosystem that will encourage the participation of all employees in lifelong learning. The business plays an important role by investing in personnel development and creating a culture of continuous learning in the workplace. The individual, in turn, is responsible for his own development, which includes self-direction in learning and mastering digital literacy for the effective use of available educational resources.

Personal aspects should be based on increasing the involvement of employees in lifelong learning, which can be achieved through the use of multi-level motivational mechanisms. They include career growth opportunities, which directly depend on the level of qualification and readiness of the employee to master new competencies. Companies are increasingly linking career advancement and salary increases with employee participation in training programmes and advanced training courses, which forms a stable internal motivation for continuous learning among employees. Obtaining digital certificates confirming the successful completion of courses or training modules is another important incentive. Such certificates have genuine value in the labour market, especially if issued by recognised educational platforms or accredited institutions and can be used when looking for a job, applying for a promotion or participating in grant competitions. Tax benefits for those who invest in their own education are also an effective mechanism.

For example, a number of countries, such as Germany, France, Switzerland, the USA and Canada, have been using mechanisms that allow for partial compensation of training costs through “tax deductions” or “partial refund of course fees”, which lowers the financial barrier and makes educational investments more accessible to employees. Finally, gamification and the use of interactive formats contribute to both a more active participation in training and better memorisation and application of the acquired knowledge. Gamification techniques enhance employees’ intrinsic motivation, make the learning process less formal and psychologically comfortable, especially for adults who may experience stress from the traditional academic approach, and interactivity contributes to increased cognitive interest, improved information assimilation and development of practical skills through active participation. Taken together, the application of the proposed methods in the development and implementation of lifelong learning will contribute to achieving the main goal – the growth and improvement of human capital in the era of digital transformation.

## ● DISCUSSION

The obtained results indicated a paradigm shift from traditional educational models to flexible, individualised and

technologically integrated formats. Key trends, such as the spread of online learning, the development of corporate academies, the use of micro-qualifications, the integration of artificial intelligence and gamification, have not only changed teaching methods but also radically influenced organisational management, personnel development strategies, and leadership styles. These findings have been widely confirmed and refined in modern scientific research by the global community.

The findings on the dominant role of online learning and digital platforms in ensuring the accessibility and flexibility of education are fully consistent with the findings of many researchers. For example, R. Huang *et al.* (2020) in their paper on the transformation of education under the influence of digital technologies emphasised that the COVID-19 pandemic has accelerated the transition to online formats, revealing their ability to overcome geographical and time constraints, which is critical for continuous professional development. The paper also considered the growing role of massive open online courses (MOOCs) and specialised platforms. S. Sharma & R. Rathore (2023) analysed the effectiveness of online learning in the corporate sector, confirming that it significantly improves the level of knowledge and productivity of employees, especially when the content is interactive and adaptive. These works fully confirmed the findings on the importance of online formats in the present research.

The conclusion about the growing importance of corporate learning and the creation of internal academies as a mechanism for adapting to changes in the labour market also resonates with global trends. K. Andriushchenko *et al.* (2022) studied the impact of corporate universities on organisational innovation and competitiveness and revealed their key role in the formation of unique competencies focused on specific business needs. This work confirmed the conclusion that such academies contribute to the continuous development of human capital. B. Mustafa & S. Lleshi (2024), having analysed the impact of investment in training on company productivity, also pointed out that internal training programmes that are directly related to business goals are more effective for improving skills and retaining talent.

The assumption in the paper about the growing popularity of micro-qualifications as a means of rapid acquisition and validation of skills was confirmed by T. Semigina & Yu. Rashkevych (2023). The authors studied how micro-certifications are becoming a response to the market need for flexible and targeted training, allowing employees to quickly adapt to new technological requirements without the need to complete lengthy programmes. The authors pointed out that micro-qualifications play a key role in creating an adaptive workforce. J.P. Roque (2023) also studied the benefits of modular learning in the context of professional development, having emphasised its ability to provide “on-demand learning” and personalised learning trajectories. The authors’ views are relevant, as they confirmed the effectiveness of this approach for a quick response to labour market dynamics.

The implementation of AI for personalising learning trajectories, analysing progress and recommending materials has become one of the most relevant research areas. M.J.K.O. Jian (2023), C. Halkiopoulou & E. Gkintoni (2024)

explored the potential of AI in transforming the educational process, emphasising its ability to adapt content to individual learning styles, optimise information delivery and provide personalised feedback. C. Romero & S. Ventura (2020) also demonstrated in their study how AI systems can identify knowledge gaps, predict performance and automatically adjust curricula, which is fully consistent with this paper findings. The above-mentioned studies also confirmed the fact that AI is a driving force for individualising learning.

The thesis of gamification effectiveness in increasing motivation and engagement in the learning process is also supported by many studies. M. Li *et al.* (2023) conducted the analysis of gamification impact on learning, having confirmed a significant increase in employee engagement, performance and satisfaction with learning. The study emphasised that the correct implementation of game elements can transform the educational experience. C. Baah *et al.* (2024) also investigated the impact of gamification on learning motivation in a corporate environment, having found a positive relationship between gamified platforms and employee engagement in learning, which was consistent with this paper findings on the significant potential of gamification to increase learning efficiency.

Regarding the evolution of leadership styles from directive to coaching and the formation of a culture of continuous learning, the findings are supported by I.M. Mogaji & H. Dimingu (2024), who emphasised the importance of organisational culture in the context of human capital development. The authors pointed out that a culture, encouraging learning, experimentation and openness to change is necessary for successful digital transformation. S. Sidenko (2024) also emphasised that modern leaders should be mentors, supporting the continuous development of their teams, rather than just managers. The study confirmed the thesis that leadership should promote self-reflection and “learnability” of employees.

Although the research results have been widely supported in the scientific literature, it is worth mentioning that some aspects have been found to differ or require further elaboration. For example, despite the overall positive evaluation, some papers, such as A. Morales-Vargas *et al.* (2023), have pointed out challenges related to the quality of online content and the need to ensure a high level of interaction to maintain motivation. Moreover, while the paper emphasises the importance of personalisation, studies, such as N. Chen *et al.* (2023), have proposed more in-depth methodologies for evaluating the effectiveness of personalised learning based on big data and machine learning, which could be the subject of further research. The present research focused on general trends, while some papers refined specific implementation models and impact measurements.

Thus, the results of the study are consistent with the general scientific trends in the field of continuing education and its impact on organisational management. The scientists’ findings confirmed the significance of the chosen topic and the need for further research to address the challenges associated with the digital divide, motivation and adaptation of educational programmes to changes in the labour market. The interest of the global scientific community in this topic suggests its importance for future development of human capital and organisations.

## ● CONCLUSIONS

The study analysed the transformational changes in approaches to human capital development driven by digitalisation, which requires continuous learning. The obtained results suggest that traditional educational models are losing their relevance, giving way to flexible, individualised and technological formats. The main drivers of this transformation include the spread of online learning, the active development of corporate academies, the increasing use of micro-qualifications, the integration of AI into educational processes and the introduction of gamification elements to increase engagement. These new educational formats have not only changed the ways of acquiring knowledge but also influenced organisational management, personnel development strategies and the evolution of leadership styles.

The study highlighted that in an environment where professional knowledge and skills are rapidly becoming obsolete, competencies such as digital literacy, critical thinking, adaptability and self-organisation are becoming as important as highly specialised knowledge. It requires managers to move from directive management to coaching leadership, where the main emphasis is on mentoring, supporting self-reflection and encouraging employees’ “learnability” – their ability to adapt quickly to new conditions and master new things. Changes in learning have directly affected team behaviour, promoting greater collaboration and knowledge sharing, internal processes and communication, which is becoming more open and transparent. The continuous development and recognition of new competencies significantly increase employee motivation and contribute to the formation of an organisational culture, where continuous learning is an integral part of professional life.

This paper proposed a number of strategic recommendations for the successful development and comprehensive implementation of lifelong learning at the national and corporate levels, as well as to overcome existing barriers such as the digital divide, lack of motivation and educational mismatch. The key tasks include developing a flexible educational infrastructure, including holistic ecosystems with access to modular programmes and micro-qualifications, which should adapt quickly to the labour market and individual requests, guaranteeing a wide choice of resources; recognising non-formal and informal learning, including assessing practical experience and developing mechanisms for validating this knowledge, which will increase motivation for self-education; increasing digital inclusion, which will ensure equal access to technologies and basic digital skills for everyone; using multi-level motivational mechanisms, linking learning with career growth, promotion and salary increase; introduction of digital certificates and tax benefits that will reduce the financial barrier; gamification and interactive formats that will make learning more interesting and effective. The proposed recommendations should be implemented comprehensively to create a favourable environment for the continuous development of human capital in the context of digital transformation. Further research can be aimed at developing specific methods for integrating AI tools and gamification to personalise lifelong learning in a corporate environment, taking into account the features of the

Ukrainian labour market and its adaptation to the requirements of the global digital economy.

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## Лайфлонг-навчання в цифрову еру: як змінюється підхід до розвитку людського капіталу

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**Анотація.** В умовах цифрової трансформації і змін на ринку праці традиційні підходи до розвитку людського капіталу втрачають ефективність, натомість актуалізується безперервне оновлення знань і навичок як ключова умова конкурентоспроможності працівників і організацій. Мета дослідження – виявити тенденції у зміні освітніх парадигм, проаналізувати вплив цифрових технологій на формування вимог до компетенцій працівників, а також дослідити найкращі практики впровадження лайфлонг-навчання на індивідуальному, організаційному та державному рівнях. Для досягнення мети застосований комплексний міждисциплінарний підхід, що поєднує теоретичні засади лайфлонг-навчання, теорії людського капіталу і психології навчання з емпіричними методами, зокрема контент-аналізом, порівняльним і системним аналізом освітніх стратегій і політик. Результати дослідження показали значний вплив цифрової трансформації на вимоги до компетенцій працівників. Установлено, що наразі значення мають не лише традиційні професійні знання працівника, а й цифрова грамотність, метакомпетенції і здатність до постійного навчання. У дослідженні також виявлені значні зміни в освітніх парадигмах, з переходом від традиційних форм навчання до гнучких моделей, орієнтованих на індивідуалізацію і використання цифрових технологій. Онлайн-курси, корпоративне навчання, мікрокваліфікації стають важливими компонентами освітніх екосистем. На основі контент-аналізу встановлено, що наразі організації відіграють активну роль у розвитку людського капіталу через інвестування в навчання і перекваліфікацію своїх працівників. Порівняльний аналіз досвіду впровадження систем лайфлонг-навчання у різних країнах виявив ряд проблем, включаючи цифровий розрив, недостатню мотивацію до навчання, невідповідність освітніх програм потребам ринку праці. На підставі проведеної роботи запропоновані рекомендації для подальшого впровадження лайфлонг-навчання з метою забезпечення розвитку людського капіталу. Практична цінність дослідження полягає у формуванні теоретичної бази для вдосконалення освітніх програм, корпоративного навчання та державної політики, спрямованої на підтримку лайфлонг-навчання в умовах цифрової економіки

**Ключові слова:** цифрова трансформація; компетенції; метакомпетенції; цифрова грамотність; онлайн-навчання

## Capital and liquidity assessment in the context of preventing corporate insolvency

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**Abstract.** The relevance of the study is stipulated by the need for a comprehensive assessment of the financial stability of enterprises through the analysis of the capital structure and liquidity in the conditions of an unstable economic environment. Directions for improving the assessment of the capital structure and liquidity of enterprises in the context of preventing insolvency have been substantiated in accordance with the purpose of the study. The methodological basis of the study included the statistical analysis, correlation research and visualisation of empirical data based on scatter plots and histograms of Equity-to-Assets and Quick Ratio indicators distribution on the example of seven enterprises of Ukraine operating in the field of non-specialised wholesale trade for the period 2021-2024. The obtained results demonstrated a moderate positive correlation between Equity-to-Assets and Quick Ratio indicators, which confirmed the complex multifactorial nature of the solvency formation. It gave grounds to argue that the general trend of increasing the share of equity capital contributes to improving the quick liquidity of the enterprises, which formed the sample under study. The analysis of Equity-to-Assets and Quick Ratio indicators distribution revealed the asymmetry in the distribution, which emphasised the feasibility of using additional research methods, in particular, cluster analysis for enterprise typology. A significant part of enterprises is concentrated in the range of moderate capitalisation (5-30%) and a sufficient level of liquidity (>80%), however, the enterprises with signs of the financial condition deterioration emphasised the need to strengthen financial risk management and restructuring of obligations. The practical value of the study is determined by

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the integration of modern quantitative analysis tools into the processes of insolvency prevention, creating the basis for a well-founded adaptation of management strategies in response to the identified statistical patterns of relationships between key solvency indicators, in particular Equity-to-Assets and Quick Ratio, which is of particular relevance in the conditions of destabilised macroeconomic environment and growing external and internal risks for business entities

**Keywords:** capital management; capital structure; Equity-to-Assets; financial liabilities; Quick Ratio

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## ● INTRODUCTION

Managing an enterprise's equity capital in the face of insolvency is critically important for ensuring financial stability and preventing bankruptcy. Modern research focuses on the use of financial indicators, risk assessment models and strategic controlling tools for timely identification of problems and making effective management decisions. According to M.A. Kumar & S. Sharma (2024) and Ł. Antos (2025), financial indicators are the key indicators for preventing enterprise insolvency, in particular liquidity ratios, capital turnover, profitability and the ratio of equity to debt capital, which allow identifying potential problems before they become critical. As H. Havrysh & M. Garbuzyuk (2024) believe, presenting discriminant models using Altman models, fuzzy set analysis and others, allow for a comprehensive assessment of the bankruptcy risk and the adaptation of the approach to the specifics of the enterprise and industry.

Scientists T. Conlon *et al.* (2020) have pointed out that the capital structure of an enterprise is closely related to the level of financial stability and therefore to the risk of insolvency, which increases in cases of borrowed capital dominance over own capital. One of the key risks in this context is the risk of financial leverage, which is caused by excessive involvement of debt resources, which, in the absence of effective liquidity management and asset profitability, leads to an increase in the financial burden and a decrease in solvency ratios. Irrational use of equity and borrowed capital can lead to an increase in the risk of insolvency. Insufficient level of capitalisation of enterprises, that is, an underestimated share of equity in the overall financing structure, creates a stable basis for financial vulnerability in the face of external adverse factors.

According to E. Alghifari *et al.* (2022), attention is focused on the relationship between capital structure, profitability, hedging policy, company size and its market value. The authors have emphasised that poor management of these elements can affect the business value. O. Bohdaniuk & O. Bohdaniuk (2021) and Q. Huynh *et al.* (2022) have studied the importance of financial leverage in the relationship between corporate governance and company performance. The findings suggest that corporate governance raises financial costs by increasing the debt ratio in financial leverage. According to M. Kaakeh & K.K. Gokmenoglu (2022), the factors, determining the capital structure of technology companies in China, have been analysed. Empirical results showed that size, financial costs, liquidity, tangibility, profitability and non-debt tax shields have a significant impact on the leverage structure of Chinese technology companies. O. Kruhlova *et al.* (2023) have focused on the impact of economic and non-economic factors on the profitability of enterprises. It has been discovered that insufficient consideration of macroeconomic instability, political factors and internal efficiency of capital management can lead to a decrease in profitability.

Scientists L. Dokiienko *et al.* (2024) have calculated key financial indicators and parameters of their financial security over the past nine years based on the financial statements of Ukrainian enterprises, grouped by types of economic activity. The research has proved that the peculiarities of financing enterprise activities, which directly affect the level of financial risks, are of crucial importance for ensuring the financial security of enterprises. Prevention of insolvency results from preventing the simultaneous impact of both internal financial imbalances associated with capital structure and liquidity and external factors that are not always subject to control by the enterprise, although must be taken into account in the process of strategic financial planning.

