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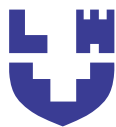
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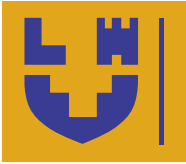
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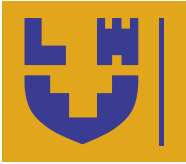
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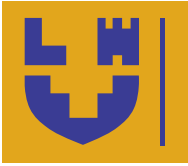
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Agentic Artificial Intelligence in financial and banking operations: A comprehensive review

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Abstract. The purpose of the study was to review of academic and industry literature, with the goal of clarifying the concept of agentic Artificial Intelligence, explaining its architectural workings, and exploring its applications in the financial and banking sectors. The rising use of Artificial Intelligence in the financial services sector had been pushing into a stage of financial automation that was not focused on rules but on systems able to reason, adapt, and act autonomously and goal-focused. This transition had led to what was currently referred to as agentic Artificial Intelligence – a category of intelligent systems that worked independently to a certain extent, which was missing in conventional Artificial Intelligence applications. The research was based on the systematic review methodology, which summarised the evidence related to the use of agentic Artificial Intelligence in autonomous trading, dynamic risk assessment, algorithmic underwriting, fraud detection, customised customer interaction, and regulatory compliance. As the analysis showed, it increased operational proactivity, situational awareness, and multi-step decision-making, allowing financial institutions to be more responsive to complex and fast-changing environments. In addition, the review outlined that there were persistent issues in regard to explainability, accountability, integration with legacy infrastructures, ethical protection, and preparedness to regulatory issues. Results suggested that agentic Artificial Intelligence had the potential ability to transform operational and strategic activities in the financial sector, but only by means of responsible governance and strict supervision, its advantages can become actual. The contribution of this review to the literature was an evidence-based integrated evaluation of the modern trends and an outline of the most prominent opportunities and limitations that will define the future of autonomous intelligent systems in the financial services

Keywords: artificial agents; autonomous finance; digital banking; financial innovations; financial algorithm

Introduction

The field of Artificial Intelligence (AI) had been a foundation of the financial field with the first applications of expert systems and rule-based decision support systems in the 1990s. However, the nature of AI-based interventions had been radically transformed in 2020s. Beginning in 2020, machine learning, reinforcement learning, and large language models have enabled a new type of intelligent system to emerge, often referred to as agentic AI, a novel type of intelligent system that was characterised by autonomy, adaptive reasoning, and goal-orientated behaviour. These systems were not merely qualitatively

different to their predecessors in that they offered assistive decision-making support by offering pre-coded rules, but in that they were multi-step, context-dependent tasks that were sensitive to dynamic financial conditions. This had been summarised in the academic enquiry. D.B. Vuković *et al.* (2025) pointed out on how agentic AI changes financial services to make real-time decisions, dynamically rebalanced portfolios, and constantly monitor risk levels, in addition to raising substantial regulatory and systemic risks. Similarly, I.A. El-gendy *et al.* (2025) argued that agentic systems played

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the role of catalysts of innovation in FinTech, enabling adaptive investment systems, autonomous compliance processes, and scalable advisory systems, which changed in line with the market environment. In the perspective of banking business, M. Mucsková (2024) recorded how smart automation contributed to improving the fundamental banking processes, such as customer onboarding, compliance procedures, and back-office tasks, thereby improving latency and eliminating human error compared to the conventional support solutions. R. Sapkota *et al.* (2026) provided a taxonomy simultaneously marking agentic AI versus the legacy rule-based systems and foregrounding autonomy, proactivity, and goal-oriented optimisation as its salient features. In addition to these contributions, contemporary empirical research showed the use of agentic AI in particular financial environments.

