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HREBENIKOVA O.¹, DENYSOVA T.²

INTEGRATION OF MODERN FINANCIAL INSTRUMENTS AND DIGITAL TECHNOLOGIES INTO INVESTMENT MANAGEMENT OF BANKING INSTITUTIONS

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Formulation of the problem. In the context of financial sector digitalization and the expanding use of artificial intelligence (AI), banking institutions face increasing vulnerability to new types of risks. Traditional security management methods lose their effectiveness under the pressure of cyberthreats, complex ESG risks, and high market volatility, which necessitates the development of adaptive protection tools. *The purpose of the research* is to substantiate theoretical and methodological foundations and to develop practical recommendations for integrating innovative financial instruments and digital AI technologies into the bank economic security system. *The object of the research* is the process of ensuring the economic security and functional resilience of banking institutions in the context of financial market digitalization. *The methods of the research:* methods of analysis and synthesis (to study the theoretical framework and identify digital risks), a systems approach (to build an ecosystem vision of security), as well as generalization and comparison methods (to systematise protection technologies). *The main hypothesis of the research* is the assumption that combining hedging instruments (currency derivatives, green bonds) with predictive AI algorithms enhances risk assessment accuracy, optimises costs, and strengthens the bank's economic security. *The statement of basic materials.* The article examines the impact of digitalisation on the structure of banking risks. The role of machine learning in forecasting volatility, assessing creditworthiness, and modelling Value at Risk (VaR) is identified. The use of green bonds to minimise ESG risks and the ethical aspects of AI deployment based on NBU recommendations are analysed. *The originality and practical significance of the research* lie in substantiating a synergy model between financial innovations and AI for rapid response to threats. The approaches proposed by the authors can be used by bank management to develop risk management systems and by regulators for formalising AI normative frameworks. *Conclusions and perspectives for further research:* the application of AI and modern hedging instruments significantly improves risk analysis accuracy and reduces operational costs, while further research should focus on developing models to assess the effectiveness of AI algorithms in internal control and protecting cloud infrastructures against cyberthreats.

Keywords:

artificial intelligence, banking risk management, economic security, digitalization, hedging instruments, green bonds, ESG risks, predictive algorithms.

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ІНТЕГРАЦІЯ СУЧАСНИХ ФІНАНСОВИХ ІНСТРУМЕНТІВ І ЦИФРОВИХ ТЕХНОЛОГІЙ В УПРАВЛІННЯ ІНВЕСТИЦІЙНОЮ ДІЯЛЬНІСТЮ БАНКІВСЬКИХ УСТАНОВ

Постановка проблеми. В умовах цифровізації фінансового сектору та розширення застосування штучного інтелекту (ШІ) зростає вразливість банківських установ до нових видів ризиків. Традиційні методи забезпечення безпеки втрачають ефективність під тиском кіберзагроз, комплексних ESG-ризиків і високої волатильності ринку, що вимагає розробки адаптивних інструментів захисту. *Мета статті* – обґрунтування теоретико-методологічних засад і розробка практичних рекомендацій щодо інтеграції інноваційних фінансових інструментів та цифрових технологій ШІ в систему забезпечення економічної безпеки банків. *Об'єктом дослідження* є процес забезпечення економічної безпеки та функціональної стійкості банківських установ у контексті цифровізації фінансового ринку. *Методи, використані в дослідженні:* методи аналізу та синтезу (для вивчення теоретичного базису та ідентифікації цифрових ризиків), системний підхід (для формування екосистемного бачення безпеки), методи узагальнення (для систематизації технологій захисту) та порівняння. *Основною гіпотезою дослідження* є припущення, що поєднання інструментів хеджування (валютних деривативів, зелених облігацій) із предиктивними алгоритмами ШІ дозволяє підвищити точність оцінки ризиків, оптимізувати витрати й зміцнити економічну безпеку банку. *Виклад основного матеріалу.* У статті досліджено вплив цифровізації на структуру банківських ризиків. Визначено роль машинного навчання у прогнозуванні волатильності, оцінці кредитоспроможності та моделюванні Value at Risk (VaR). Проаналізовано використання зелених облігацій для мінімізації ESG-ризиків та етичні аспекти застосування ШІ за рекомендаціями НБУ. *Оригінальність та практична значимість дослідження* полягає в обґрунтуванні моделі синергії фінансових інновацій і ШІ для оперативного реагування на загрози. Запропоновані авторами статті підходи можуть бути використані менеджментом банків для розбудови ризик-менеджменту та регуляторами для нормативного оформлення ШІ. *Висновки та перспективи подальших досліджень:* застосування ШІ та сучасних інструментів хеджування суттєво підвищує точність аналізу ризиків і знижує операційні витрати банку, а подальші дослідження доцільно спрямувати на розробку моделей оцінки ефективності алгоритмів ШІ у внутрішньому контролі та захист хмарних інфраструктур від кіберзагроз.