One of the key aspects of ensuring the financial balance of an enterprise is the formation of an effective capital structure, providing for achieving an optimal ratio between own and borrowed sources of financing. As S. Achkasova & O. Platukhin (2023) have pointed out, the right balance between the level of debt and the share of equity allows minimising the cost of enterprise capital, while simultaneously reducing the risk of financial instability and increasing the investment attractiveness of the business entity. According to these scientists, a high level of capitalisation creates a strategic financial reserve that serves as a shock absorber in the event of external shocks.

All this prompted the authors of the present article to focus on comprehensive approaches to assessing the financial stability of enterprises, taking into account their capital structure and liquidity level in the conditions of increased insolvency risk. The purpose of the article was to identify areas for improving the assessment of the enterprise capital structure and liquidity, taking into account the need to prevent their insolvency. This goal was achieved through the following objectives: to analyse the financial indicators (Equity-to-Assets and Quick Ratio) of non-specialised wholesale trade enterprises of Ukraine for the period 2021-2024 in order to identify trends in changes in the capital structure and quick liquidity in the conditions of economic instability; to assess the nature and strength of the correlation between Equity-to-Assets and Quick Ratio indicators in order to determine the dependence between the level of financial autonomy and quick liquidity of enterprises in the context of preventing insolvency.

## ● MATERIALS AND METHODS

The object of this research is the financial performance of seven Ukrainian enterprises, operating in non-specialised wholesale trade (KVED 46.90). The following enterprises have been studied: Subsidiary Enterprise of the State Company "Ukrspetsexport" – State Self-Supporting Foreign Trade Enterprise "Spetstechnoexport", LLC "Enterprise with Foreign Investments 'ASBIS-Ukraine'", LLC "Nestlé

Ukraine”, LLC “ERU Trading”, LLC “UK Distribution”, PJSC “SAV Orbico”, LLC “Avtobanservice”. The analysis covers the period from 2021 to 2024. The selection of enterprises was carried out based on the availability of complete annual reports and active economic activity during the studied period. Primary data were collected from public financial reporting and aggregated using the YouControl (n.d.) service.

For each enterprise, two financial ratios, characterising the capital structure and the level of liquidity, were selected: Equity-to-Assets (%) – the share of equity in the total asset structure of the enterprise; Quick Ratio – the quick liquidity ratio, which characterises the enterprise’s ability to repay short-term liabilities with the most liquid assets. The autonomy ratio (Equity-to-Assets) is an indicator of solvency, which characterises the share of the company’s equity in the total amount of funds invested in its activities. The higher this ratio, the more financially independent the company is from creditors. The quick liquidity ratio (Quick Ratio) is an indicator of liquidity, which describes the short-term liquidity position of the enterprise, i.e. the ability to cover short-term liabilities with the most liquid assets.

Data processing and graphing were performed in Jamovi (n.d.) software environment (version 2.6.26), which is based on the R statistical programming language (The comprehensive..., n.d.). The following statistical and economic methods were used in the analysis: descriptive statistics to assess variables in dynamics, construction of distribution graphs (histogram and boxplot), correlation analysis to identify the relationship between Equity-to-Assets and Quick Ratio. The choice to use Jamovi is justified by the possibilities it offers, for example, deeper statistical processing of the R programming language, which is a powerful environment for performing complex calculations, statistical modelling and graphing.

This study used statistical and economic methods to process primary empirical data, characterising the financial condition of enterprises engaged in non-specialised wholesale trade (KVED 46.90), which made it possible to carry out a comparative assessment of the dynamics of changes in the capital structure and liquidity level over time, identify general trends, asymmetry and illustrate the

behaviour of indicators in a sample of enterprises. Correlation analysis was used to determine the relationship between the share of equity and the level of liquidity, which made it possible to quantitatively assess the strength and direction of the relationship between variables and analyse the potential impact of capital structure on the current solvency of enterprises.

The graphical method was used to visualise the obtained results on the construction of scatter diagrams, histograms, which made it possible to clearly present the financial profiles of enterprises by key indicators of Equity-to-Assets and Quick Ratio. The abstract-logical method was used to formulate conclusions and develop recommendations for improving financial management in the conditions of insolvency risk, which involves strengthening the requirements for the capital structure. Digital management models offer an integrated vision of insolvency risk, which takes into account the efficiency of resource use and the potential for restoring solvency. The integration of these tools into the research methodology contributed to obtaining objective results.

## ● RESULTS AND DISCUSSION

Insolvency occurs when a company is unable to meet its debt obligations, which can lead to bankruptcy. The number of enterprises with negative equity and critical liquidity indicators increased by approximately 20% in 2022-2023, especially in the wholesale trade sector (Assets, equity, liabilities..., 2024). A comprehensive assessment of the capital structure and liquidity of enterprises was carried out based on empirical data from seven Ukrainian companies, operating in the non-specialised wholesale trade sector (KVED 46.90) for the period 2021-2024. The analysis covered the values of Equity-to-Assets and Quick Ratio indicators, which are key indicators of financial stability and liquidity. The results are presented in the form of distribution histograms and scatter plots, which allows identifying intra-group differences and general trends. Equity-to-Assets and Quick Ratio indicators of seven Ukrainian enterprises (main KVED 46.90, non-specialised wholesale trade) for the period 2021-2024 as a percentage are presented in Table 1.

**Table 1.** Equity-to-Assets and Quick Ratio indicators of seven Ukrainian enterprises (main KVED 46.90, non-specialised wholesale trade) for the period 2021-2024, %

Business entity	Equity-to-Assets				Quick Ratio			
	2021	2022	2023	2024	2021	2022	2023	2024
Subsidiary Enterprise of the State Company “Ukrspetsexport” – State Self-Supporting Foreign Trade Enterprise “Spetstechnoexport”	8.4	3.7	1.8	2.3	97.1	96.8	95.3	90.8
LLC “Enterprise with Foreign Investments ‘ASBIS-Ukraine’”	6.7	13.3	14.1	11.3	88.2	78.4	83.6	73.6
LLC “Nestlé Ukraine”	-119.3	-106.6	-65.8	8.7	28.5	34.6	30.7	62.5
LLC “ERU Trading”	11.9	13	14	19.4	131.5	110.8	115.0	119.4
LLC “UK Distribution”	27.8	24.5	20	18.3	90.1	80.2	93.4	81.8
PJSC “SAV Orbico”	9.8	19	36.9	45.5	75.3	75.1	104.2	84.5
LLC “Avtobanservice”	22.5	13.6	14.7	7.7	82.6	83.3	64.6	58.4

Source: created by the authors based on YouControl (n.d.)

As it can be seen from Table 1, the analysis of Equity-to-Assets and Quick Ratio indicators for seven Ukrainian enterprises, operating in non-specialised wholesale trade (KVED 46.90), for the period 2021-2024, allows for a comprehensive assessment of the state of equity management in the face of insolvency. In general, the dynamics of the specified financial ratios indicate significant variability in approaches to financing activities, the efficiency of current assets use, as well as the risks of losing financial stability, which, in turn, determines the need for systematic strategic control over the capital structure.

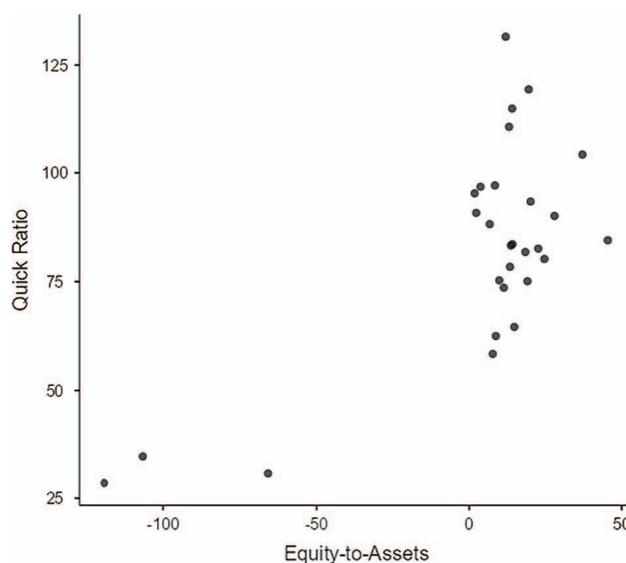
The most critical situation is at LLC “Nestlé Ukraine”, where during 2021-2023 a deeply negative value of Equity-to-Assets ratio is observed (from -119.3% to -65.8%), which indicates an excess of liabilities over assets and an actual loss of equity. Only in 2024 the value of this indicator moved into the positive zone (8.7%), which can be interpreted as the result of additional capitalisation or restructuring measures, however, even with such an improvement, the company remains in the high-risk zone. At the same time, Quick Ratio values demonstrate an increase in liquidity (from 28.5% to 62.5%), which, despite the negative values of equity, can result from a change in the structure of short-term assets, in particular due to the management of receivables or inventories.

The rest of the enterprises demonstrated relatively stable or positive trends in equity management, among which special attention is drawn to LLC “ERU Trading”, which during the analysed period consistently increases the equity share in the total asset structure (from 11.9% to 19.4%), while maintaining a high level of quick liquidity ratio (within 110.8-131.5%), which indicates a low probability of insolvency. Similarly, the indicators of LLC “UK

Distribution” demonstrated a decreasing trend in a gradual change in the structure of equity (from 27.8% to 18.3%), however, the level of liquidity remains relatively stable and makes it possible to promptly cover current liabilities.

In the case of LLC “ASBIS-Ukraine”, there was an increase in Equity-to-Assets from 6.7% in 2021 to a peak value of 14.1% in 2023, with a subsequent somewhat unfavourable decrease to 11.3% in 2024, while Quick Ratio decreased to 73.6%, which may indicate a weakening of operational liquidity due to a decrease in the volume of easily sold assets or an increase in short-term liabilities, which creates additional risks of losing solvency in the event of external shocks. The indicators of PJSC “SAV Orbico” demonstrated a positive trend in increasing the share of equity (up to 36.9% in 2023), with Quick Ratio remaining at a high level (from 75.1% to 104.2%), which indicates effective liquidity management and financial stability.

The least favourable dynamics is demonstrated by LLC “Avtobanservice” with Equity-to-Assets decreased from 22.5% in 2021 to 7.7% in 2024 and Quick Ratio indicator decreased from 82.6% to 58.4%. Thus, the results of the analysis suggest that in the conditions of economic instability, caused by both internal and external factors, maintaining short-term liquidity is not the only challenge for enterprises, whereas ensuring long-term financial stability by optimising the capital structure, reducing dependence on external sources of financing should not be underestimated. All this is a prerequisite for maintaining solvency in the face of growing challenges and an unstable financial environment. The scatter diagram of Equity-to-Assets and Quick Ratio indicators of seven Ukrainian enterprises for the period 2021-2024 is presented in Figure 1.



**Figure 1.** The scatter diagram of Equity-to-Assets and Quick Ratio indicators of seven Ukrainian enterprises (main KVED 46.90, non-specialised wholesale trade) for the period 2021-2024

**Source:** compiled by the authors

Figure 1 visualises the relationship between Equity-to-Assets and Quick Ratio for a set of observations obtained from a sample of seven Ukrainian enterprises for the period 2021-2024 by constructing a two-dimensional

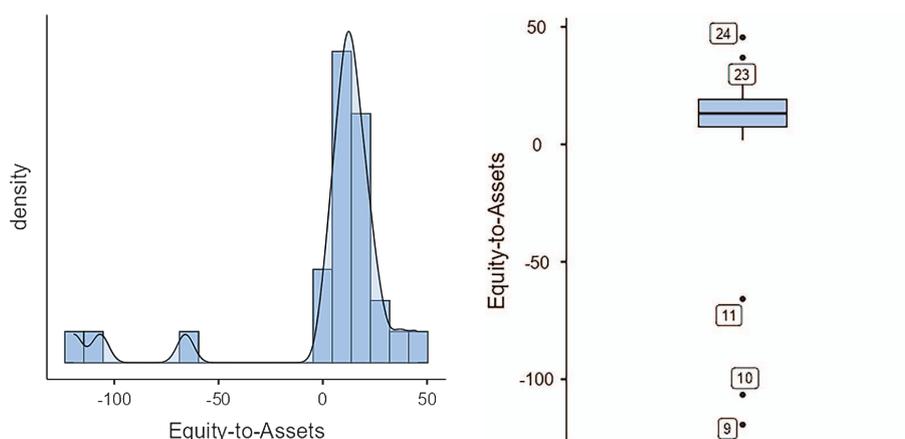
scatter diagram. Each point on the graph corresponds to one enterprise in a particular year (i.e., a total of 28 points: 7 enterprises × 4 years). The absence of a strong trend or correlation structure between the indicated

variables suggests a low level of linear dependence between the equity capital structure of the enterprise (Equity-to-Assets) and its short-term liquidity (Quick Ratio). This emphasises the multifactorial nature of liquidity formation, which is determined by the capital structure, as well as working capital management policy, average receivable collection period, inventory levels and external financial constraints.

The clustering of points in the upper right quadrant of the graph (where Equity-to-Assets > 0, and Quick Ratio > 80%) suggests that some enterprises with an adequate capital structure, combined with high operational solvency, are able to repay their short-term liabilities on time without a significant risk of losing financial equilibrium. At the same time, the points in the lower left quadrant, especially with negative values of Equity-to-Assets (up to -119%), indicate enterprises whose capital is exhausted, which from a mathematical perspective suggests a negative equity share in the balance sheet (liabilities exceed assets) and

meanwhile demonstrate low liquidity, which is a direct indicator of the threat of bankruptcy. The high degree of dispersion along the X-axis confirms the significant heterogeneity in the capital structure among the sample, which makes it difficult to form a single financial strategy without adapting to the specifics of each entity.

The points concentrated in the upper right quadrant of the graph illustrate the enterprises with a stable positive value of Equity-to-Assets and a sufficient level of liquidity (Quick Ratio > 80%), which meets the conditions of financial stability and low risk of insolvency. On the contrary, single observations with negative values of equity (Equity-to-Assets < 0), especially in combination with low or borderline values of Quick Ratio, signal the presence of enterprises with signs of a potential financial crisis. Figure 2 presents the distribution of Equity-to-Assets indicator according to the data from seven Ukrainian enterprises (main KVED 46.90, non-specialised wholesale trade) for the period 2021-2024.



**Figure 2.** The distribution of Equity-to-Assets indicator according to the data from seven Ukrainian enterprises (main KVED 46.90, non-specialised wholesale trade) for the period 2021-2024

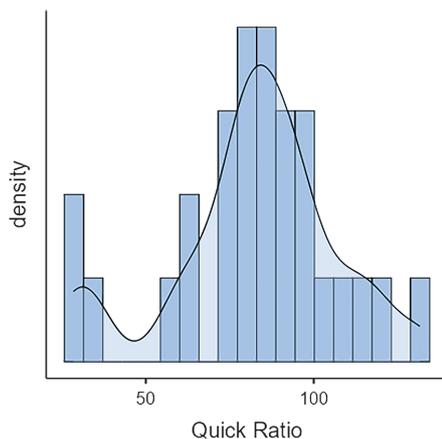
**Source:** compiled by the authors

Figure 2 presents the distribution of Equity-to-Assets ratio of enterprises, in the form of a combination of a density histogram and a boxplot. The histogram demonstrates that the highest density of the distribution falls on the interval from 0% to 30%, which indicates the dominance in the sample of enterprises with a positive, yet a low share of equity in the asset structure. This group includes: Subsidiary Enterprise of the State Company “Ukrspetsexport” – State Self-Supporting Foreign Trade Enterprise “Spets-technoexport”, LLC “Enterprise with Foreign Investments ‘ASBIS-Ukraine’”, LLC “ERU Trading”, LLC “UK Distribution”, PJSC “SAV Orbico” (in 2021-2022), LLC “Avtobanservice” (in 2022-2024). At the same time, the left-sided asymmetry and expressed negative values, reaching -119.3%, are explained by the indicators of LLC “Nestlé Ukraine” in 2021-2023 (-119.3%, -106.6%, -65.8%, respectively). It is this enterprise that forms the “long left tail” of the distribution, which indicates a high variability of the capital structure in the sample. This feature indicates a shift of the arithmetic mean towards lower values, which mathematically reduces its representativeness and requires the use of the median or trimmed-mean as alternative indicators.