C. Dutta *et al.* (2023) discussed the use of autonomous algorithms in high-frequency trading and suggested that contemporary trading platforms were becoming more and more dependent on agents that can self-adjust positions, assess liquidity, and implement trades under minimum human involvement a trend that highlighted the growing operational dependence on agentic architectures. B. Vyas (2023) also illustrated that intelligent agents with behavioural analytics were significantly more successful in fraud-prevention compared to classical rule-based detection models because they can learn the patterns of individual users and even update detection thresholds in real time. H.K. Sriram & B. Somu (2025) argued that autonomous agents together with continuous anomaly detection can be used to strengthen credit risk assessment and fraud surveillance, which can reduce false positives with an increase in the sensitivity of the detection. Furthermore, A.Y. Topraklı (2025) examined agentic AI-driven algorithmic underwriting systems that found that these systems expedited the loan-approval process, enhanced the accuracy of credit decisions, and reduced bias by applying risk models in the large applicant populations in a consistent manner. Taken together, these studies pointed to the fact that the shift to purely autonomous, adaptive, and goal-oriented systems as an extension of the conventional, rule-based approach to automation was not only an evolutionary one but also a reorganisation of financial and banking processes. The capabilities in agentic AI (such as situation awareness, lifelong learning, proactive decision-making, and multi-step action execution) were beyond the assistance paradigm. These features will guarantee improvements in the trading performance, optimisation in underwriting, fraud detection, compliance automation, and real-time customer interaction. However, as the academic discourse was becoming more and more aware, this change presented significant challenges in substance. The ability to interoperate with legacy infrastructures, data governance, ethical alignment, and cross-institutional

interoperability were still daunting challenges. Besides, the empirical literature was not complete as few studies synthesised agentic AI uses, the risks involved, and the prerequisites of governance across domains.

Given the rapid technological advancements since 2020 and the growing body of distributed literature, there was a strong need for a systemic, integrative review. The purpose of the study was to provide such a review, which will present a systematic and extensive evaluation of agentic AI, its conceptual basis, practical implementation, its limitations, and opportunities in the future research and practice. The systematic literature review methodology used in this study will be aimed at synthesising and critically evaluating the academic and corporate literature related to agentic AI in the financial and banking sectors. The review followed three major steps: the process of a broad literature search and selection, the purposeful retrieval of relevant information, and the thematic framework of extracted data. The systematic approach to research allowed identifying general conceptual frameworks, defining practical application, and sorting empirical data into fundamental thematic groups, i.e., conceptual foundations, applications, and challenges or opportunities, in that way producing a consistent yet detailed view on the subject.

Conceptualising agentic AI in the financial context

To understand the impact of agentic AI on finance, it is important to define the concept of “agency” in relation to AI. According to B. Somu (2024), agentic AI was AI that had “the ability to act on its own in an environment to achieve given goals”. This definition evolved from prior AI definitions, which were systems that passively analysed data or executed human instructions and commands. The process of moving from automation to autonomy was essentially a realignment of the role of technology in finance. Traditional automation was for automating repetitive and rules-based tasks at high scale. G. Jindal (2024) noted that an example can be data entry or a standard transaction. Machine learning models allowed using predictive analytics to find patterns in data for uses such as credit scoring or fraud detection. V. Garg (2025) explained that agentic AI, however, moved beyond prediction to action, referring to a machine that can sense its environment, made decisions on its own, planned multi-step action, and executed those actions with the goal of changing its environment. Z. Yordanova & Y. Hristozov (2025) identified the key characteristics of agentic AI as proactivity, goal directedness, and adaptability. Proactivity meant the agent can act without waiting for an external trigger or explicit command. Goal directedness meant its actions were not random but were coherent to achieve a predefined often complex objective. Adaptability was the most important feature; an agentic system can learn from its interactions and outcomes and modify its future behaviour to improve

performance in dynamic and uncertain environments like volatile financial markets. I.A. Elgendy (2025) argued that this ability to operate autonomously was what made agentic AI a catalyst for innovation especially in FinTech, where new agents were being developed to re-imagine financial services.