Ключові слова:

штучний інтелект, банківський ризик-менеджмент, економічна безпека, цифровізація, інструменти хеджування, зелені облігації, ESG-ризиків, предиктивні алгоритми.

Formulation of the problem. Modern financial instruments and technologies are radically changing approaches to investment management in banking institutions, combining traditional methods with the capabilities of machine learning, artificial intelligence, and big data analytics to increase forecast accuracy and operational decision-making efficiency. This is driven by the growing complexity of financial markets, as well as heightened requirements for transparency, decision-making speed, and risk management.

However, the expansion of available financial instruments and technological capabilities in itself does not guarantee an increase in the investment performance of banking institutions. One of the key problems remains their fragmented use, in which financial instruments, information resources, and digital technologies are applied separately, without forming a unified information and analytical management framework. Under such conditions, digital technologies often perform predominantly auxiliary functions of automating individual operations, while their

potential for comprehensive investment information analysis, forecasting, risk assessment, and decision-making support remains underutilized.

Analysis of recent research and publications. The nature of modern financial instruments and a critical evaluation of their role in risk management are considered in [1]. The issues surrounding the application of artificial intelligence (AI) and machine learning (ML) in financial institutions, particularly in credit, market, and operational risk management, as well as trade and investment analysis, are investigated by Y. Radionov [2], N. Kholiavko, I. Sadchykova, and M. Kolotok [3], as well as D. M. Pavliuchenko [4]; the opportunities and limitations of applying AI directly in financial portfolio formation are highlighted in the work by V. Wang [5].

The issues of hedging banks' financial risks using derivatives are addressed in the works of L. Prymostka, I. Krasnova, I. Okhrymenko, M. Shcheliuk, and A. Prymostka [6], who systematised approaches to developing financial risk hedging strategies, as well as in the study by O.



Krasnoporov regarding the role of currency derivatives in smoothing exchange rate volatility under the digitalization of the financial market [7]. The specifics of incorporating green bonds into the investment portfolio of Ukrainian banks are revealed by O. Rats and A. Alfimova [8], while a structural analysis of sustainability risks (ESG) in the activities of Ukrainian banks was conducted by H. Bortnikov and O. Liubich [9].

Technological aspects of modern portfolio management – asset management platforms, cloud solutions, and analytical tools – are highlighted in reviews [10; 11; 12; 13], while the impact of technology on costs and efficiency in banking activities is addressed in a study by S. Sinha [14]. Issues surrounding the risk-based regulation of artificial intelligence application by financial market participants are outlined in a discussion paper by the National Bank of Ukraine [15].

However, it should be noted that most studies consider financial instruments and technologies for bank portfolio management in isolation from one another, whereas a comprehensive integration of instrumental and technological components, backed by an economic rationale for a specific technological solution tailored to the operational environment of Ukrainian banks, remains insufficiently developed.