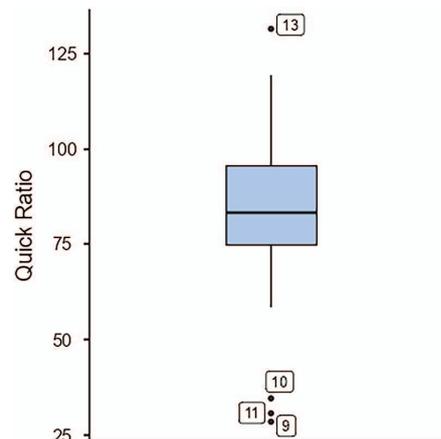
From the standpoint of descriptive statistics, the distribution histogram of Equity-to-Assets indicator (Fig. 2) allows for assessing the distribution density over the years and identifying the instances of asymmetry. In particular, it is evident that the majority of enterprises (Subsidiary Enterprise of the State Company “Ukrspetsexport” – State Self-Supporting Foreign Trade Enterprise “Spets-technoexport”, LLC “Enterprise with Foreign Investments ‘ASBIS-Ukraine’”, LLC “ERU Trading”, LLC “UK Distribution”, PJSC “SAV Orbico”, LLC “Avtobanservice”) have indicators ranging from 0% to 30%, which indicates a normal or almost normal concentration of capital in the corresponding range, however, the presence of extreme left values (Nestlé Ukraine, with results up to -119.3%) causes a left-sided asymmetry of the distribution, which can significantly affect the arithmetic mean as a representative indicator.

The boxplot identifies statistical outliers, significantly exceeding the limits of the interquartile range, as well as records a wide spread of Equity-to-Assets values, which formalises the problem of capital base instability in the analysed enterprises. In particular, the boundaries of the boxplot “box” are in the range of 5-20%, which from a

mathematical perspective indicates a relatively weak internal capitalisation of most enterprises, which does not allow creating a depreciation buffer to compensate for potential external shocks. All this requires strengthening strategic equity management, in particular by transforming the passive balance sheet structure, increasing the share of retained earnings and restructuring debt obligations. In particular, in 2021-2023, LLC “Nestlé Ukraine” had a negative value of this indicator (minimum -119.3% in 2021). Out of



28 observation points, 3 were determined to be the lowest, which is shown by the marks 9 (LLC “Nestlé Ukraine”, 2021), 10 (LLC “Nestlé Ukraine”, 2022), 11 (LLC “Nestlé Ukraine”, 2023) in Figure 2. Observations 24 (PJSC “SAV Orbico”, 2024 – 45.5%) and 23 (PJSC “SAV Orbico”, 2023) demonstrate the highest values. The distribution of Quick Ratio indicator according to the data from seven Ukrainian enterprises (main KVED 46.90, non-specialised wholesale trade) for the period 2021-2024 is presented in Figure 3.



**Figure 3.** The distribution of Quick Ratio indicator according to the data from seven Ukrainian enterprises (main KVED 46.90, non-specialised wholesale trade) for the period 2021-2024

**Source:** compiled by the authors

The analysis of the scatterplot and distribution histogram of Equity-to-Assets indicator together with Quick Ratio coefficient, presented in Figure 2 and Figure 3 respectively, makes it possible to both visualise the empirical relationship between the capital structure and liquidity of enterprises and identify the nature of statistical distribution and instances of potential deviations that can significantly affect the overall financial stability in the context of insolvency risk. In particular, the scatterplot suggests that there is no clear linear relationship between Equity-to-Assets and Quick Ratio indicators, which implies a complex, multifactorial nature of the relationship between capital structure and liquidity, in which other latent variables can play a significant role, including the financing model, the duration of the operating cycle, the specifics of working capital and the market conditions of the enterprise operation. The boxplot in the right part of Figure 3 additionally visualises the data scatter, where observation 13 (LLC “ERU Trading”, 2021) has the highest value. Also, a significant length of the lower “whiskers” and one or more outliers were determined, which is shown by the marks 9 (LLC “Nestlé Ukraine”, 2021), 10 (LLC “Nestlé Ukraine”, 2022), 11 (LLC “Nestlé Ukraine”, 2023), which indicates an enterprise with a capital structure far from the median value that emphasises a high degree of financial unevenness even within one industry.

Summarising the above-mentioned, it can be argued that from the point of view of applied financial mathematics and statistics, the set of graphs confirms the need for segmented management of capital structure and liquidity, since average industry approaches lose their effectiveness subject to high dispersion, distribution asymmetry and extreme values. Thus, the management of the enterprise

equity capital under the threat of insolvency should be based on individual financial profiles, taking into account the distribution of key indicators, built on the basis of adaptive statistics, modelling of risk scenarios and regular monitoring of key financial ratios deviations from regulatory boundaries.

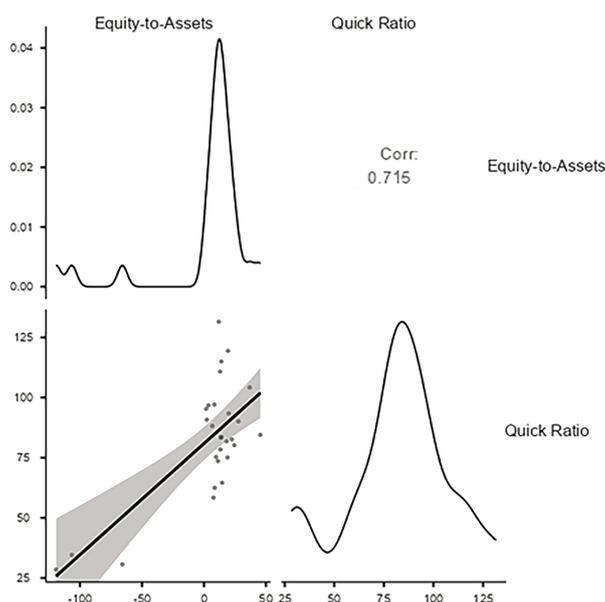
The analysis of the distribution of Quick Ratio indicator, presented in Figure 3 in the form of a density histogram and boxplot, made it possible to carry out a deep mathematical insight of the state of short-term liquidity of enterprises in the non-specialised wholesale trade sector of Ukraine for the period 2021-2024, which is an important component of the overall financial stability management mechanism under insolvency risk conditions. The visualised frequency of Quick Ratio values demonstrated noticeable variability, characterised by the asymmetric distribution, of those aspects, which do not correspond to the norm (according to the Gaussian law). For Quick Ratio indicator, a distribution at the level of approximately 25% and above 130% indicates instances of deviations, since a value below 50% reflects a lack of liquid assets to cover current liabilities, while values above 120% may signal excessive conservatism in asset management, which leads to inefficient use of financial resources. Thus, the analysis of Quick Ratio indicator made it possible to conclude that there are enterprises with sufficient liquidity, which ensures their ability to function in the conditions of external shocks and solvency risk.

Based on data from seven enterprises in the non-specialised wholesale trade sector of Ukraine for the period 2021-2024, the results of the correlation analysis between the indicators of capital structure (Equity-to-Assets) and liquidity (Quick Ratio) are presented in Figure 4, built in Jamovi software environment (version 2.4.26) using a

standard regression analysis tool that visualises a scatter plot with density fields for both variables. The depicted matrix of scatter plots makes it possible to visually assess the nature of the relationships between these variables and identify trends inherent in the sample of enterprises under study. The line plotted on the graph is a linear regression line constructed from the empirical values of the indicators. The grey area around was the 95% confidence interval, which is automatically generated by Jamovi system to visualise the statistical relationship. A scatterplot with marginal distribution densities illustrated the relationship between Equity-to-Assets and Quick Ratio for seven enterprises in 2021-2024. The upper part displayed the distribution of Equity-to-Assets (X-axis – frequency, Y-axis –

corresponding indicator value), the right – the distribution of Quick Ratio (X-axis – frequency, Y-axis – corresponding indicator value).

As it can be seen from Figure 4, the graph in the lower left corner clearly demonstrates a positive correlation: enterprises with a higher level of equity tend to maintain a higher level of quick liquidity. Such a relationship is an important marker of balanced financial performance, in which an increase in the share of equity is accompanied by an increase in quick solvency, which allows enterprises to respond more effectively to external shocks and reduce the risk of default. It is consistent with the theoretical provisions of financial management regarding the role of equity as a stability buffer in conditions of economic turbulence.



**Figure 4.** The distribution of correlation values between Equity-to-Assets and Quick Ratio indicators according to the data from seven Ukrainian enterprises (main KVED 46.90, non-specialised wholesale trade) for the period 2021-2024

**Source:** compiled by the authors

The confidence intervals around the regression line emphasise a statistically significant trend, strengthening the reliability of the observed dependencies. Moreover, the uniformity of the distribution of observations confirms the generalisability of findings for a sample of enterprises, different in size and level of financial autonomy. This result suggests that the relationship between liquidity and capital structure is a systemic characteristic of financial resource management within the industry. In general, the identified dependencies support the hypothesis that in an

unstable economic environment, enterprises try to maintain or even strengthen financial autonomy, which is accompanied by the appropriate optimisation of liquidity indicators. It can serve as the basis for further development of integrated models for assessing insolvency risk, which take into account the interaction between the main financial indicators. The correlation between Equity-to-Assets and Quick Ratio indicators according to data from seven Ukrainian enterprises (main KVED 46.90 Non-specialised wholesale trade) for 2021-2024 is presented in Table 2.

**Table 2.** Correlation between Equity-to-Assets and Quick Ratio indicators according to the data from seven Ukrainian enterprises (main KVED 46.90, non-specialised wholesale trade) for the period 2021-2024

Correlation Matrix		Equity-to-Assets	Quick Ratio
Equity-to-Assets	Pearson's	-	-
	<i>p</i> value	-	-
	<i>N</i>	-	-
Quick Ratio	Pearson's	0.715	-
	<i>p</i> value	<0.001	-
	<i>N</i>	56	

**Source:** compiled by the authors

As it can be seen from Table 2, a statistically significant, moderate, positive correlation was found between Equity-to-Assets indicator (the share of equity in the enterprise assets) and Quick Ratio (quick liquidity ratio), as the Pearson correlation coefficient suggests  $r = 0.715$  at a significance level of  $p < 0.001$ . This result mathematically confirms the hypothesis that with an increase in the share of equity in the asset structure, the enterprise capability to promptly cover its short-term liabilities without the need to sell inventories increases as well, which is an important factor of solvency. In other words, enterprises that have a higher share of financing from equity also demonstrate higher current liquidity, which suggests a certain financial discipline, stable resource management and a lower probability of insolvency risks in the short term. Thus, the results of the correlation analysis are fully consistent with theoretical expectations in the context of studying capital management strategies of enterprises in difficult economic conditions.

The analysis of the capital structure and liquidity level of an enterprise is traditionally considered an important element in ensuring its financial stability. However, there are still ongoing discussions in the scientific literature about optimal proportions of equity and debt capital, as well as the sufficient level of liquidity in changing market conditions. The obtained results on the relationship between Equity-to-Assets indicator (the share of equity in the enterprise assets) and Quick Ratio are consistent with A. Hajisaaid (2020) findings, who, using the example of eight companies in Saudi Arabia during the period from 2009 to 2018, discovered that profitability has a positive correlation with short-term liabilities and equity, whereas it is negatively related to long-term debt. Thus, the results confirm the thesis that enterprises are able to maintain liquidity at the expense of short-term resources, while losing strategic financial stability in the long-term perspective.

P. Pronoza *et al.* (2022) have identified the correlation-regression method as the basis of the approach to assessing financial security of an enterprise, which is widely applied in economic research and is used to determine the degree and nature of the influence of various factors. Similarly, Z.-M. Zadorozhnyy *et al.* (2024) believe that ensuring financial stability of enterprises provides for a systemic analysis and assessment formalisation within the framework of sustainable development. The algorithm proposed by the authors is built on the balance sheet model and a set of indicators (financial independence ratio (autonomy), the financial dependency ratio (equity multiplier), the loan capital concentration ratio, the financial risk ratio, the financial stability ratio, the long-term debt ratio, and the equity mobility ratio), which allows for timely detection of imbalances in the capital structure and improving the enterprise stability.

According to V. Glonti *et al.* (2024) the lack of conflict identification in business leads to the creation of the wrong strategy and tools, losses and unprofitability. In turn, a high level of liquidity contributes to avoiding short-term financial difficulties and reducing default probability. Effective management of working capital and liquid assets is critical to maintaining solvency (Kamau *et al.*, 2024). The obtained results are partially consistent with the findings of A. Akhmedi *et al.* (2022), suggesting the lack of statistically significant evidence of a considerable positive impact

of capital structure on the company value. The obtained results are also consistent with the findings of F.C. Sogomi *et al.* (2024) and Y. Yang *et al.* (2025), who have found out that the increase in debt financing costs significantly reduces the resilience of enterprise real estate, demonstrating a U-shaped dynamic trend. The study has also identified a negative relationship between patient capital and resilience, as well as its moderating effect on the relationship between debt financing costs and resilience, with differences in impact depending on standard and non-standard audit opinions.

The obtained results partially confirm the findings of previous studies on the relationship between capital structure, insolvency risk and solvency of enterprises. According to A. Gennaro (2021) and A. Patel *et al.* (2022), a low value of Equity-to-Assets indicator may suggest a potential financial instability. These considerations are backed by data for LLC "Nestlé Ukraine", where values up to -119.3% were recorded during 2021-2023, suggesting the dominance of liabilities over assets, although in 2024 the indicator increased to 8.7%. This may indicate attempts to restructure the debt portfolio, as predicted in insolvency risk scenarios (Gennaro, 2021).

According to C. Kamau *et al.* (2024), liquidity, rather than profitability, should be the priority of financial policy during economic turbulence. This idea is consistent with the results for LLC "ASBIS-Ukraine", where the Equity-to-Assets indicator is only 11.3%, whereas Quick Ratio amounts to 73.6%, which demonstrates an emphasis on maintaining solvency, despite a low share of equity. Similar characteristics were found in LLC "UK Distribution" (Equity-to-Assets – 18.3%; Quick Ratio – 37.5%), which indicates a similar way of financial management. Thus, the obtained empirical results are consistent with theoretical provisions on the relationship between capital structure, liquidity and solvency, while simultaneously demonstrating significant heterogeneity of approaches to financial policy among enterprises operating in the field of non-specialised wholesale trade (KVED 46.90).