Agentic AI's capabilities were the result of a combination of several specialised AI fields. The theoretical foundations were diverse and largely based on reinforcement learning, large language models, and classical AI planners. R. Sapkota *et al.* (2026) stated that reinforcement learning provided the mechanism for agents to learn optimal behaviours through trial and error, receiving rewards or penalties based on their actions. This was especially valid in financial applications like trading or portfolio management. An agent learnt to maximise returns over a period of time. Over a hundred billion parameter large language models had emerged as a building block that endowed agents with sophisticated understanding, reasoning, and communication abilities. Large language models (LLMs) functioned as the reasoning engine or brain for a number of contemporary agentic architectures, which assisted the systems in processing non-structured information (e.g., news reports or financial filings) or complex user requests and producing logical plans. A typical agentic system's architecture usually consisted of a number of interacting components. There was a perception module that helped in fetching data from the environment. Then there was a memory module that held information about the past. Further, reasoning and planning engine (usually based on LLM) facilitated decision-making. M. Luqman *et al.* (2025) described an action module that helped in carrying out actions through the respective tools or application programming interfaces (APIs). Frameworks often utilised an action-perception cycle. An agent may first take the user's question and the relevant market information before performing the financial analysis. After creating the prompt, the planning module was utilised to break it down into sub-goals. Like fetching historical stock data, discounted cash flow analysis, judging valuation, and summarising key findings. Ultimately, these sub-goals were carried out by interacting with financial data APIs and creating a detailed report. The multi-tasking modular architecture can complete a series of steps on its own. This was far from the capabilities of single-tasking ones. The architectural frameworks were continuously researched and great strides have been made since 2020 (Joshi, 2025).

It was important to understand the difference between agentic AI and the typical AI systems being used in finance. Algorithmic systems and ML models have been around since the 1990s to serve financial institutions. But these systems were not typically autonomous agents. The new paradigm's disruptive potential was evident when the differences were clarified. First, typical AI in finance was often reactive and task-oriented. Fraud

detection model was a good example of machine learning. The system learnt from past information where fraud was usually detected. Then, suspicious transactions were identified for frauds. It performed a specific task well-defined in advance in response to new data but did not take it upon itself to investigate root cause of fraud, decide on new rules to stop fraud, or interact with other systems to block a user's account. The fraud detection system, which was agency-based, not only detected suspicious fraudulent transfers, but could also independently freeze accounts and use a communication robot to communicate with customers to determine whether such transactions were similar to legitimate past transactions. H.K. Sriram & B. Somu (2025) noted that it could also analyse for more suspicious transactions in the user's past history and adjust its parameters based on the result.

Conventional systems cannot communicate over a wider link spectrum. It meant algorithmic trading systems that were either speedy or complicated but essentially heavy trading had been allowed to happen in its own magic. Automating trading systems responded to market data in the context of a defined strategy, but did not themselves develop entirely new trading strategies based on macroeconomic research analysis or dynamic reallocation. An agentic trading system could be assigned a high-level objective, such as "maximise alpha for this portfolio, while locking in a particular risk profile". Classic AI systems aimed to boost human decisions through a "human-in-the-loop" approach. The machine analysed or alerted the user and a human finalised the decision. AI that was agentic still required governance or oversight but it was built to work in a "human-on-the-loop" or "human-over-the-loop" mode. The agent does everything from start to finish. The human sets the goals and constraints only intervening in exceptional cases. This change had a major impact on the way work was performed and the skills and roles needed in the financial industry. K. Huang (2025) observed that there was an ever-growing number of innovative FinTech companies utilising these autonomous methods, which was already showing promise in opening up access to complex financial services that had traditionally been costly and labour-intensive. Consequently, the integration of agentic capabilities signified a fundamental shift in financial operational models, moving from static automation to dynamic, autonomous interaction. This evolution necessitated a re-evaluation of operational oversight and the integration of adaptive technologies within the banking sector.