The purpose of this research is to substantiate the theoretical and methodological foundations of integrating modern financial instruments and digital technologies into the investment management of banking institutions, identify the key problems of their comprehensive application, and develop an integrated model for digital management of investment activity.

Presentation of the main material.

Among the new financial instruments that expand a bank's traditional portfolio management toolkit, derivatives, structured products, ETFs/ETCs on new asset classes, and tokenised assets stand out. Modern financial instruments enable banks to better manage risk and enhance investment efficiency [1]. Instruments that make it possible to diversify risks, hedge losses, and generate additional income include the following groups:

- derivative instruments (derivatives) are designed to manage various types of risk: futures and forward contracts are used to hedge interest rate, currency, and commodity risks: a bank can enter into a forward contract to lock in a future exchange rate for buying or selling currency for a portfolio of foreign assets. Options grant the right, but not the obligation, to buy or sell an asset at a

predetermined price, serving as a more flexible form of risk insurance – for example, purchasing a put option on a bond protects against a decline in its price. Interest rate swaps make it possible to exchange fixed interest payments for floating ones and vice versa: a bank holding fixed-rate assets paired with floating-rate liabilities can use a swap to eliminate interest rate risk. Credit default swaps (CDS) are applied as an instrument to hedge against default by a security issuer within the portfolio, thereby serving to manage credit risk;

- structured products are designed to combine multiple financial components: these are hybrid instruments that typically include a fixed-income component (for capital preservation) and a derivative component (to yield additional returns); banks can either invest in them or structure such products for clients;

- emerging market instruments are designed to expand investment opportunities and diversification: they encompass private equity and venture capital – investing in non-public companies to achieve high long-term profitability (predominantly through specialized funds) – as well as green bonds and ESG bonds, which finance environmental and social projects, enhance the bank's reputation, and align with modern trends of responsible investing. A distinct direction is asset securitization: the bank repackages a portion of its assets (for instance, mortgage loans) into securities (specifically MBS) and sells them to investors, which frees up capital and diversifies risks.

Formulating financial risk hedging strategies remains one of the key areas for improving bank portfolio management under conditions of increased financial market instability [6]. Amid the digitalization of financial markets, the development of the organized currency derivatives market is viewed as a crucial tool for hedging currency risks and enhancing the predictability of a bank's cash flows, particularly in the context of high hryvnia exchange rate volatility during 2021 – 2026 [7]. The practical application of derivatives within a bank's portfolio involves combining several strategies: locking in a future exchange rate using forward contracts for a portfolio of foreign assets, mitigating losses from adverse interest rate movements through options and interest rate swaps, and transferring a portion of the security issuer's credit risk to a counterparty via credit default swaps. Importantly, the effectiveness of hedging with derivatives directly depends on the maturity of the national derivatives market,





the liquidity of the respective instruments, and the quality of internal bank risk assessment models.

The inclusion of green bonds in the investment portfolio of Ukrainian banks is viewed as a promising direction for diversification that simultaneously enhances the portfolio's yield, liquidity, and social responsibility [8]. The primary advantages of such instruments include access to concessional financing, improved bank reputation among international partners, and alignment with sustainable development requirements, whereas the lack of development in the national green bond market, the absence of a unified rating methodology for ESG issuers, and a limited pool of qualified projects remain key barriers. At the same time, a structural analysis of sustainability risks indicates that Ukrainian banks are at the initial stage of developing a fully fledged business model based on sustainable finance principles, and integrating ESG into portfolio and investment policy requires reinforcing the three lines of defence against risks with new functions and competencies [9].