## ● CONCLUSIONS

The study results of the financial stability of Ukrainian enterprises engaged in non-specialised wholesale trade for the period 2021-2024 has shown a significant heterogeneity in the structure of equity and liquidity within the studied sample. The analysis of Equity-to-Assets ratios has revealed that positive capitalisation is inherent for some enterprises, which ensures financial autonomy, while in some cases critically low or negative values were detected, which indicates the risks of financial destabilisation and bankruptcy. Scatter plots of Equity-to-Assets and Quick Ratio indicators have been constructed, which suggests a complex, multifactorial nature of the influence of capital structure and liquidity. The results of the correlation analysis have indicated a moderate relationship between these variables ( $r = 0.715$ ;  $p < 0.001$ ), which gives grounds to assert: according to the general trend, an increase in the share of equity contributes to improving the short-term solvency of enterprises.

The analysis of the distribution of Equity-to-Assets and Quick Ratio indicators has revealed extreme values (outliers), as well as a distinct asymmetry, which requires

the use of additional statistical approaches – in particular, a cluster analysis for typology of enterprises by the level of solvency. A significant part of enterprises is concentrated in the range of moderate capitalisation (5-30%) and sufficient level of liquidity (>80%), however, the presence of enterprises with signs of financial condition deterioration emphasises the need to strengthen financial risk management and restructure liabilities. As a result of the analysis, statistically significant data have been obtained, which emphasise the importance of balanced financial management and indicate the need to implement adequate controlling tools to minimise insolvency risks in a dynamic market environment and economic instability.

Further scientific research should be aimed at studying the effectiveness of implementing digital tools in the financial management of enterprises, since effective management of an enterprise under the threat of insolvency is

based on the use of financial indicators, modern risk assessment models and strategic controlling tools. It is important to take into account both quantitative and qualitative factors, identify risks in a timely manner and adapt management strategies to ensure a long-term solvency of the enterprise, which indicates the need to improve strategic capital and liquidity management to minimise insolvency risks.

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None.

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## Оцінювання капіталу та ліквідності в контексті запобігання неплатоспроможності

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**Анотація.** Актуальність дослідження зумовлена необхідністю комплексного оцінювання фінансової стійкості підприємств через аналіз структури капіталу та ліквідності в умовах нестабільності економічного середовища. Відповідно до мети дослідження обґрунтовано напрями удосконалення оцінювання структури капіталу та ліквідності підприємств у контексті запобігання неплатоспроможності. Методична основа дослідження включала застосування статистичного аналізу, кореляційного дослідження та візуалізації емпіричних даних на основі діаграми розсіювання та гістограм розподілу показників Equity-to-Assets та Quick Ratio на прикладі семи підприємств України, що здійснюють діяльність у сфері неспеціалізованої оптової торгівлі за період 2021-2024 років. Отримані результати продемонстрували помірний позитивний кореляційний зв'язок між показниками Equity-to-Assets та Quick Ratio, що підтвердив складний багатофакторний характер формування платоспроможності. Це надало підстави стверджувати, що за загальною тенденцією зростання частки власного капіталу сприяє покращенню швидкої ліквідності підприємств, що сформували досліджувану вибірку. Аналіз розподілу показників Equity-to-Assets та Quick Ratio виявив наявність асиметрії розподілу, що підкреслило доцільність використання додаткових методів дослідження, зокрема, кластерного аналізу для типологізації підприємств. Значна частина підприємств зосереджена в діапазоні помірної капіталізації (5-30 %) та достатнього рівня ліквідності (>80 %), однак присутність підприємств з ознаками погіршенні фінансового стану наголосило на необхідності посилення управління фінансовими ризиками та реструктуризації зобов'язань. Практична цінність дослідження полягає в інтеграції сучасного інструментарію кількісного аналізу у процеси запобігання неплатоспроможності, формуванням підґрунтя для обґрунтованої адаптації управлінських стратегій у відповідь на виявлені статистичні закономірності взаємозв'язків між ключовими індикаторами платоспроможності, зокрема Equity-to-Assets та Quick Ratio, що має особливу релевантність в умовах дестабілізації макроекономічного середовища та наростання зовнішніх і внутрішніх ризиків для суб'єктів господарювання

**Ключові слова:** структура капіталу; Equity-to-Assets; Quick Ratio; фінансові зобов'язання; управління капіталом

## Overview of artificial intelligence-based project management tools for business representatives

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**Abstract.** The study aimed to identify effective artificial intelligence tools that can improve the productivity, accuracy, and flexibility of management processes in the field of project management. The study analysed the functionality of digital project management platforms and artificial intelligence-based tools, as well as cases of their practical application in international and Ukrainian companies. Trello, Wrike, Monday, Microsoft Power Automate, Taskade and Timely were noted to differ in terms of automation, integration, process visualisation and flexibility. For example, Microsoft Power Automate provides the setup of automated task flows, and Timely provides accurate time tracking. Chat Generative Pre-trained Transformer, Gemini, International Business Machines Corporation, Watson Assistant, Jasper, ClickUp Artificial Intelligence Assistant and Fireflies tools increase analytics, personalise processes, support natural language interaction and automate routine tasks. The analysis of the cases proved the effectiveness of artificial intelligence. Duolingo implemented Chat Generative Pre-trained Transformer for adaptive learning, Webster First Federal Credit Union uses Jasper to create marketing content, Lulu Press uses ClickUp Artificial Intelligence Assistant to optimise task management, and Moonfrog Labs integrated Fireflies to analyse online meetings. Asana, used by Kenshoo Skai, improved the coordination of multi-channel campaigns, while Zoho Projects at Sgurr Energy increased control over technical phases of projects. Ukrainian examples also demonstrated the successful integration of artificial intelligence tools. Ajax Systems implemented relevant solutions for real-time security monitoring, Nova Poshta optimised logistics and customer support, and Liga:Zakon automated the processing of legal information. The analysis of strengths, weaknesses, opportunities, and threats showed that artificial intelligence tools contributed to the automation and analytical nature of project management, although they required significant resources and specialised training. The practical significance of the study is determined by the identification of tools that can be integrated into management processes to achieve greater efficiency

**Keywords:** automation; chatbot; forecast; resource allocation; machine learning

### ● INTRODUCTION

Amid rapid technological transformation and growing competition, businesses need innovative approaches to organising and controlling project activities. The use of AI-based (artificial intelligence) tools provides a new level of automation, improves forecast accuracy, optimises resource allocation, and reduces the time required to make management decisions. Companies are increasingly integrating digital platforms with machine learning elements to adapt to market changes and mitigate risks. The absence of set approaches to the introduction of smart technologies

into business processes complicates their effective use in a highly competitive environment.

N. Bolkvadze *et al.* (2023) systematised the areas of application of generative solutions and outlined the key areas of their implementation in global practice, in particular in China, India, Canada, and the United States. The paper provides examples of both successful and ineffective experiences and proposes a five-stage model for integrating AI into the activities of enterprises. In turn, the instability of performance indicators in project management and

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the difficulties in processing large amounts of data have stimulated the search for new technological solutions. V.M. Vasylenko & T.A. Vakalyuk (2024) analysed the potential of AI to transform traditional project management, highlighting its potential in automating routine processes, analytics, risk forecasting, and rational resource allocation. The study also emphasised the importance of ethical implementation of algorithmic solutions and ensuring transparency of their operation.

The low level of digital competence of staff and the lack of adapted strategies for integrating the latest technologies into work processes make it difficult to use AI effectively in management. D. Gudakov & Y. Kolodinska (2025) examined the main directions of AI implementation in communication and management practices in the business environment. In their work, they focused on changes in the structure of workflows arising from the use of generative AI and analysed new requirements for employees' digital skills. The researchers also outlined the risks associated with dependence on algorithms and reduced autonomy of solutions. The use of intelligent systems in business processes requires aligning technical capabilities with the practical needs of managers and specific business objectives. Y. Smoliak & A. Kholodnytska (2024) reviewed the key aspects of introducing AI into the corporate environment, focusing on assessing the efficiency, costs, and automation potential. The study described popular tools already used by companies to optimise operational processes and emphasised the importance of digital literacy among employees. The study analysed the barriers that arise when transitioning to new technologies and emphasised the importance of adapting management strategies to the conditions of digital transformation.

The lack of flexibility of traditional approaches to project management in the context of digital transformation necessitates the introduction of tools that can quickly respond to changes in the environment. R. Snishchenko (2024) examined AI as a mechanism for improving the efficiency of management decisions, emphasising the changing functional roles of the manager in the new economy. The study analysed the potential of generative technologies for processing large amounts of information, forming analytical conclusions and accelerating planning, as well as transforming the competencies of managers who need to master digital tools. In response to the complexity of management processes and the growing information load, Ya. Hryenko (2024) investigated the role of AI in the transformation of strategic management, emphasising its importance for the formation of a new paradigm of interaction between managers and information systems. The study highlights the functionality of AI in trend analysis, scenario forecasting, and decision support, as well as the importance of developing managers' digital competencies.

The low level of adaptation of intelligent systems to the needs of small and medium-sized businesses, as well as the lack of structured approaches to their implementation in management processes, make it difficult to fully utilise the technological potential. I.B. Azarova & T.M. Bezverkhniuk (2024) analysed the benefits of using AI to improve the efficiency of business processes, emphasising the impact of digitalisation on management decision-making. The study presents a classification of AI functions used in

management and identifies areas for optimising the activities of enterprises using automated solutions. The study emphasised the need for digital transformation of Ukrainian business as a condition for maintaining competitiveness. Insufficient integration of advanced digital solutions into the project management system reduces the efficiency and accuracy of management actions. A. Babichev *et al.* (2024) studied the use of AI tools in the context of project management automation, focusing on the possibilities of risk modelling, resource load assessment, and formalisation of scenario analysis. The study identified the functional benefits of using neural networks, machine learning, and data mining, which can significantly improve the efficiency of planning, monitoring, and adjusting project processes.

Despite the developments on the role of AI in management, studies do not contain a systematic review and classification of tools used specifically in project management, nor do they provide empirical assessments of their effectiveness at different stages of business initiatives, which necessitates further research on this topic. The study aimed to summarise the key characteristics of AI-based digital solutions used in project management, with a focus on their feasibility for implementing business initiatives. The main objectives were to conduct a comparative analysis of the functionality of AI tools focused on supporting different stages of the project cycle; and to identify the practical value of using such tools to improve the efficiency of management decisions in business.

## ● MATERIALS AND METHODS

This study used a descriptive approach to systematise current practices of implementing AI in project management. The analysis was based on theoretical models of managerial maturity that are widely used in international practice. In particular, the Organisational Project Management Maturity Model (OPM3) (Miller, 2004) was considered, which provides a systematic assessment of the maturity of an organisation in the context of portfolio and programme management. The Project Management Maturity Model (PMMM) (Samolovac, 2022), which can be used for the diagnosis of the effectiveness of project management procedures, and the PRINCE2 Maturity Model (n.d.) (P2MM), designed for use in organisations implementing the PRINCE2 methodology, were analysed. These models were chosen due to emphasis on strategic planning, compliance with international standards and adaptability to the digital environment.

The study conducted a comparative review of project management platforms and systems that support AI functionality. Trello, which is known for intuitive task visualisation, Wrike, known for its integration with Microsoft Office 365, Monday work management, which provides high flexibility in setting up workflows, Microsoft Power Automate, which emphasises automation of actions, Taskade, a platform with query-based task generation, and Timely, which uses AI to monitor time and improve productivity were considered. They were chosen due to their high level of automation, integration with other services, and adaptability for teams of different sizes. The study addressed the functioning of AI assistants and chatbots, which provide interactive communication and automated user support, such as Chat Generative Pre-trained

Transformer (ChatGPT), Gemini (ex-Bard), and International Business Machines Corporation (IBM) Watson Assistant. This approach also included Jasper, ClickUp AI Assistant, and Fireflies.ai, which can be used to generate content, analyse meetings, and generate reports, and improve project management efficiency.

The Asana and Zoho Projects platforms were also analysed. Asana is used by Kenshoo Skai (n.d.), a company that implements AI in digital marketing. Sgurr Energy (n.d.), a leading engineering consultancy, uses Zoho Projects to manage technical projects. These examples demonstrated the widespread use of AI not only in information technology (IT), but also in energy and services. In addition, Ukrainian cases such as Ajax Systems (n.d.), Nova Poshta (n.d.), and Liga:Zakon (n.d.) were investigated, which demonstrate local examples of successful integration of AI solutions into the business environment. The study also developed a SWOT (strengths, weaknesses, opportunities, threats) analysis of AI integration into project management based on the studies of M.Z. Nabeel (2024), M. Al-Arafat *et al.* (2025), and M.L. Prasetyo *et al.* (2025). Based on this, comprehensive recommendations were developed for both internal modernisation of business processes and external adaptation to global technological challenges.

## ● RESULTS

### **Project management models and typology of AI tools**

Project management is a complex set of interconnected processes, where imperfect execution or a mistake at any stage can have negative consequences for subsequent stages. Despite the continuous improvement of project management approaches, several challenges remain, largely due to the influence of the human factor. These challenges include ineffective communication, vague or inaccurate tasking, incorrect prioritisation, the use of unrepresentative data samples for decision-making, and decision-making based solely on personal experience or subjective expert opinions without considering business data analytics. Researchers also identified structured groups of risks that exacerbate these difficulties: project complexity, contractual risks, financial risks, legal factors, uncertainty about project requirements and scope, and planning risks (Taherdoost & Keshavarzsaleh, 2016). To reduce the negative impact of such risks, it is advisable to introduce a systematic approach to project management, which involves organising activities based on clearly defined business processes (Bashynska & Khristova, 2017).

An efficient solution in this area is the PMMM, which is used as a roadmap for the sustainable, systematic and predictable development of management processes. Such models can be used for assessment of the current level of development of the project management system at an enterprise, identifying ways to improve its components, and providing access to best practices tested by leading organisations. The most used models are OPM3 (Miller, 2004), PMMM (Samolovac, 2022), and P2MM (PRINCE2 Maturity Model, n.d.), which differ in structure and approaches to assessing the maturity of project management processes. The OPM3 model, developed by the Project Management Institute, unlike other models, does not divide processes into maturity levels, but instead focuses on the relationship between projects, programmes, and portfolios within

an organisation. It can be used to assess how effectively an organisation achieves its strategic goals through project management. The PMMM model has five levels of maturity from initial to optimised and covers ten functional areas of project management, making it convenient for phased implementation of changes and strategic development. The P2MM model, based on the PRINCE2 methodology, combines management aspects with process control, which improves adaptation accuracy of the management system to the specific needs of projects. All these models identify key components of project management that may differ in name or structure but generally boil down to similar functions. For example, in the PMMM model, procurement and cost management are considered separate components, while the P2MM model combines these areas into one component – financial management. Given the objective of this study, which emphasises the analysis of the potential of AI in project management, it is advisable to use the PMMM model, as it can be used for a more structured comparison of the functionality of intelligent solutions.

To further analyse the application of AI in project management, the tools were divided into four types depending on their level of complexity: integration and automation, virtual assistants and chatbots, machine learning-based systems, and fully autonomous project management solutions. The first type of tools automates routine tasks, including status updates, sending reminders, maintaining to-do lists, etc. (Lahmann, 2018). The second type includes virtual assistants and chatbots that help users set tasks, generate texts, and communicate. The third type consists of tools based on machine learning algorithms: they analyse large amounts of data, identify patterns, predict risks, and make recommendations on resource allocation and priorities (Ruiz *et al.*, 2020). The fourth type includes complex autonomous systems that can make management decisions on their own, based on current data and context, reducing the need for human intervention (Bachynskiy, 2024). It should be noted that most platforms are not limited to just one of these types. For example, Smartsheet cloud-based project management software combines task automation (type one) with text generation based on user activity history, indicating the use of machine learning (type three). Another example is Taskade, a set of project management tools that includes organisational task automation and a built-in chatbot for generating and analysing information, combining the first and second types, respectively.