Applications of agentic AI in financial operations

Due to a major paradigm shift in financial operations, a transition was occurring from rules-based AI to agentic AI. Z. Yordanova & Y. Hristozov (2025) noted that AI systems such as Artificial General Intelligence and Artificial Super Intelligence, characterised by autonomy

and goal-directedness, were moving past automation into undertaking works previously reserved for human experts. The space of trading and investment had long been an area for sophisticated computational techniques, from early quantitative models to high-frequency trading algorithms. C. Dutta *et al.* (2023) discussed the use of autonomous algorithms in high-frequency trading, suggesting that agentic AI was positioned to usher in the next evolutionary phase by providing traders with autonomy beyond the conventional set of pre-defined rules for trading. Unlike classic algo trading, which was programmed to trade when reaching certain price levels or technical signals, agentic AI systems were able to devise and adapt their own trades. The ability of these autonomous agents to analyse multiple data sources such as market data, news sentiment, macroeconomic data, and social media data, allowed the systems to spot trading opportunities. M.S. Amin *et al.* (2024) demonstrated that these models can create hypotheses, test them on both historical and simulated data, and deploy cash automatically without human involvement. An example of agentic AI could be an AI system assigned the task of managing a portfolio. It may decide autonomously to move money out of equities and into bonds, based on reasoning regarding rising inflation and central bank signalling. A lot of autonomous trading agents relied on reinforcement learning as a foundational technology.

Alpha agents took actions (buying, selling or holding on to an asset) in a simulated market environment by trial and error. They learnt an optimal policy that maximised the cumulative reward signal (for example, profit). The reward can also be an indicator of risk-adjusted return (like the Sharpe ratio). As a result of this, the systems were able to discover patterns and relations that were complex and non-linear. The role of agentic AI was particularly apparent in derivatives trading and arbitrage: markets that relied on speed and the rapid calculation of multi-variable information. These intermediaries enabled complex multiple trades in various exchanges and assets to take place instantly to benefit from price inefficiencies. R. Inala (2023) emphasised that a key application domain was the ability to offer autonomous investment and advisory services. But fully autonomous trading agents bring new challenges. Multiple independent agents could create emergent, herd-like behaviour and amplify market volatility or trigger flash crashes. To ensure these agents operate within risk parameters and the firm's overall investment thesis, robust governance frameworks, real-time monitoring, circuit breakers, and "human-in-the-loop" oversight were required. Table 1 illustrated high performance of agentic AI systems in trading applications, specifically analysing data regarding market share and return rates.

Table 1. Algorithmic trading performance metrics and financial market penetration

| Metric | Conventional algorithms | Agentic AI systems | Improvement (%) |
|--------------------------------------|-------------------------|--------------------|-----------------|
| Market share of total trading, % | 65 | 75 | 15.4 |
| Average annual returns, % | 12-18 | 25-35 | 82 |
| Success rate, % | 60-70 | 85-97 | 35 |
| Risk-adjusted returns (Sharpe ratio) | 0.8-1.2 | 1.5-2.1 | 65 |
| Trade execution speed (milliseconds) | 50-100 | 10-25 | 75 |

Source: Grand View Research (n.d.), Quantified Strategies (n.d.)

The 82% improvement in average annual returns and 35% increase in success rates demonstrated the transformative potential of autonomous trading agents. The significant enhancement in risk-adjusted returns, as measured by the Sharpe ratio, indicated that agentic systems not only generate higher returns but do so with more efficient risk management. Sharpe ratio was important for evaluate the portfolio's performance by adjusting the return for the level of risk taken. The foundational block of the financial system was effective risk management. Conventional risk management techniques utilised static models like Value-at-Risk, which were calculated periodically, and may fail to capture the rapidly changing dynamics of the financial market. R. Gangavarapu (2025) stated that agentic AI was changing this field by allowing dynamic, proactive risk assessment, making the shift from reactive monitoring to predictive and preventative control. AI systems can function as independent risk management watchdogs that monitor a firm's whole portfolio and market

exposure constantly and in real-time. These agents can simultaneously ingest information streams from thousands of sources, including trading positions, counterparty credit information, market liquidity indicators, and geopolitical information streams. Through sophisticated machine learning models, subtle anomalies can be identified, emerging concentrations of risk spotted, and possible market shocks forecast before tipping over. For instance, an agent might identify a growing correlation between two assets in a portfolio, alerting a human risk manager to a hidden exposure that models might overlook. M. Luqman *et al.* (2025) highlighted that an important ability of agentic AI in this space was a real time evaluation and metering of risk scores. These systems can provide a more real-time, flexible, or dynamic view of risk instead of the end of day reports.