Simultaneously with the expansion of instruments, portfolio management technologies that provide analytics, automation, and security are also evolving. The essence of modern technologies lies not merely in automation, but in a fundamental shift in the management paradigm – from reactive («what happened?») to proactive («what if...?»), from intuitive to data-driven, and from discrete to continuous. Technologies that are expedient for use in constructing and managing a bank's investment portfolio include the following:

- artificial intelligence (AI) and machine learning (ML) are designed to process systems capable of learning from data, discovering complex non-obvious relationships, and constructing predictive models. Integrating AI and ML into financial services enhances the accuracy and speed of decision-making, improves risk analysis and fraud detection, and personalizes customer service [4]. Predictive analytics processes historical data on prices, macroeconomic indicators, news feeds, and social sentiment to forecast the dynamics of individual assets and entire markets: a built model makes it possible to detect that a combination of bond market volatility, shifts in currency indexes, and specific words in geopolitical news precedes a stock market correction, thereby giving the bank a signal to reduce risk. Algorithmic and high-frequency trading automatically executes trades based on set rules at speeds unachievable by humans: practical applications include arbitrage (simultaneously tracking asset prices across different exchanges) and statistical

arbitrage (identifying pairs of assets whose prices have historically moved in a correlated manner). The use of Natural Language Processing (NLP) for sentiment analysis enables real-time evaluation of the emotional tone of news, corporate reports, and social media posts, making it possible to respond to information flows even before official financial indicators emerge. Within financial institutions, AI and ML significantly enhance the quality of credit, market, and operational risk management through more accurate and rapid analysis of large data volumes [3; 5];

- big data analytics are designed to process extremely large (Volume), high-speed (Velocity), and diverse (Variety) data sets, transforming them into structured information. Banks model portfolio behaviour under thousands of different scenarios (sharp rate changes, recession, geopolitical crises) through stress testing, while behavioural analysis and the construction of a «digital twin» of the market help to better understand market drivers and make informed decisions;

- blockchain and Distributed Ledger Technology (DLT) are designed to enhance transparency, automate specific settlement stages, and reduce transaction costs under appropriate technological and regulatory conditions: asset tokenisation converts real-world assets (real estate, fine art) into digital tokens, simplifying their trading and division while opening up new asset classes for the bank's portfolio; smart contracts automatically execute contractual terms (for example, paying bond coupons) upon the occurrence of specified events, thereby lowering operational risks and increasing the speed and accuracy of settlements;

- cloud technologies are designed to rapidly scale computing power for complex calculations (such as Monte Carlo simulations), reduce bank expenditure on internal infrastructure, and enable shared data and analytics access across various departments, including traders, risk managers, and reporting teams [10; 11; 12]. Major cloud providers offer ready-to-use AI services, eliminating the need for bank investment analysts to build ML infrastructure from scratch, which significantly accelerates technology adoption even in mid-sized banks. Empirical research confirms that technological transformation positively impacts expenditure and operational efficiency in banking institutions [13; 14].

In general, the essence of modern technologies in bank portfolio management lies in creating a unified intelligent space where data from various sources (markets, news, reporting) are collected into a single repository, AI/ML models

analyse these data and generate trading signals, algorithms automatically execute transactions, risk management systems monitor operations in real time, and blockchain together with a cloud platform ensure the security, transparency, and scalability of the underlying infrastructure. In such a system, the portfolio manager shifts from the role of someone who makes all decisions intuitively to that of a strategist who manages and configures complex systems, sets overall goals, and intervenes in critical, non-standard situations.

The use of modern technologies provides the bank with the following advantages: increasing profitability through better analytics and access to new asset classes; effective management of credit, market, and liquidity risks; compliance with regulatory requirements (for example, Basel III standards) owing to the accurate and timely generation of reporting; cost optimisation through the automation of routine operations; and making fast, informed decisions based on real-time data. At the same time, the National Bank of Ukraine emphasizes the need for risk-oriented management and the implementation of AI management systems as a component of the overall corporate governance, risk management, and internal control framework, which aligns with the approaches of the EU Artificial Intelligence Act (EU AI Act) and the ISO/IEC 42001:2023 standard [15].

Based on the results of the conducted analysis and the fundamental analysis performed by H. Merdzanis [12], it was revealed that the main issue remains the fragmented application of financial instruments and digital solutions without integrating them into a unified management system. Issues were also identified regarding the

fragmentation of information flows, insufficient interoperability of information systems, the complexity of integrating heterogeneous data, model risk, and the insufficient explainability of certain AI/ML-solutions.