AI tools from the integration and automation group standardise and automate routine project management tasks and aggregate data from internal information systems to form a representative sample for informed decision-making. Typical scenarios for using such tools include sending reminders to managers or executors when a task deadline is approaching, automatically generating and distributing reports on the status of tasks, and creating template tasks and descriptions for them. The use of such tools reduces the cost of repetitive operations and increases the efficiency of standard project management procedures. Notably, some of these tools do not function as standalone products but as elements of larger systems or require integration with other data sources.

One example is the Butler extension for the Trello platform, which can be used to set up automatic triggers

and actions that are performed in response to certain events in the system, significantly reducing the time spent on routine operations and minimising the human factor. The Wrike system provides functionality for monitoring task progress, optimising resource utilisation, and visualising performance indicators, using AI algorithms to automatically create and edit task descriptions. Monday work management functions as a multifunctional platform for project management support, including structure building, status monitoring, report generation, and automatic text completion. Smartsheet provides flexible automation and scalability of management using tables, boards, templates, formulas, and analytical reports. Microsoft Power Automate focuses on creating conditional action flows with the ability to synchronise with Project, Outlook, and Power Business Intelligence (BI). Taskade integrates process automation, task visualisation, and a chatbot that processes text queries, analyses documents, and generates responses (Chandra, 2024). Timely specialises in automatic time tracking and workload analysis, integrating with Asana, Trello, and Jira to structure information and generate reports in real time. Thus, chatbot assistants are increasingly being integrated into project management processes, providing users with new tools for analytics, text generation, communication, and automation. According to a forecast by research company Gartner, by 2027, chatbots will be used as the primary customer service channel in at least 25% of companies (Gartner predicts chatbots..., 2022). This demonstrates the relevance and potential of such tools in the field of project management.

Project management remains a complex area where traditional methods do not always effectively address the challenges posed by human factors and structural risks. The use of management maturity models such as OPM3, PMMM and P2MM helps to systematise processes and

identify areas for improvement. The integration of AI tools, from automating routine tasks to autonomous decision-making, creates new opportunities for efficiency.

**Chatbot assistants and intelligent platforms in project management**

The use of chatbots, virtual assistants, and intelligent platforms based on AI technologies is transforming project management, increasing its flexibility, automation, and adaptability. They can be used to respond quickly to changing conditions, optimise resources, minimise risks, and improve the efficiency of internal communication. By integrating such tools with digital environments (planning, communication, and analytics systems), organisations can significantly accelerate the implementation of tasks and make informed decisions in real time. Depending on the functional purpose and the level of integration with other systems, chatbots can perform a wide range of tasks, including informing about the status of current tasks, generating project documentation, identifying potential contradictions in requirements, and analysing data.

One example of the commercial use of AI chatbots is H&M’s bot integrated into the Kik messenger, which has over 300 million users. This bot asked customers questions to identify their style preferences and showed them clothing options in the form of images, simplifying the selection process. In addition, it was used to demonstrate ready-made outfits, vote for them, and engage in interactive discussions, which personalised the brand experience and increased customer loyalty (Conversational AI..., 2021), or the Ukrainian mobile operator Kyivstar (n.d.), which uses the chatbot Zoriana to provide tariff advice. Below is a comparative description of chatbot assistants that can be effectively used for project management tasks (Table 1).

**Table 1.** Examples of chatbot assistants and scenarios of their use in project management

Tool name	Main functions	Features of integration/purpose
ChatGPT	Answer generation, text analysis, documentation, risk identification	Ability to integrate with project management systems to improve input data
Gemini (ex-Bard)	Similar functions to ChatGPT; report generation, risk identification, and visualisation	Integration with Asana, Trello, Jira, Monday.com
IBM Watson Assistant	Improving customer experience, analytics, and decision support	Customer-focused, but applied to internal project management processes
Jasper	Formulation of tasks, project documentation, letters, and presentations	Priority on textual content and marketing, but effective for project documentation
ClickUp AI Assistant	Automatic creation of tasks, generation of documents based on a template	Deep integration with ClickUp
Fireflies.ai	Transcribing meetings, generating structured reports	Accurate communications, mitigation of loss of claims

Source: compiled by the author

The analysis in Table 1 shows that chatbot assistants significantly expand the project management toolkit, automating key processes, improving decision-making, and enhancing communication. An illustrative example of the effective use of ChatGPT in this context is the case of Duolingo, which integrated the GPT-4 model into its learning application to personalise the user experience. By the implementation of Duolingo Max features, users are able to receive detailed explanations of their answers in a natural language format that simulates individual tutoring. In

addition, tools have been implemented to simulate role-playing dialogues with virtual characters that have unique communication scenarios. This experience confirms the potential of GPT platforms to provide flexible user support, particularly in environments where individualised learning, adaptive assistance, or real-time solutions to atypical problems are required (Marr, 2023).

Jasper can be used to formalise tasks and project documentation following predefined formats, which ensures structured and unified project materials. The successful

use of this platform has been demonstrated by Webster First Federal Credit Union (n.d.), where Jasper has become central in the marketing infrastructure, contributing to a nine-fold increase in organic traffic through consistent content, improving search engine optimisation, accelerating A/B testing of advertising campaigns, and ensuring brand consistency through the Brand Voice feature, which is critical in the financial services industry. This scaled the small team without increasing headcount, while maintaining high quality and trusted content (How first Webster Federal Credit Union..., n.d.).

ClickUp AI Assistant, as an integrated tool, automates the process of creating tasks and documentation within the respective management platform, reducing the time required to perform routine actions. An example of the effective implementation of this technology is Lulu Press (n.d.), which replaced two previous project management systems (Jira and Basecamp) with a single ClickUp platform with more than 100 employees. Due to the automation functionality and integration with GitLab, the company managed to eliminate duplication of tasks and significantly reduce the time for manual status updates. This increased work efficiency by 12%, accelerated product development and marketing campaigns. In addition, the implementation of ClickUp has standardised the processes of creating training videos, webinars, guides, and other materials within the Lulu University series, which has improved collaboration between teams and ensured transparency in the implementation of each stage of projects (Lulu furthers..., n.d.).

In turn, Fireflies.ai improves the efficiency of project communications through automated meeting protocols, which minimise information loss and improve the tracking of decisions and agreements. A notable example of the effective implementation of this tool is the use of Fireflies.ai by Moonfrog Labs (n.d.), a mobile game developer with an active user base in India and neighbouring countries. After switching to a remote format, the company's team faced problems with loss of concentration due to the need for manual note-taking and frequent omissions of relevant details in communication. Integration of Fireflies.ai, which automatically records, transcribes, and structures meetings, eliminated the need for a separate note-taker, reduced the number of missed tasks, increased productivity, and ensured that all participants were actively involved in the discussion. Using AI filters and the automatic identification of action items, the tool also improved collaboration and accelerated decision-making in teamwork (Kulshreshtha, 2021). The introduction of such chatbots not only increased productivity in project management but also created additional value in terms of shaping the digital environment of project activities.

AI tools based on machine learning technologies are being actively implemented in project management to improve the efficiency of planning, risk forecasting, and resource allocation. They can be used for predictive analysis that generates real-time recommendations for the user based on previous project experience. As noted by V. Samolovac (2022), the source of input data for such systems can be indicators of time spent on tasks in previous projects, associated risks, and information about the dependencies between individual tasks. This makes it

possible to build alternative project plans, identify critical points, model task chains, and identify potential risks in real time.

One example of such solutions is the Asana platform, which provides comprehensive project management functionality, including automation of routine processes, task monitoring, and report generation. Based on AI tools, Asana can be used to create tasks based on the analysis of similar previous tasks, predict their completion dates, identify risks, make recommendations for resource allocation, and respond to project participants' requests for the current status of work (Asana unveils new..., 2023). The introduction of Asana into the activities of Kenshoo Skai (n.d.), an omnichannel marketing platform, occurred during the period of customer growth in the context of the pandemic and was designed for centralisation of project management. By using Asana, the customer service team managed to centralise project management, standardise customer service, and integrate workflows with Zendesk, Slack, Zoom, and internal systems, which was used by managers to serve three times as many customers without losing quality. The solution has significantly reduced the time spent searching for information, synchronised activities between departments, and increased the effectiveness of teamwork in remote work (Skai's retail media..., n.d.).

The Zoho Projects platform is also a complete project management solution that covers all stages of the project lifecycle. It predicts the amount of resources and time required to complete tasks based on historical data analysis, which provides a more informed approach to managing team workload. In addition, the system includes a built-in chatbot called Zia, which acts as a virtual assistant, providing information on the status of tasks, creating new tasks, and editing them according to current needs. An example of an effective implementation of this tool is the experience of Sgurr Energy (n.d.), a leading renewable energy engineering consultancy that faced difficulties in project management due to fragmented systems, manual processes, and inefficient task tracking. By integrating Zoho Projects into its overall digital solutions ecosystem (along with Zoho Customer Relationship Management (CRM), Zoho Books, and Zoho Analytics), the company was able to centralise project planning, monitoring, and collaboration. This has resulted in better resource management, timely invoicing, automated reporting, and increased overall productivity. Zoho Analytics was used to receive reports on profitability and team utilisation, which significantly improved the quality of management decision-making. This integration has provided the company with process transparency, increased team efficiency, and reduced financial delays associated with project activities.

Another example is the Forecast platform, which, similarly to Taskade, is positioned as an AI-based solution for project management. It includes functionality for budget control, resource management, automated reporting and invoicing. A feature of Forecast is the ability to automatically generate tasks, allocate resources, and identify risks at an early stage, which significantly increases the adaptability of management decisions (Viter, 2020). The development of machine learning technologies has resulted in the concept of autonomous project management, which

provides for the possibility of implementing projects without direct human involvement or with minimal human intervention. According to this concept, AI systems should function as a project manager, automating the full cycle of management processes from initiation to completion. However, fully autonomous project management systems have not yet been created. It is only known that Taskade AI is developing such a system, but there are currently no commercially available solutions of this level (Bednarski, 2023). An analysis of AI tools in project management has shown their ability to automate routine processes, improve planning efficiency, and optimise resource use. Machine learning-based systems provided predictive analytics, and chatbot assistants supported communication and documentation generation. Despite the progress, fully-fledged autonomous control systems remain at the conceptual stage of development.

**Prospects for the development and integration of AI into project management**

In the context of active digital transformation and growing competition, Ukrainian businesses should consider the introduction of AI as a strategic tool to improve project management efficiency. AI technologies help optimise management processes, improve forecast accuracy, reduce time spent on routine operations, and create a new culture of data-driven decision-making. Processing large volumes of information in real time can be used to create project strategies based on analytics rather than assumptions. However, the expansion of access to AI tools is accompanied by difficulties in integrating them into existing management systems, the need to update IT infrastructure, comply with ethical data processing standards, and train a new generation of specialists. To assess the feasibility of using AI in project management, a SWOT analysis was developed (Table 2).

**Table 2.** SWOT analysis of AI integration into project management

Strengths	Weaknesses
Automate repetitive tasks and processes. Increase the accuracy of timing and cost forecasting. Improve risk management through analytics. Ability to adapt to changes in the environment in real time. Centralised access to project information and knowledge.	High costs of AI technology implementation. Limited staff competence in the use of AI. Dependence on the quality and completeness of input data. Difficulties with integrating AI into existing management systems. Risks of reduced trust due to lack of transparency in algorithms.
Opportunities	Threats
Expansion of the use of AI for project portfolio management. Integration with other digital platforms (Enterprise Resource Planning (ERP), CRM, BI). Use of generative AI to create documentation. Development of AI-based decision support systems. Application of AI to assess performance and team dynamics.	Rapid development of technology, which complicates long-term planning. The threat of losing control over critical decision-making. Legal restrictions on data collection, storage and use. Growing cyber threats and vulnerabilities in AI systems. Ethical challenges in the use of personal data in modelling.

**Source:** compiled by the author based on M.Z. Nabeel (2024), M. Al-Arafat *et al.* (2025), M.L. Prasetyo *et al.* (2025)

In the context of intense digital transformation and an increasingly competitive environment, Ukrainian businesses should consider the integration of AI as one of the key strategic tools to improve project management efficiency. The use of AI technologies can significantly optimise management processes, improve forecasting accuracy, reduce time spent on routine tasks, and develop new approaches to data-driven decision-making. Incorporating the results of the SWOT analysis, the prospects for the development of AI in project management require the development of comprehensive management recommendations designed for both internal modernisation of business processes and external adaptation to global technological challenges.

The first step in implementing AI in a project management system should be to audit current processes and identify critical areas where the use of intelligent technologies can have the greatest impact. These areas include planning automation, budgeting, risk management, performance monitoring, and communication between project team members. Based on the results of such an analysis, it is advisable to develop a step-by-step integration strategy, incorporating the size of the enterprise, the availability of technological resources, and industry specifics. As an initial step, it is recommended to introduce local tools, such as chatbots, AI scheduling modules, and task management systems with machine learning elements (Hashimzai & Mohammadi, 2024). The second area is staff training to

work with innovative technologies. Without proper qualifications, the introduction of AI may be ineffective or not used in practice at all. Therefore, businesses should invest in the training of management and technical staff, prioritising the development of digital literacy, basics of AI, the principles of the use of machine learning platforms, and the formation of strategic thinking adapted to the requirements of the digital economy. Particularly effective is the formation of multidisciplinary teams that combine IT experts, analysts, and managers who can work together to adapt algorithms to the specifics of the business environment (Rodgers *et al.*, 2023).

Integrating AI into an enterprise’s existing IT architecture requires careful planning. To prevent data fragmentation, system outages, and loss of consistency in information flows, it is advisable to use platforms with an open application programming interface and a high level of compatibility with existing CRM, enterprise resource planning, and project management systems. Flexible cloud solutions can be used to adapt the system configuration to the needs of the enterprise without the need for a complete modernisation of the information infrastructure. After that, a substantial step is to implement policies for the ethical and responsible use of AI technologies. This is especially necessary for businesses that handle personal or sensitive data (e.g., in the healthcare, banking, or insurance sectors). Businesses should ensure transparency in the use

of algorithms, avoid biased decisions caused by model training, and implement backward control mechanisms. Among such tools, human-in-the-loop models should be highlighted, which retain the right to make the final management decision. This will help build trust in technology on the part of employees and external stakeholders (Brodny & Tutak, 2025).

Given the limited financial capacity of most Ukrainian businesses during the war and recovery period, it is advisable to attract external support for the implementation of digital projects. This includes participation in international donor programmes that finance digital initiatives for small and medium-sized businesses, as well as cooperation with Ukrainian IT companies that create specialised solutions based on AI. Additional support can be obtained through participation in government initiatives such as Diia.Business (n.d.) or the Digital Strategy (Resolution of the Cabinet of Ministers of Ukraine No. 1351-2024-r, 2024). One example of digital adaptation in a resource-constrained environment is Ajax Systems (n.d.), which develops security systems using AI. In the difficult conditions of wartime, it not only maintained full operations in Ukraine but also continued to implement AI solutions for automatic threat detection and maintenance forecasting. Such initiatives demonstrate an example of a strategic rethinking of management and production processes using the latest technologies (New notifications..., 2024).

Another successful case is Nova Poshta (n.d.), which in 2024 introduced a service for automating the processing of international shipments. The technology has reduced the processing time for one shipment from two minutes to 1.5 hours to 20 seconds. The system automatically collects and verifies data, integrates with directories of prohibited goods, and costs only 0.12 UAH per request. This increased efficiency, reduced costs, and minimised the risk of violating customs requirements (Stark, 2024). Another example of the effective use of AI in the field of information management is Liga:Zakon (n.d.), which has developed the LIGA360 platform. Its functionality is based on analytical tools with elements of AI, which can be used for automation of monitoring of changes in legislation, analysis of court practice, and assessment of legal risks in real time. This is especially relevant for small and medium-sized businesses seeking to effectively adapt to dynamic changes in the legal environment (Liga:Zakon has developed..., 2020).