An agentic system can quickly assess the credit risk of a sovereign bond issuer following an abrupt political event. In the same manner, it was possible to reassess the counterparty risk of the bank upstream or

downstream. Moreover, it was possible to estimate the impact of the political event on the overall capital sufficiency of the firm. This ability made risk mitigation efforts significantly more agile. R. Inala (2023) pointed out that by emphasising intelligent risk control, financial institutions can prepare for worst-case scenarios instead of using past events as a reference. Agentic AI can run advanced stress tests and scenario analyses autonomously. The firm's portfolio can be tested by thousands of market situations ranging from a rise in interest rates to a disruption in the supplies. By using this tool, gaps can be identified, and suggestions provided to hedge and change the portfolio. Analysis of the impact of cyber security and emerging technology developments on financial stability was gaining momentum since 2020 among policymakers and financial authorities. A. Dodda (2024) observed that the combination of such advanced risk assessment tools allowed for deeper analysis of complex risk management issues. Underwriting and lending were always done manually based on data analysis and heuristic methods. Agentic AI transformed this landscape by introducing autonomous systems that can handle the entire lending lifecycle from application to approval to monitoring. N. Chitturi (2025) indicated this was most evident in the mortgage lending space, where operational challenges and paperwork had always created friction. In algorithmic underwriting, agentic AI systems act as autonomous decision makers. They can collect and verify applicant data from multiple sources including credit bureaus, bank statements, employment records, and even alternative data sets where permitted.

Using advanced machine learning algorithms, these agents can assess a borrower's creditworthiness with a level of granularity and predictive accuracy that surpassed conventional credit scoring models. Complex patterns in an applicant's financial history can be analysed to better predict the likelihood of default and enable lenders to make more informed and consistent decisions. The autonomy of these agents goes beyond a simple "approve" or "deny" decision. Loan terms such as interest rates, loan to value ratios, and repayment schedules can be dynamically structured to personalise the offer to the applicant's risk profile and financial situation. For example, an agent might identify a self-employed applicant with fluctuating income but strong cash reserves and offer a mortgage product with features that accommodate income volatility. Agentic AI can also speed up the lending process, reducing time from application to close from weeks to days or even hours. A.Y. Toprakli (2025) explained that by automating document verification, property appraisals (using automated valuation models) and compliance checks, these systems reduced manual overhead and minimised human error. AI agents can monitor transactions and data throughout the mortgage lifecycle and ensure compliance, identifying potential issues early on. This improved the customer experience and reduced operational costs for financial

institutions. The goal was to create a more streamlined, data driven, and accessible lending ecosystem.

Financial analysis and reporting were the foundation of investment decisions, corporate strategy, and regulatory compliance. These tasks involved sifting through vast amounts of structured and unstructured data – financial statements, earnings call transcripts, industry reports, regulatory filings – to extract insights. Agentic AI was automating and augmenting these processes so analysts can get deeper, faster, and more accurate insights. Agentic AI can be an autonomous financial analyst. It can be given a high-level goal such as "evaluate Company X" or "what are the growth drivers in the semiconductor industry". The agent would then devise and execute a plan to achieve that goal. This could involve automatically retrieving and parsing 10-K and 10-Q filings from the SEC database, extracting key financial metrics, doing ratio analysis, and benchmarking the company against its peers. It is important that these agents used natural language processing (NLP) and generation (NLG) to understand unstructured text and synthesise findings into human readable reports. R. Inala (2023) noted that an agent could analyse the sentiment of an earnings call transcript, identify the key themes discussed by management, and cross reference statements with the quantitative data from the financial statements. It could then generate a summary report with charts, tables, and a narrative of conclusions. This ability to author quality content for these analytical tasks frees human analysts from data gathering and allows focusing on higher level strategic interpretation and client communication. By analysing historical data and identifying leading indicators from alternative data sources, these systems can generate more accurate and dynamic forecasts for revenues, earnings, and cash flows. Simulations can be run to model the impact of different economic scenarios on a company's performance. For regulators and compliance departments, these autonomous systems can continuously monitor corporate disclosures and market activity to flag potential instances of accounting fraud, insider trading, or other forms of misconduct, thereby helping to strengthen market integrity.