Consequently, a transition is required from the fragmented application of digital solutions to the creation of an integrated information and analytical environment within which financial instruments, digital technologies, analytical algorithms, and risk management procedures function as interconnected elements of a single cycle for formulating, implementing, and monitoring investment decisions.

Precisely the need to ensure such systemic interaction substantiates the expediency of developing an integrated model of digital investment management for a banking institution, which provides a sequential transition from using modern financial instruments and digital technologies to establishing a unified information and analytical environment, applying AI/ML analytics, performing comprehensive risk analysis, optimising investment parameters, making digital investment decisions, and subsequently monitoring their efficiency.

The authors have developed an integrated model of digital investment management for a bank (Figure 1), which provides a sequential synthesis of modern financial instruments and digital technologies into a single information-analytical loop, within which data on financial assets, market conditions, risks, and investment performance are transformed into substantiated management decisions.

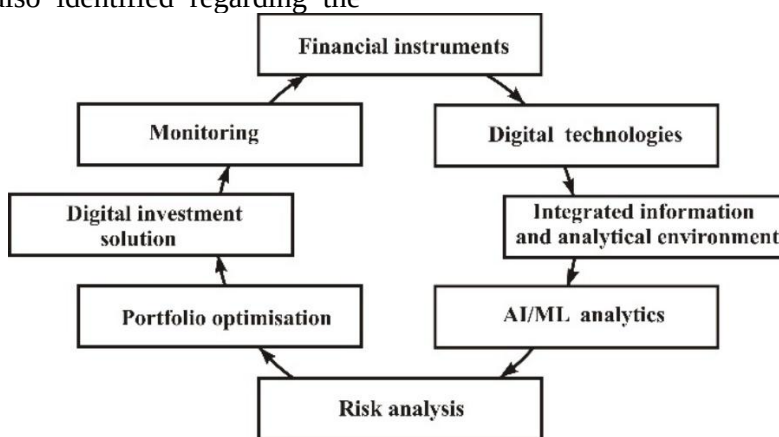


Figure 1 – Integrated model of digital investment management for a banking institution

Source: compiled by the authors

At the first stage, a range of financial instruments available to the bank for conducting investment activities is formed. These may include

government and corporate securities, equities, bonds, investment funds, derivatives, green and ESG-bonds, and other instruments. The selection





of specific instruments should be carried out taking into account their yield, risk level, liquidity, maturity, and potential for portfolio diversification. The article has already emphasized the necessity of combining instruments with appropriate risk management strategies.

The second stage – digital technologies – provides the technological foundation for working with financial instruments. AI/ML, big data analytics, cloud technologies, blockchain, and other digital solutions perform various functions: data collection and processing, forecasting, pattern detection, operation automation, scenario modelling, and risk monitoring. Consequently, digital technologies in the model act not as an end in themselves, but as an infrastructure and analytical tool for improving the quality of investment management.

At the third stage, an integrated information and analytical environment is formed, combining data from various sources: financial instrument characteristics, market quotations, financial statements, macroeconomic indicators, information flows, and results of previous portfolio management. This specific element is of fundamental importance, as it enables a transition from using separate digital technologies to their systemic integration. The article itself has already articulated the concept of a unified intelligent space where data from different sources are combined and analysed, with the results being utilised to generate investment signals and control risks.

The fourth stage is AI/ML analytics. At this level, accumulated information is processed using artificial intelligence and machine learning algorithms. Their functions may include identifying patterns, forecasting market parameters, analysing relationships between asset characteristics, generating analytical signals, and modelling potential market development scenarios. Thus, AI/ML ensures a transition from simple information accumulation to the intelligent data processing necessary for making investment decisions.