Another component of the AI implementation strategy is to conduct a business case for the planned innovations. Before launching each project, it is necessary to estimate the expected return on investment, formulate performance indicators, which may include reducing time spent on routine tasks, shortening project implementation time, reducing the error rate, increasing customer satisfaction, and improving internal process transparency. Thus, AI technologies should not only reduce the operational burden but also create added value, which is reflected in the strategic development of the enterprise. In general, a systematic approach to the introduction of AI in project management involves the implementation of several interrelated stages (Hajipour *et al.*, 2023).

As a result, the successful implementation of these management solutions can be used by Ukrainian enterprises not only to automate certain elements of project

management but also to create a new quality of management based on intelligent data processing and increased flexibility of management decisions. Such an approach will increase resilience to external challenges, strengthen the competitiveness of enterprises, and contribute to an overall increase in the efficiency of economic activity. In the long run, AI will become an integral part of the management culture of Ukrainian businesses.

## ● DISCUSSION

In the context of digital transformation, the use of AI has changed approaches to project management at both the strategic and operational levels. Its implementation ensured the automation of routine tasks, improved planning accuracy, reduced the impact of the human factor, and optimised resource allocation. AI tools contributed to the adaptability of management systems to changes in the external environment, increased transparency of processes and provides prompt response to challenges. At the same time, the ability to process large amounts of data in real time provided more accurate forecasting of project timelines, budgets, and quality, which strengthened companies' ability to make informed decisions and act proactively.

The study correlated with the approach proposed by D. Vergara *et al.* (2025) in interpreting AI as an effective tool for transforming project management. Both studies addressed the automation of routine processes, the use of machine learning algorithms for data analysis, risk assessment, and optimisation of resource allocation. The study also shared a common focus on the challenges of implementing AI, from technical complexity to ethical barriers and growing demands on managers' digital competencies. At the same time, the study by D. Vergara *et al.* was mainly a review and theoretical study that included bibliometric analysis of publications, classification of neural network architectures, and identification of scientific trends. In contrast, this study was distinguished by its applied focus, the construction of a typology of tools by level of complexity, and a functional analysis of platforms already implemented in business practice.

A logical extension of this comparison is the study by J.K. Das *et al.* (2025), which also recognised the potential of AI to improve project management efficiency. Both papers emphasised the role of automation in reducing the impact of human error, accelerating decision-making, and increasing the accuracy of estimates. They also recognised barriers to implementation, including organisational, technical and ethical factors. However, the study by J.K. Das *et al.* focused mainly on conceptual foundations, including the development of a model for integrating cognitive AI, with an emphasis on the behavioural aspects of management. The study offered a practical analysis of the functionality of existing tools, such as Smartsheet, ClickUp, Zoho Projects, and Taskade, which assessed the real impact of technology on modern project environments. Common positions were also traced in the work of N. Haefner *et al.* (2021), which emphasised the importance of AI for the transformation of organisations in the digital environment. Both studies agreed on the need to rethink management processes and develop new competencies. At the same time, the study by N. Haefner *et al.* addressed the strategic level, in particular on the role of CIOs in the digital transformation of

companies, while the present study examined in detail the specific tools already in use to automate tasks, coordinate teams, and increase productivity in project management.

A similar study was conducted by J. Silva *et al.* (2024), which considered AI in the context of Industry 5.0 as a technology that ensures a symbiosis between human potential and digital platforms. Both studies emphasised the importance of integrating AI into digital governance environments, increasing the role of data analytics, and improving inter-team coordination. However, J. Silva *et al.* examined the technical architecture, principles of cognitive interaction, and areas of development within robotic automation, while the study focused on the applied aspect of assessing the effectiveness of the functionality of platforms already used in business processes. Another vector of analysis was proposed by S. Salimimoghadam *et al.* (2025), which highlighted models of AI implementation in project management through the prism of life cycle optimisation. The study developed a structured conceptual model of AI integration with a distinction between the stages of planning, execution, monitoring, and evaluation. The study did not build universal models but provided a practical analysis of which tools ensure accurate forecasting, reduce human error, and better adaptation to a rapidly changing environment. A comparison with the study by A.M. Felicetti *et al.* (2024) was also relevant, where AI was analysed as a tool for optimising agile methodologies, digital work environments, and self-managed teams. Both studies focused on AI's ability to reduce the impact of human error, improve the accuracy of calculations, and adapt to changing conditions. The study, although not exclusively on agile, confirmed the importance of flexibility of systems and technologies in digital governance, exploring tools that provide such flexibility regardless of the chosen methodology.

R. Yadav (2024) focused on a strategic vision of the transformation of project management under the influence of AI. The study considered AI as a factor in the formation of new models of corporate governance, also raising issues of ethics, technology dependence, and privacy threats. The study instead assessed the application of the platforms and their impact on the efficiency of project tasks. Both approaches coincided in their conclusions about the change in management logic from reactive to proactive and the need to adapt management practices but differed in the level of detail: R. Yadav worked at the macro level, and this study is at the operational level of implementation. The analysis by M.E. Nenni *et al.* (2025) had a similar strategic perspective, where AI was studied in the context of the transition to the Industry 5.0 paradigm. The focus was on the changing role of the manager, cognitive automation, and the need for new models of adaptive control. This study continued this logic, but with a focus on the everyday use of digital tools, reducing the influence of the human factor, and the prompt implementation of tasks in the digital environment.

M. Salimi (2024) addressed the impact of AI on the project lifecycle, with a particular focus on risk prediction, data processing, and structural changes in teams. These aspects were also reflected in the study, in particular in the use of ClickUp and Taskade platforms that provide integrated support for the planning, implementation, and monitoring stages. Both approaches were based on the thesis of the need for digital adaptation of teams, but M. Salimi

remained in the theoretical plane, while the study outlined specific examples of practical implementation. R. Parekh & O. Mitchell (2024) addressed cloud solutions, ethical challenges, and the potential of AI to provide flexibility in management. Both studies acknowledged that AI tools are transforming the approach to management, but R. Parekh & O. Mitchell highlighted potential risks and strategic rationale for change, while the study demonstrated the applied implementation in the form of platforms that already ensure productive work of teams and increase transparency of processes. To conclude the comparative analysis, it is worth mentioning the study by S. Georgiev *et al.* (2024), in which AI was considered as an element of strategic management aimed for forecasting, decision support, and reducing uncertainty. This study complemented this vision with a tool-level demonstration, demonstrating how the functionality of Smartsheet, Zoho, or ClickUp platforms contributes to the achievement of the stated strategic goals in real business conditions.

The use of AI in project management has significantly transformed traditional approaches to planning, controlling, and implementing tasks. Its implementation has automated routine operations, improved the accuracy of risk forecasting, allocated resources more efficiently, and adapted to changing conditions. This minimised the impact of the human factor, accelerated decision-making, and increased the overall efficiency of project activities. As a result, AI has become not only an auxiliary tool but also a key factor in the transformation of modern project management.

## ● CONCLUSIONS

The study summarised the functionality of AI tools used to support project management in the business environment. The analysis showed that the introduction of AI systems could significantly optimise key project management processes, including planning, monitoring, risk assessment, communication, and project documentation. The study determined that the most effective tools were those that combined the automation of routine tasks with the functions of predictive analytics and real-time management decision support. The study identified four main types of AI solutions: integration and automation systems, chatbots and assistants, machine learning tools, and autonomous systems. Most modern platforms, such as Smartsheet, ClickUp, Taskade, Asana, and Zoho Projects, combine several levels of functionality at once, which can be used in adaptation to the specifics of the tasks and scale of the organisation.

The experience of practical application of AI in project management has shown that the use of such solutions reduced the influence of the human factor, increased the accuracy of estimates, reduced the cost of performing repetitive operations, and provided analytical support to managers. In particular, the case of Asana implementation at Kenshoo Skai demonstrated a threefold increase in the efficiency of customer service managers without losing the quality of service. After switching to ClickUp, Lulu Press reduced manual status updates and increased productivity by 12%, while the implementation of Fireflies.ai at Moonfrog Labs eliminated information loss, increased engagement in communication processes, and improved compliance with agreements. Webster First Federal Credit Union's Jasper

platform helped drive a nine-fold increase in organic traffic through automated content creation, while Zoho Projects' tools helped Sgurr Energy centralise planning and automate reporting, which improved resource management and accelerated billing.

The SWOT analysis conducted as part of the study identified key advantages (forecasting, automation, adaptability), weaknesses (high cost, lack of digital skills), opportunities (integration with ERP, CRM, BI systems), and threats (cyber risks, ethical dilemmas, lack of transparency of algorithms). This made it possible to form a strategic vision for the development of AI tools in project management and identify areas for their rational implementation, incorporating current challenges. The use of intelligent tools in Ukrainian companies has demonstrated the ability to adapt modern technologies even with limited financial and technical resources. Ajax Systems, Nova Poshta, and Liga:Zakon have successfully implemented digitalisation strategies with AI elements, which were used for strategic flexibility, faster processing of requests, increased employee productivity, and more accurate accounting. Such examples have proven that even in difficult conditions,

innovation is possible and effective if internal processes are properly organised and result-oriented.

Overall, the study confirmed that the systematic use of AI contributed to the formation of a new management paradigm based on an analytical approach, flexibility, prompt decision-making, and digital awareness. In the long term, smart technologies have the potential to become crucial for ensuring business competitiveness, especially in a highly volatile environment. Further research could be aimed to expand the empirical base by quantifying the impact of certain types of AI on managerial performance indicators, as well as developing industry-specific models for integrating AI, incorporating the specifics of business processes.

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## Огляд інструментів на основі штучного інтелекту для управління проектами для представників бізнесу

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**Анотація.** Метою даного дослідження було виявлення ефективних інструментів штучного інтелекту, здатних забезпечити підвищення продуктивності, точності та гнучкості управлінських процесів у сфері проектного менеджменту. У межах дослідження було проаналізовано функціональні можливості цифрових платформ управління проектами та інструментів на основі штучного інтелекту, а також кейси їхнього практичного застосування в міжнародних і українських компаніях. Платформи Trello, Wrike, Monday, Microsoft Power Automate, Taskade і Timely відрізняються за рівнем автоматизації, інтеграції, візуалізації процесів і гнучкості. Наприклад, Microsoft Power Automate забезпечує налаштування автоматизованих потоків завдань, а Timely здійснює точний облік часу. Інструменти Chat Generative Pre-trained Transformer, Gemini, International Business Machines Corporation Watson Assistant, Jasper, ClickUp Artificial Intelligence Assistant і Fireflies підвищують аналітичність, дозволяють персоналізувати процеси, підтримувати природномовну взаємодію та автоматизувати рутинні завдання. Аналіз кейсів засвідчив ефективність застосування штучного інтелекту. Компанія Duolingo впровадила Chat Generative Pre-trained Transformer для адаптивного навчання, Webster First Federal Credit Union використовує Jasper для створення маркетингового контенту, Lulu Press застосовує ClickUp Artificial Intelligence Assistant для оптимізації управління завданнями, Moonfrog Labs інтегрувала Fireflies для аналізу онлайн-зустрічей. Платформа Asana, яку використовує компанія Kenshoo Skai, покращила координацію мультиканальних кампаній, а Zoho Projects у компанії Sgurr Energy підвищила контроль технічних етапів проектів. Українські приклади також продемонстрували успішну інтеграцію інструментів штучного інтелекту. Ajax Systems впровадила відповідні рішення для моніторингу безпеки в реальному часі, Нова пошта оптимізувала логістику та клієнтську підтримку, а Ліга:Закон автоматизувала обробку правової інформації. Аналіз сильних і слабких сторін, можливостей та загроз показав, що інструменти штучного інтелекту сприяли автоматизації й аналітичності управління проектами, хоча й вимагали значних ресурсів і спеціалізованої підготовки. Практичне значення дослідження полягає у визначенні інструментів, які можуть бути інтегровані в управлінські процеси для досягнення вищої ефективності

**Ключові слова:** автоматизація; чат-бот; прогноз; розподіл ресурсів; машинне навчання

## Project management in the hospitality industry: Theoretical foundations and practical aspects

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**Abstract.** The aim of the study was to identify ways to implement adaptive project management in the hospitality industry of Ukraine using digital technologies, in particular artificial intelligence based on machine learning. The methodological basis consisted of statistical analysis of the Ukrainian hospitality market indicators for 2020-2024, a comparative study of international practices, and a case study using the example of hotel enterprises in Ukraine and Bulgaria. The results of the study showed that the Ukrainian hospitality market, despite the challenges of the COVID-19 pandemic and full-scale war, is showing signs of recovery: the growth rate of the number of accommodation establishments in 2024 increased by 2%, and tax revenues from tourist fees increased by 23% compared to 2023. It was found that Ukrainian hotels are mainly in the second stage of artificial intelligence implementation (using chatbots for external customer interaction), while Bulgarian companies have reached the third stage (integration of analytics and automation of internal processes). Using the example of the Casa di Fiore SPA & Medical and Izgreva Hotel Complex hotels, the effectiveness of chatbots with machine learning functions was analysed, which made it possible to reduce staff working hours and improve the level of service. A comprehensive assessment of the readiness of Ukrainian hospitality companies to move to higher stages of artificial intelligence implementation was provided, and practical recommendations for the integration of digital technologies into project management were formulated. The practical significance lies in providing a roadmap for the implementation of artificial intelligence tools, taking into account financial, technical and human resource constraints

**Keywords:** digitalisation; artificial intelligence; chatbots; machine learning; virtual assistant; hotel business; project management; automation; digital competencies

### ● INTRODUCTION

The Ukrainian hospitality market is experiencing economic difficulties due to the invasion of Ukrainian territory by Russian occupation forces. Adaptive project management at each enterprise plays an important role in developing the potential of hospitality establishments. The relevance of this study is due to the need to modernise traditional management approaches at Ukrainian enterprises, which are losing their effectiveness due to digitalisation, changing consumer priorities and demand in the hospitality market.

Adaptability in project management can be achieved with the help of the latest digital technologies. Working conditions have changed radically since the onset of the

SARS-CoV-2 coronavirus pandemic due to the increase in remote work and the development of project management software. These trends have increased interest not only among scientists but also among entrepreneurs and managers in the topic of digital technologies and the prospects for their implementation in management (Icard *et al.*, 2023). In analysing the possibilities for implementing digital technologies in project management, M.E. Nenni *et al.* (2024) found that about 35% of all projects have a low success rate due to the low level of use of digital tools to improve their effectiveness. The researchers concluded that artificial intelligence (AI) in this case complements the capabilities of managers through rapid data analysis.

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Given the availability and advantages of using digital tools for project management, S. Bento *et al.* (2022), researching the topic of project management and AI based on a systematic analysis of the literature, concluded that AI is an inevitable implementation for all enterprises in the near future. For example, as a result of analysing the development of project management, H. Tarasyuk (2023) concluded that the optimal approach to management is a combination of new technologies and human labour. The researcher determined that AI can partially fulfil the duties of project managers. Analysing the potential of AI, R.D. Savio & J.M. Ali (2023) determined that in project management, decisions are automated, which expands the possibilities for forecasting and making effective decisions. The researchers saw the prospect of implementing digital technologies, but did not provide recommendations on how this could be achieved in practice.