Applications of agentic AI in banking operations

While financial operations focused on markets and investments, banking operations concentrated on serving customers, managing transactions, and maintaining the core banking system. Agentic AI was shifting these functions from a reactive, product-centric model to a proactive, customer-centric one. B. Somu (2024) observed that as financial institutions and FinTech companies developed new agents, the presence of these systems was becoming ubiquitous across the sector. The following analysis examined agentic AI in personalised customer service, fraud detection, regulatory compliance, and the modernisation of core banking infrastructure. The

modern banking customer expected personalised, seamless, and instant services. Agentic AI enabled banks to deliver these capabilities at scale. This technology transcended simple chatbots and rule-based virtual assistants, offering truly autonomous financial assistants capable of understanding context, anticipating needs, and executing complex tasks on the customer's behalf. S. Brohi *et al.* (2025) emphasised that these systems were designed with trustworthiness as a core principle to foster strong customer relationships. Autonomous customer service agents powered by large language models (LLMs) and conversational AI can handle a wide range of inquiries and transactions without human intervention. For instance, a customer might request to pay a credit card bill, dispute a recent transaction, and inquire about better interest rates on a savings account simultaneously.

An agentic AI system can process this multi-part request, authenticate the user, execute the payment, initiate the dispute process by requesting relevant details, and analyse the customer's account history to proactively offer a higher-yield savings product. This level of interaction and task execution reduced the load on human call centres and improved customer satisfaction.

The substantial capability of agentic AI lay in the provision of proactive and hyper-personalised financial guidance. By analysing transaction history, income patterns, and financial goals, an autonomous agent can function as a personal financial advisor. For example, the system might identify a large cash balance yielding minimal interest and, based on the user's risk profile, suggest investing a portion in a low-cost index fund, accompanied by a simulation of potential returns. The system can assist customers in creating budgets, setting savings goals, and automatically optimising financial decisions, such as sweeping excess cash into higher-interest accounts or suggesting efficient debt repayment strategies. K. Huang *et al.* (2025) noted that the objective was to democratise access to sophisticated financial services that were previously available exclusively to high-net-worth individuals. Although these systems offer significant advantages, M. Mucsková (2024) argued that seamless handovers to human agents remained essential, when complex or sensitive issues requiring human empathy and judgment arise. Table 2 demonstrated the substantial performance advantages of agentic AI systems over traditional chatbot implementations.

Table 2. AI customer service performance metrics in banking

| Performance indicator | Traditional chatbots | Agentic AI systems | Performance gain (%) |
|---------------------------------|----------------------|--------------------|----------------------|
| Query resolution rate, % | 45-55 | 80-90 | 65 of improvement |
| Customer satisfaction score | 3.2/5.0 | 4.3/5.0 | 34 of increase |
| Average response time, seconds | 120-180 | 15-30 | 83 of reduction |
| Cost per interaction, USD | 8.50 | 2.10 | 75 of cost reduction |
| Multilingual support capability | 5-8 languages | 50+ languages | 700 of expansion |
| 24/7 availability rate, % | 85 | 99.9 | 17 of improvement |

Source: Springs (n.d.), OpenText (n.d.), CoinLaw (n.d.)

The 65% improvement in query resolution rates, coupled with an 83% reduction in response time, indicated that agentic systems can handle more complex interactions autonomously, while maintaining superior speed. The 75% cost reduction per interaction represented significant operational efficiency gains for banking institutions. Financial fraud represented a growing threat as fraudsters continuously evolve methods to circumvent existing security measures. While rule-based systems were effective in detecting pre-enacted fraud schemes, such systems struggle with novel threats. H.K. Sriram & B. Somu (2025) described agentic AI as a dynamic and adaptive defence mechanism capable of learning and evolving to address emerging threats. Fraud detection systems powered by agentic AI function as autonomous security analysts monitoring billions of transactions in real-time on the bank's network. These agents do not merely verify transactions based on static criteria; rather, the systems utilised machine learning techniques to identify anomalies. B. Vyas (2023) highlighted the use of behavioural analysis in this context. Consequently, the agent created a unique profile for each customer containing average transaction times, locations, amounts,