At the fifth stage, the results of AI/ML analytics are used to conduct comprehensive risk analysis. Market, credit, currency, interest rate, liquidity, operational, and concentration risks are evaluated, alongside the potential impact of changing market conditions on portfolio structure and performance. Crucially, risk analysis within the proposed model does not serve as a concluding procedure, but functions as an input parameter for subsequent portfolio optimisation. This approach aligns with the risk-based logic of digital

management, which is emphasized in modern approaches to using AI within financial institutions.

At the sixth stage, investment portfolio optimisation is carried out. Based on projected yields, evaluated risks, liquidity levels, and established constraints, an optimal allocation of financial instruments is determined. The optimisation should ensure the search for a portfolio structure option that aligns with specified investment goals and an acceptable risk level. Thus, the result of this stage is not merely a set of assets, but an optimised portfolio structure and the parameters of an investment strategy.

At the seventh stage, a digital investment decision is formed. Based on the results of analytics, risk assessment, and optimisation, the system generates recommendations regarding the choice of financial instruments, adjusting their portfolio weights, executing relevant transactions, or maintaining the current structure. At the same time, a digital decision does not necessarily imply complete automation. For a bank, maintaining human oversight remains appropriate, particularly with respect to non-standard situations, compliance with regulatory constraints, and the control of model risks.

The final stage is monitoring, which involves the continuous evaluation of actual yield, risk, liquidity, portfolio structure, and compliance with established constraints. A key feature of the model is that monitoring provides a feedback loop to the information and analytical environment. Shifts in market conditions, financial instrument characteristics, or portfolio results become new input data for AI/ML analytics, risk re-evaluation, and subsequent portfolio optimisation.

Thus, the proposed model is cyclical rather than linear in nature. Its fundamental distinction from a mere set of digital tools lies in the fact that each subsequent element utilizes the outputs of the preceding one, while monitoring results feed back into the information and analytical loop, ensuring the adaptation of investment decisions to shifts in the internal and external environments.

Conclusions and prospects for further research. The conducted research demonstrated that the application of modern financial instruments creates opportunities for investment diversification, optimising the risk-return profile, and enhancing the flexibility of bank investment policy, while digital technologies provide new capabilities for collecting, processing, and analysing large volumes of financial data, forecasting, and supporting investment decisions. It has been substantiated that the digitalisation of investment activity should be considered not merely as a means

of automating individual operations, but as the foundation for transforming the entire investment management process.

An integrated digital management model for bank investment activity has been proposed which, unlike the piecemeal use of individual financial instruments and digital technologies, provides their functional integration within a single adaptive information and analytical loop. Its fundamental feature is a cyclical nature, whereby monitoring results are used to update the information base, re-evaluate risks, and adjust investment decisions. The proposed approach ensures the functional alignment of financial instrument characteristics with the capabilities of digital analytics, establishing the prerequisites for enhancing the robustness and adaptability of bank investment decisions. The practical implementation of the model can contribute to increasing analytical responsiveness, risk assessment quality, diversification efficiency, and the bank's capacity to react to market shifts. Concurrently, its deployment requires adequate data quality, cybersecurity, algorithmic model validation, technological compatibility, and regulatory compliance.

The research is grounded in systemic, risk-based, and portfolio approaches. To summarise contemporary approaches to the use of financial instruments and digital technologies, methods of analysis, synthesis, systematisation, and comparative analysis of academic literature were applied. Structuring the interaction between financial instruments and digital technologies was achieved through the conceptual modelling method. To define the operational logic of the proposed model, a process-oriented approach was employed, encompassing a sequence of information base formation, analytics, risk assessment, optimisation, investment decision-making, and the monitoring of its results.

Prospects for further research lie in developing a system of quantitative metrics to evaluate the efficiency of the proposed model, determining the economic impact of integrating digital technologies into investment management processes, and its empirical validation using data from specific banking institutions. A distinct direction involves investigating the optimal balance between automated algorithmic decisions and professional human oversight in bank investment activity management.

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