After conducting empirical research in the form of a survey of employees and their perceptions of the implementation of digital technologies in project management, A.A. Vărzaru (2022) concluded that the result of such implementation is an improvement in all types of activities in project management at the enterprise. I. Taboada *et al.* (2023) came to similar conclusions as a result of a systematic analysis of the literature. The use of AI in project management was studied by F. Shoushtari *et al.* (2024). As a result of the analysis, the researchers found that, compared to traditional management methods, which are accompanied by unpredictable problems and repetitive tasks, AI effectively solves such issues and is therefore appropriate in project management.

However, the opinions of researchers differed, from those who support the implementation of digitalisation in project management to those who argue that such measures are inappropriate. In the course of researching the topic of AI in project support, L. Pereira *et al.* (2024) conducted a survey of managers, which found that most project managers have difficulties with financial and labour resources in their projects. Such difficulties cannot be solved by AI, which calls into question the feasibility of its implementation in project management. Comparing daily operations in a company and project management, M. Bugarčić & M. Slavković (2023) concluded that digital tools are changing traditional processes of planning, controlling and organising projects. The researchers explain this by the fact that the main characteristics of a project – uncertainty and interdependence of operations – must be fulfilled in a specific order, which cannot be achieved by involving, for example, AI.

The conclusions based on the results obtained by previous researchers are general and do not focus on the hospitality industry, given the specifics of how the market works. There are no specific examples of the implementation of AI or other digital technologies in project management in the hospitality industry to increase their adaptability, and there are no details of their implementation or effectiveness for other companies to learn from. This study aimed to determine how Ukrainian hospitality companies can implement adaptive project management using digital technologies. To achieve the study's goal, the following objectives were set: to analyse the potential for development of the hospitality industry in Ukraine after

the SARS-CoV-2 coronavirus pandemic and in the context of the Russian-Ukrainian war; to identify successful international experiences in implementing change and the place of Ukrainian and foreign companies in this process; to substantiate and develop recommendations for Ukrainian companies.

## ● MATERIALS AND METHODS

An analysis of the hospitality industry in Ukraine for the period 2020-2024 was carried out. To fully understand the changes in the industry, both statistical analysis of indicators for each calendar year and analysis of indicators in dynamics were used: the number of collective accommodation facilities (individuals and legal entities), the structure of accommodation facilities, tax revenues, occupancy rates of accommodation facilities, and the projected number of tourists after the end of hostilities in Ukraine. To review the current state of the hospitality market, official statistics from the State Statistics Service of Ukraine (2020) were analysed. Data for the period 2021-2024 were taken from the annual reports of Ribas Hotels Group (2024) due to the lack of necessary data on the official website of Ukraine's statistics service, which is primarily due to the non-publication of statistical data during the hostilities in the country. In addition, all of the above data does not take into account information from the occupied territories for each year of data publication and the Autonomous Republic of Crimea. After analysing the development potential of the hospitality industry, possible measures to improve project management for enterprises in the context of digitalisation were identified through a literature review. As a result, not only digital tools that can be implemented in project management were identified, but also the stages of development for the implementation of such tools.

The comparative and descriptive case study method was chosen as the basis for the analysis. The following criteria were established for the selection of practical examples: enterprises had to operate in the hospitality industry; improvements had to be implemented in the enterprise no later than 2020; information on the changes being implemented had to be easily accessible and verifiable, i.e. published on the official website of the enterprise. Two enterprises from Bulgaria and one enterprise from Ukraine operating in the hospitality industry were selected as examples. The objects of the study were hotels: Premier Hotels and Resorts in Ukraine, Casa di Fiore SPA & Medical and Izgreva Hotel Complex in Bulgaria. Within the framework of Ukrainian and Bulgarian hotels, a case study was conducted as an example of the implementation of AI tools in the field of hotel services. For Premier Hotels and Resorts, the effectiveness of the chatbot, introduced in 2019 to ensure automated communication with customers, was evaluated. Particular attention was paid to the functional capabilities of the chatbot, its language adaptation, the scalability of responses, and accessibility through various digital channels (official website, social networks). The effectiveness of the chatbot's implementation was assessed at the Bulgarian hotels Premier Hotels and Resorts and Izgreva Hotel Complex, not only in terms of improving communication with customers, but also in terms of increasing the efficiency of internal hotel management processes related to optimising employee performance and

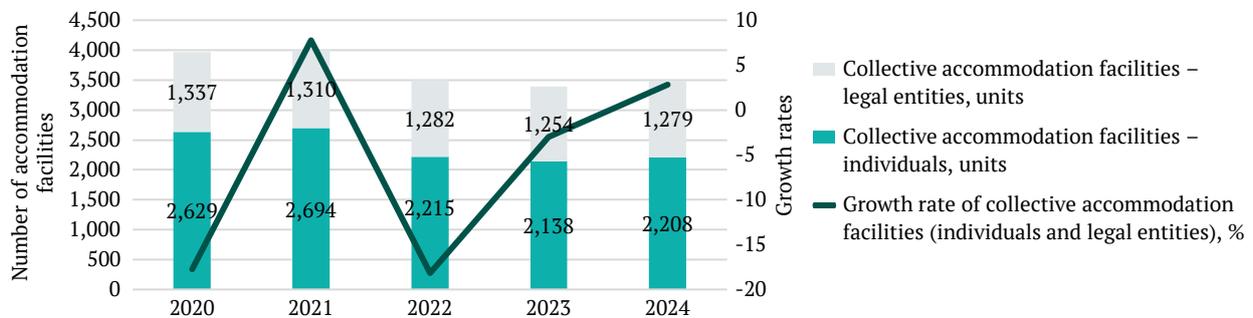
the management of the entire hotel complex. Particular attention was paid to the functional capabilities of chatbots, technological capabilities and practical advantages. Based on the experience of successful Bulgarian practices, appropriate changes were proposed for Ukrainian enterprises in order to meet market needs and operating conditions.

## ● RESULTS

Despite the impact of the SARS-CoV-2 coronavirus pandemic, Russia's full-scale invasion of Ukraine and occupation of parts of the Kherson, Mykolaiv, Zaporizhzhia, Kharkiv, Donetsk and Luhansk regions, as well as the annexation of the Autonomous Republic of Crimea in 2014, the hospitality industry in Ukraine continues to function. Looking at the structure of the hospitality market, the vast majority of establishments, namely 46%, are hotels and motels (Ribas Hotels Group, 2024). In 2020, the corresponding figure was 64.16%. This means that the number of hotels and motels decreased by more than 0.5 times between 2020

and 2024 (State Statistics Service of Ukraine, 2020). Despite these statistics, tax revenues increased in 2024 compared to 2023 by 23% (UAH 273 million in tourist tax in 2024 compared to UAH 222.618 million in 2023).

The growth of the hospitality industry is due to the partial revival of tourism and the gradual return of foreign visitors. In particular, hotel occupancy in western regions of Ukraine, such as Ivano-Frankivsk, Lviv and Zakarpattia, reached about 50% in 2023-2024. According to analysts' forecasts, after the end of the full-scale invasion, the number of tourists in the Ukrainian market could reach 14 million people. Given these trends, significant investments are needed exclusively for the construction of new recreation and tourism complexes, which are currently insufficient for the projected number of tourists (Ribas Hotels Group, 2024). As of 2024, the number of accommodation establishments in the country decreased by 12.07% and reached 3,487 units (Fig. 1). This absolute indicator is close to the 2017 figure (State Statistics Service of Ukraine, 2020).



**Figure 1.** Number of collective accommodation facilities in Ukraine for the period 2020-2024

**Source:** created by the author based on data from State Statistics Service of Ukraine (2020), Ribas Hotels Group (2024)

Based on the statistical data presented in Figure 1, it can be concluded that both the number of collective accommodation facilities – natural persons and collective accommodation facilities – legal entities decreased by 16.01% and 4.34%, respectively, during the period 2020-2024. The overall growth rate of all accommodation facilities decreased by 18.17% in 2022 compared to the previous year. In other words, a significant decline occurred with the start of Russia's full-scale invasion of Ukraine. Possible reasons include: the occupation of Ukrainian territory and the closure of accommodation facilities; the destruction of Ukrainian hotels and other accommodation facilities by Russia; the bankruptcy of enterprises, etc. However, in 2023, the growth rate slowed to 3%, and in 2024, it exceeded 2%, showing positive dynamics and further prospects for the development of the hospitality industry even in the context of the Russian-Ukrainian war (Ribas Hotels Group, 2024). Therefore, one of the main criteria for success in this process is effective project management in the hospitality industry through the inevitable introduction of new digital tools.

Digitalisation began with the advent of industrial automation (Gsell & Nikodemus, 2025). It was the transition from informatisation to digitalisation that marked the beginning of Industry 4.0 (Bölting *et al.*, 2016). Industry 4.0 is associated with a vision of completely new production structures and value creation based on the widespread use of intelligent information and communication technologies as well as robotics (Hirsch-Kreinsen, 2020; Xu *et al.*, 2021).

Digital transformation is characterised by four features: inevitability, high speed, uncertainty in implementation, and irreversibility in production processes (Oswald *et al.*, 2018; Vogel-Heuser & Bengler, 2023). Automation of project management is one of the promising and expedient areas for hospitality industry enterprises. By implementing digital technologies, management personnel can save financial resources and improve the achievement of clearly defined goals. In particular, this applies to the use of AI to perform labour-intensive tasks (Bachynskiy, 2024). The concept of AI was developed over 70 years ago (1956), but it is considered a breakthrough innovation that can change the way various business processes work (Pokorni *et al.*, 2021; Patuelli & Keplinger, 2023). The hospitality industry is no exception. AI is the ability of robots or computerised systems to mimic human intelligence and emotions and behave like humans, based on structuring patterns in large amounts of data, recognising ambiguous and contradictory information, supporting situational decisions based on relative importance, and learning from experience (Bory *et al.*, 2024; Parekh & Mitchell, 2024). AI is used to make informed decisions or recommendations (Volkmar *et al.*, 2021).

As of 2025, there are already successfully implemented projects that have been carefully selected to meet the needs of hospitality industry enterprises based on AI. As a result of comparing the implemented projects, it was found that Ukrainian projects are significantly inferior to international ones in terms of the stages of implementation of AI

in project management. The criterion for comparison was the stages of AI implementation in project management. According to O. Bachynskyi (2024), the improvement of AI in project management involves step-by-step changes. The first stage involved the implementation and automation of certain processes in project management. The optimisation and automation of individual processes is a common practice in enterprises. Examples of such systems include Microsoft Project, Open Plan Professional, Spider Project, Sure Trek Project Manager, Primavera Project Planner and several dozen similar systems that focus in particular on the functions of planning and controlling the execution of tasks.

The second stage involved the introduction of chatbots as project assistants. Text- or speech-based dialogue systems that interact with other users are called chatbots (Weber *et al.*, 2024). Functions such as understanding, reasoning, and learning based on AI enable chatbots to function (Volkmar *et al.*, 2021). Chatbots can perform tasks such as organising communication, checking task completion, and reminding users to complete specific tasks. A significant number of Ukrainian companies in the hospitality industry use chatbots primarily not for internal project management, but for external customer interaction. This feature is the main difference in the focus of AI use in management between Ukrainian and foreign companies in the hospitality industry. An example of such a chatbot is Case 1.

Case 1 – Premier Hotels and Resorts – a chain of 13 Ukrainian hotels located in Kyiv, Lviv, Odesa, Poltava, Po-chaiiv, Sumy, and Kharkiv. The hotel chain has 1,725 rooms, restaurants, themed event halls, fitness centres, libraries, etc. (Ribas Hotels Group, 2024). In 2019, Premier Hotels and Resorts introduced a chatbot as a channel for communicating with customers. As of 2019, it was the first chatbot implemented in hotels in Ukraine. The chatbot provided round-the-clock communication with customers with 540 possible responses. The chatbot supported a bilingual interface, including Ukrainian and English, on the hotels' official website and official social media pages. In other words, the main goal of implementing the chatbot was to improve customer interaction, rather than project management.

The third stage of implementing AI in project management involved the use of machine learning through available digital tools (Bachynskyi, 2024). In particular, machine learning is one of the most revolutionary technologies in the field of AI (Sharifani & Amini, 2023). That is, this type of learning is the scientific study of algorithms and statistical models with which a computer system performs a specific task. Machine learning is divided into shallow learning and deep learning, which can be based, for example, on supervised or unsupervised learning (Chahal & Gulia, 2019; Pokorni *et al.*, 2021). Deep learning is a growing field of predictive analytics due to its fast and automated processing of information. An example of the practical implementation of such technologies, namely shallow learning, is the hotels in Bulgaria analysed in cases 2 and 3.

Case 2 – Casa di Fiore SPA & Medical Hotel. This is a five-star hotel in Kranevo (Bulgaria), located on the Black Sea coast. The hotel has 184 rooms and 4 apartments, mineral water pools, a beauty salon, a medical facility, a garden, a gym, massage rooms, etc. Due to the large number of different services and requests from hotel guests, as well as internal personnel issues, there was a need to

introduce digital technologies in hotel management. The idea behind the introduction of digital technology was not only to improve and automate communication with customers, but also to integrate it with other hotel services (Umni, 2023a).

To achieve this, in 2022, the hotel introduced AI in the form of a chatbot and assistant named "Miss Fiora". The name and avatar of the digital assistant are the result of a carefully thought-out marketing campaign aimed at increasing interest in the use of AI. In addition to developing an avatar in the form of a fairy-tale character, the hotel has introduced a continuous visual presentation on all photos of the hotel website of a real woman whose image is as close as possible to Miss Fiora. This chatbot is located on the main page of the official website of Casa di Fiore SPA & Medical. Due to the fact that the chatbot was developed based on Umni (2023a) AI, it is now possible to support more than 750 topics about the hotel and answer more than 10,000 questions. In the process of communicating with customers, AI learns, improves and expands on the topics that were set as basic when creating the chatbot. The advantage of implementing a chatbot based on Umni was that such digital technologies do not require significant technical knowledge, skills, or competencies on the part of hotel employees to interact effectively with AI. As a result, the chatbot began to perform its main functions, solving the following problems for the hotel: creating and posting information for customers about current discounts and promotions; providing answers to customers in the form of a text or voice module; communicating with guests at night in the form of responses to requests; solving the problem of staff shortages. The chatbot has a main menu where all information about the hotel is presented in a structured manner. Since the hotel complex is also family-oriented, the hotel's chatbot has a special section for children, where all the necessary information for them is provided.

By implementing the chatbot, more than 83,000 hotel guests were helped during the first calendar year of operation. Considering that the chatbot communicated with each guest for a minimum amount of time, for example 1 minute, communication with guests took more than 1,300 hours in total during the year. This corresponds to the work of one employee per month. In this case, the use of a chatbot is an advantage, as communication can take place on weekends and holidays, outside of normal working hours. About 40% of chats with the digital assistant took place at night. Over the course of the year, there were over 500,000 interactions with the chatbot from customers. As a result, the hotel saved 7,000 hours for its employees. At peak times, the chatbot processed about 60,000 interactions per month, as well as about 4,000 interactions per day. Due to high customer demand, the chatbot was integrated with the WebHotelier booking system and a voice recogniser was added, thereby speeding up and simplifying the hotel booking process. As of 2025, the chatbot supports communication with customers via text and voice modules in English and Bulgarian. Thus, the hotel was able to achieve direct integration into the hotel's business processes, improving customer engagement with services and employee engagement with work. At the same time, AI not only provides assistance, but also collects and processes statistical information for management personnel.