merchants, and devices used. Any deviation from the established pattern was immediately flagged as suspicious. For instance, if a customer typically making small purchases in one location attempts to withdraw a large amount from an ATM in a different country, the agent flags this as an unusual occurrence. However, the system proceeded beyond a simple flag; the agent was capable of autonomously executing a number of actions to verify the transaction. The system may send an interactive notification to the customer's banking application for biometric verification. The card may be temporarily suspended, while the system simultaneously cross-checks other data points, such as the location of the customer's mobile device. This ability to reason and act in real-time, considering context, reduced false positives and enabled quicker and more precise responses to genuine threats. Furthermore, H. Jo *et al.* (2025) indicated that agentic systems can collaborate and share intelligence across the network, alongside privacy-protecting tools, to discover large-scale coordinated fraud attacks. By identifying similar fraudulent behaviours across thousands of unrelated accounts, these agents can identify and dismantle fraud rings more rapidly than

human teams. Fraud detection systems continuously learnt, automatically updating models to detect novel fraud attempts, thereby ensuring that banking defences evolved in parallel with new fraud strategies.

The banking regulatory landscape was complex and constantly changing, involving requirements such as Anti-Money Laundering, Know Your Customer, and transaction monitoring. Meeting these obligations was a resource-intensive task that had traditionally required large teams of compliance officers to manually review alerts and file reports. Agentic AI was automating and enhancing these compliance functions, improving accuracy and reducing operational costs. In transaction monitoring, agentic AI systems can autonomously screen financial activities for money laundering, terrorist financing, or sanctions violations. These agents transcended simple keyword matching or rule-based thresholds. A. Dodda (2024) noted that graph analytics and network analysis were utilised to uncover hidden relationships between entities and trace the flow of funds through complex multi-layered transaction chains. For example, an agent could identify a network of shell companies used to obscure the origin of illicit funds by analysing money flows, ownership structures, and transaction patterns that would be difficult to detect manually. When an agent identified suspicious activity, the system can autonomously initiate an investigation, gathering customer information, transaction history, and public records to compile a preliminary case file. The system can then use natural language generation to create a draft of a Suspicious Activity Report, highlighting the reasons for suspicion and the evidence. This automated the most time-consuming part of the compliance workflow, allowing human officers to focus on complex cases and final determinations. S. Paleti (2022) asserted that agentic AI also assisted banks in maintaining alignment with changing regulations. An agent can be tasked with monitoring regulatory websites and legal updates from multiple jurisdictions. Upon the announcement of a new rule, the agent analysed the text, interpreted the impact on the bank's operations, and suggested changes to internal policies and monitoring systems. M. Mucsková (2024) concluded that these AI applications were key to improving overall operational efficiency within banking institutions.

Core banking systems constituted the foundation of a bank's critical operations, including account management, deposits, lending, and payments. Many of these systems were legacy platforms developed in the 1980s and 1990s that were monolithic, inflexible, and difficult to integrate with modern digital technologies. R. Inala & B. Somu (2025) identified agentic AI as a key enabler of core infrastructure transformation toward a more agile, efficient, and intelligent banking architecture. A primary use case was back-office automation, where agentic AI orchestrated complex workflows across multiple legacy systems. For example, in payment processing, an agent can manage the entire lifecycle of a cross-border

payment – from initiating the transaction and performing compliance checks to choosing the most efficient payment rail (e.g., SWIFT, FedNow), handling foreign exchange conversions, and performing automated reconciliation. This reduced manual intervention, minimised settlement times, and lowered processing costs. Agentic AI also played a key role in managing the health and performance of the IT infrastructure itself. Autonomous agents can monitor system performance, predict potential failures or bottlenecks, and take pre-emptive corrective actions, such as routing traffic or allocating additional computing resources. This ensured high availability and resilience of critical banking services. Looking forward, L. Hughes *et al.* (2025) described agentic AI as central to the vision of an autonomous financial services paradigm. In the future state, the core banking system could be conceptualised as a network of specialised, interoperable AI agents. One agent might manage customer identities and permissions, another might manage loan origination, and a third might manage liquidity and treasury functions. These agents would communicate and collaborate seamlessly via Application Programming Interfaces (APIs) to deliver banking services. This agent-based, decentralised architecture would be far more flexible, scalable, and resilient than the monolithic core systems prevalent in 2024 and 2025, allowing banks to innovate and deploy new products and services rapidly, ultimately redefining the fabric of banking operations.