Case 3 – Izgreva Hotel Complex. This hotel is located in Banya (Bulgaria), near the Rozlog Valley between the three mountains of Pirin, Rila and Rhodope, not far from the Bansko ski resort. The hotel has rooms and apartments, regular swimming pools and mineral water pools, a restaurant and a summer garden, etc. The problem was that hotel employees were unable to handle a large number of incoming calls, inform customers about booking details, hotel events, etc. Another problem was that the hotel was popular among international tourists, but only a small number of employees were fluent in foreign languages. This reduced the efficiency of the employees' work. The hotel did not actively market itself on social media due to a lack of financial resources and only operated through a poorly functioning website. Since the hotel had an official website, the idea of introducing an AI-based assistant became the main task to be implemented (Umni, 2023b).

At the end of 2021, the hotel implemented an AI-based chatbot called "Izgrevo". This chatbot is located on the main page of the official website of the Izgreva Hotel Complex. Due to the Umni base, it became possible to support a large number of functions: round-the-clock customer service; communication with international customers; booking rooms, services and venues for events; assisting customers at all stages of the booking process; providing information about the hotel's location; guide to the most important places to visit (ATMs, tourist attractions, etc.). The chatbot has a main menu where all information about the hotel is presented in a structured manner: it is now

possible to support over 1,000 topics about the hotel and answer over 10,500 questions.

The implementation of the chatbot into the hotel's operations engaged over 16,000 customers in communication during the first calendar year, resulting in more than 80,000 interactions. On average, the chatbot processed between 200 and 500 requests per day, and on the busiest day of the year, it handled over 4,000 interactions with 3,200 customers. In the busiest months, such as July, there were over 13,000 interactions during the month. Its bilingual interface (Bulgarian and English) enabled the chatbot to interact with customers from 17 countries around the world. Over 40% of customer requests were processed by the chatbot outside of normal working hours. In addition, digitising the restaurant menu enabled the hotel to process and fulfil requests via the chatbot from local villagers and tourists who were not customers of the hotel complex. In total, in 2022, communicating with customers via the chatbot saved over 1,400 hours of management staff time at the hotel. QR codes were introduced to direct all customers to the website with AI and a chatbot.

The placement of the analysed cases in the system of stages of AI development in project management is shown in Table 1. As of 2025, there are no real examples of the use of autonomous AI in hospitality industry enterprises. Given the transition from computerisation to digitalisation of enterprises and the functioning of Industry 4.0, the evolution and development of AI in project management and the transition of enterprises to the fourth stage over time is inevitable (Bölting *et al.*, 2016; Bachynskiy, 2024).

**Table 1.** Placement of cases in the structure of AI development for project management

Development stage	Stage name	Systems	Company example
1	Process automation	Microsoft Project, Open Plan Professional, Spider Project	Typical hospitality industry enterprise
2	Human-computer interaction	Fireflies.ai, Stratejos.ai	Typical hospitality industry enterprise
3	Analytics and advice	Umni.ai, shallow machine learning	Casa di Fiore SPA & Medical (Bulgaria), Izgreva Hotel Complex (Bulgaria)
4	Autonomous control	Deep machine learning	Future developments

**Source:** created by the author based on data from A. Chahal & P. Gulia (2019), Umni (2023a; 2023b), O. Bachynskiy (2024)

The use of AI in project management, in addition to automation, improved efficiency, data analytics, and increased productivity, carries significant risks. The relationship between information and trust is the limit of AI. It also concerns the complexity of social relations. Technically mediated communication has its advantages, but also its disadvantages. The limits of AI lie in the complexity of knowledge. This means that the potential of human labour cannot be fully realised through technology. A data- or function-oriented approach to work does not take into account important aspects of human behaviour at work that are necessary for solving complex problems at various levels in the project management process. It also does not take into account the importance of social relationships not only within the team but also outside it (Bachynskiy, 2024). On the other hand, there is also the issue of data security for companies and customers, especially in the cloud. Unpredictable circumstances caused by human intervention or technical errors can cause difficulties for companies in the real estate sector. In other words, a hacker attack

jeopardises the security and functionality of companies. It cannot be ruled out that the functionality of digital tools may be compromised in practice (Vornholz, 2021).

Another important recommendation for remedying the situation has a preventive effect, as it concerns not only data protection but also ethics. It is important to adhere to ethical principles when working with AI. AI offers the hope that decisions can be made not only faster and more cost-effectively, but also more objectively and fairly. Ethical requirements of fairness, accountability and transparency must serve as the basis for such interaction (Thalmann *et al.*, 2022). If AI is equipped with an explanatory component, ethical problems are significantly reduced. Therefore, on the one hand, it is important to understand the reasons for a particular prediction made by AI. On the other hand, it is necessary to ensure its predictability. Only if these two aspects are taken into account can decisions based on AI be reliable (Sudmann, 2020).

Ukrainian companies in the hospitality industry should rely on Bulgaria's experience of successfully implementing

AI and chatbots with superficial machine learning not only in the process of communicating with customers, but also in the process of managing projects within the company. Namely, the main task for Ukrainian hospitality businesses in 2025 is to identify the main problems in project management that can be eliminated with digital tools and move on to the phase of actively searching for software developers, taking into account and anticipating the threats of AI and achieving maximum benefit from its use in project management. The biggest problems that could create barriers to Ukrainian hospitality businesses moving to the third stage of AI implementation could be a lack of financial resources and insufficient employee competence, as well as the opacity of AI algorithms. However, these problems can be solved in practice.

Another problem is that AI algorithms are not transparent, and systemic inequality is exacerbated by bias in data sets. Companies in the property management sector need to develop concepts that regulate how digital tools collect and process information. The Ukrainian hospitality industry has every opportunity to stimulate the development of such concepts and solve these problems in the near future. The implementation of digital technologies is an expensive process that requires constant investment in technology, processes and systems. For employers, the introduction of digital tools in a company entails additional costs for employee training, software licensing and investment in equipment, restructuring and modernisation. This, in turn, affects the company's productivity. If companies do not have the financial resources to implement complex digital tools, digital technologies can be implemented using mobile devices rather than computers. In addition to the advantages of constant access and ease of use, such implementation requires fewer resources, but can also cause problems. For example, mobile devices have less computing power and less memory than stationary ones (Vornholz, 2021).

In addition, the skills of employees who are new to using AI must also be taken into account. On the one hand, employees need to be trained to use such tools correctly in their work to improve efficiency and safety. On the other hand, technical experts who develop AI-based solutions must understand the specifics of the hospitality industry, its legal restrictions and needs. Therefore, Ukrainian hospitality businesses should first and foremost focus on improving the digital skills of their employees. This refers mainly to digital literacy, i.e. the ability to use computers and software, rather than computer literacy. Digital literacy includes the confident, critical and responsible use of digital technologies and interaction with them for learning, working and participating in society. It is advisable to develop the digital literacy of employees, which includes information literacy, communication and collaboration, security, including cybersecurity skills, problem solving and critical thinking (Vuorikari *et al.*, 2022). In other words, it is critically important for employees to be able to use information and communication technologies in such a way that they can easily and quickly search for, evaluation, create and transmit information using digital tools in various forms and formats (Nikou *et al.*, 2022). Given the possible rapid transition to the third and fourth stages of AI implementation in the hospitality industry, skills development should not be a one-off approach but requires constant

professional intervention on the part of the management of hospitality businesses in Ukraine. If such actions are not implemented, mistrust of new technologies may arise, which will complicate their implementation and use in the hospitality industry in Ukraine.

## ● DISCUSSION

As a result of case studies and literature analysis, it was established that the implementation of AI in project management in the hospitality industry by 2025 is feasible and possible, as confirmed by the successful practice of a Bulgarian company. AI based on superficial machine learning is the basis for chatbots that can be implemented in project management, which has already been implemented in 2022 at the Casa di Fiore SPA & Medical and Izgreva Hotel Complex hotels in Bulgaria. An analysis of practical cases has shown that currently, the only advanced technologies for the Ukrainian hospitality market are chatbots for quick interaction with customers. However, implementation in project management not only at the level of communication between employees and customers, but also the introduction of analytics and statistical processing of information, assistance in managing staff, as revealed by the experience of the Bulgarian enterprise, has not been implemented in Ukraine in 2025. Despite the fact that entrepreneurs in the Ukrainian hospitality industry do not implement similar digital technologies in practice, the results of the study show that the hospitality market has already shown improvement in terms of growth in the number of accommodation facilities and an increase in tax revenues for 2023–2024. This indicates the prospects for the development of this market and the importance of introducing digital technologies into project management. M.I. Shamim (2024) came to similar conclusions, improving the effectiveness of decision-making by introducing AI into project management. After analysing the advantages and risks, the researcher found that it is advisable for companies to follow trends in the technology market in order to maintain their competitiveness among their closest competitors.

Studying current trends in project management in the hotel and restaurant business in Ukraine, V. Postova (2023) identified the main trends that will become reality in the near future. It should be noted that the researcher highlighted data analysis and process automation, which confirms the findings of this study regarding the prospects for the development of AI not only for communication with customers, but also for improving project management performance. However, the researcher identified two more trends that were not analysed in this study: data security when using digital tools and the organisation of remote work for employees. With the increasing number of remote and distance work, project managers must combine the implementation of digital technologies with the ability of employees to work from home. Such conditions significantly complicate the search for alternative solutions. At the same time, it is important to focus efforts on maintaining confidentiality and data protection when working with new digital technologies based on AI. Similar conclusions were reached by researchers A.R. Nabil *et al.* (2025) when studying the possible ethical and legal problems that arise when implementing AI in project management. As a result of interviews and systematic analysis combined with case

studies, the researchers noted that confidentiality is one of the main risks in this process, along with bias in management. Uncontrollable bias in AI can lead to inefficient resource allocation and discrimination in decision-making, which directly affects project outcomes. Due to the large amount of data involved, confidentiality is a weak point in the use of AI in project management. Separate management structures are needed to address these issues. Given the data obtained in this study on the weak implementation of AI in project management in the hospitality industry, it can be predicted that the development and implementation of separate management structures is far from reality for Ukrainian hospitality companies. However, this is only an assumption, which should be analysed in more detail in future studies.

Analysing the stages of evolution of AI implementation in project management, this study has determined that Ukrainian hospitality companies are at the second stage of four in terms of development. However, there is a prospect of increasing the level of AI implementation in project management to the third level, which is characterised by decision-making models for chatbots based on statistical data analysis and staff assistance in project management. This study has identified the potential for the fourth stage of AI evolution in project management: autonomous project management using only AI. However, given the current state of AI implementation in the hospitality industry, this is a distant prospect for Ukraine. This is in contrast to Bulgarian companies, for which such implementation is a near prospect, given the technologies already being implemented in the hospitality industry. As a result of this work, it has been established that there are still no successful examples of autonomous project management in the hospitality industry, due to the complexity of their implementation in practice. Comparing traditional and digital project management tools, J. Gil *et al.* (2020) found that AI-based tools provide more accurate results in terms of process control and monitoring, but an autonomous management system can only be implemented in the distant, but not the near, future, which confirms the results of the analysis conducted in this study. In the coming years, the role of a manager in management will be based on processing information from AI and making decisions. As a result of the analysis, J. Gil *et al.* concluded that the main barriers to the implementation of such models in practice remain the lack of funding. These aspects were not considered in this study. However, these conclusions once again emphasise the importance and feasibility of implementation by enterprises in the hospitality industry based on shallow machine learning rather than deep machine learning, which is more realistic from a financial point of view and has examples of effective implementation in practice.

The analysis revealed that for the effective implementation of digital tools in hospitality businesses, training staff to interact with AI is not a problem, but attention should be paid to training management personnel, i.e. managers who manage projects. The need for professional development was also noted as a result of a comprehensive analysis of the literature by E.K. Zadeh *et al.* (2024), which confirms the conclusions obtained as a result of this study. However, E.K. Zadeh *et al.* noted that despite all the advantages of implementing AI in practice, there are also risks.

As a result of this study, these risks include: the aspect of managers' trust in AI and the complexity of social relations in the project implementation process. These results are consistent with those of E.K. Zadeh *et al.*, as the researchers drew attention to the problem of managers' dependence on AI and the importance of maintaining a balance between data from digital technologies and managers' experience. The researchers believe that automated solutions are not appropriate in project management and that managers should use AI as a support tool. Therefore, the project management industry is an industry that is constantly changing and evolving along with the business environment in which projects are planned, executed, and completed. Given the opportunities offered by the introduction of third-generation AI chatbots into Ukraine's hospitality industry, it is important for companies to develop this area, starting with training managers and finding software developers.

## ● CONCLUSIONS

The study found that despite a 12.07% decline in the number of accommodation establishments between 2020 and 2024, tax revenues increased by 23% between 2023 and 2024, with the projected number of tourists reaching 14 million. This means that the hospitality industry has opportunities for development, and companies operating in this sector have the opportunity to improve their performance. The analysis determined that a promising direction for the development of this industry is the introduction of digital technologies in project management, namely through AI based on surface machine learning. The study found that Bulgarian hotels have actively implemented such technologies based on Umni AI and achieved better results. Of the four stages of AI evolution in project management, Ukrainian companies are in the second stage of development, while Bulgarian companies are in the third.

Given that as of 2025 there are still no successful examples of the fourth stage of implementing AI based on deep machine learning in project management, and considering the successful experience of Bulgarian enterprises, it is advisable for Ukrainian enterprises to adopt this practice as an example to follow. Adopting this experience is one of the main determinants of enterprise development, on the one hand, and following digitalisation trends, on the other, solving problems that may arise during implementation. Literature on the implementation of AI in project management in the hospitality industry in Ukraine is still in its nascent, which is a limitation of this study as it complicates the analysis of theoretical analysis and practical examples. Therefore, it is advisable to conduct further research with a more detailed analysis of this topic and focus on conducting interviews and qualitative content analysis among Ukrainian entrepreneurs in the hospitality industry, supplementing the results obtained in this study.

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None.

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## Управління проектами в індустрії гостинності: теоретичні основи та практичні аспекти

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**Анотація.** Мета дослідження полягала у визначенні шляхів впровадження адаптивного управління проектами в індустрії гостинності України з використанням цифрових технологій, зокрема штучного інтелекту на основі машинного навчання. Методологічну основу становили статистичний аналіз показників ринку гостинності України за 2020-2024 роки, порівняльне дослідження міжнародних практик та метод case-study на прикладі готельних підприємств України та Болгарії. Результати дослідження засвідчили, що ринок гостинності України, попри виклики пандемії COVID-19 та повномасштабної війни, демонструє ознаки відновлення: темпи приросту кількості закладів розміщення у 2024 р. зросли на 2 %, а податкові надходження з туристичного збору – на 23 % порівняно з 2023 р. Встановлено, що українські готелі переважно перебувають на другому етапі впровадження штучного інтелекту (використання чат-ботів для зовнішньої взаємодії з клієнтами), тоді як болгарські підприємства досягли третього етапу (інтеграція аналітики та автоматизація внутрішніх процесів). На прикладі готелів Casa di Fiore SPA & Medical та Izgreva Hotel Complex проаналізовано ефективність чат-ботів із функціями машинного навчання, що дозволило скоротити робочий час персоналу та підвищити рівень обслуговування. Надано комплексну оцінку готовності українських підприємств індустрії гостинності до переходу на вищі етапи впровадження штучного інтелекту та сформовано практичні рекомендації щодо інтеграції цифрових технологій у проектний менеджмент. Практичне значення полягає у наданні дорожньої карти впровадження інструментів штучного інтелекту, з урахуванням фінансових, технічних та кадрових обмежень

**Ключові слова:** цифровізація; штучний інтелект; чат-боти; машинне навчання; віртуальний помічник; готельний бізнес; проектний менеджмент; автоматизація; цифрові компетенції

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