Emerging challenges, risks, and opportunities of agentic AI in financial and banking operations

Integration of agentic AI into financial and banking operations brought unprecedented efficiency and innovation but also a complex landscape of challenges, risks, and opportunities. The transition from automated to autonomous systems required a fundamental rethinking of regulatory frameworks, ethical standards, technical infrastructure, and strategic priorities. Navigating this will determine the long-term viability and societal benefit of agentic AI in the financial sector. The autonomous nature of agentic AI presented a significant problem for existing financial regulatory structures, which were based on human decision-making and clear lines of accountability. Regulators globally were struggling to adapt frameworks designed for predictable, rule-based systems to agentic AI that can learn, evolve, and act independently. One of the key issues was liability, when an autonomous agent causes financial loss, market instability, or non-compliant outcomes. The uncertainty around whether the developer, the deploying institution, or the end user was responsible complicated the legal and regulatory landscape and required new models of accountability for algorithmic behaviour. Furthermore, H. Pappil Kothandapani (2025) argued that the “black box” problem in many advanced AI models directly conflicted with regulatory requirements for transparency

and explainability. Financial institutions were required to justify decisions, especially in areas like credit scoring and loan underwriting, to prevent discriminatory practices. When an agentic system denied a loan based on complex, non-intuitive correlations learned from vast datasets, explaining the decision became impossible. This opacity hindered not only regulatory oversight and auditing but also internal risk management processes. Therefore, developing “explainable AI” (XAI) was not just a technical goal but a regulatory requirement. The pace of AI development was always ahead of the deliberative process of legislative and regulatory bodies, creating a persistent gap, where innovation operated in a state of legal uncertainty. S. Brohi *et al.* (2025) suggested that a proactive and adaptive regulatory approach was needed to enable responsible innovation, while protecting the financial system’s stability and fairness.

Beyond compliance, long-term adoption of agentic AI depended on building and maintaining trust with all stakeholders – customers, employees, investors, and regulators. Trust in this context was multi-faceted – reliability, security, fairness, and ethical integrity. A key ethical challenge was the risk of embedding and amplifying societal biases in historical training data. If an agentic underwriting system was trained on biased historical lending data, discriminatory outcomes against protected groups may be perpetuated or even exacerbated, undermining fairness and equal opportunity. Therefore, bias detection, mitigation strategies, and continuous algorithmic audits were critical components of a trustworthy AI governance framework. The principle of human oversight was another cornerstone of ethical AI. While the appeal of agentic AI was autonomy, ceding complete control was risky. The speed and scale, at which agents operated can lead to situations, where errors propagated through the system faster than human operators can intervene. E. Svetlova (2022) noted that creating systems that were not only technologically advanced and efficient but also aligned to human values and societal good was crucial for maintaining a long-term social licence to operate. Implementing agentic AI within existing financial institutions was full of technical challenges, the biggest one being integration with legacy IT infrastructure. Many banks and financial firms had core systems that were decades old and not designed for the data-heavy, real-time processing of modern AI. These systems were fragmented, making the creation of unified, high-quality data pipelines difficult. Developing and maintaining sophisticated agentic systems required specialised talent that was in high demand and short supply. Financial institutions were competing with tech giants for data scientists, machine learning engineers, and AI ethics specialists. Building in-house expertise was a long-term play, while relying on third party vendors brought its own set of risks around data security, model ownership and vendor lock-in. Data security and privacy were also big concerns. Agentic systems need access to

huge amounts of sensitive financial and personal data, making them an attractive target for cyber-attacks. Ensuring robust data governance, encryption, and access control was critical to prevent data breaches that can have financial and reputational damage. S. Joshi (2025) indicated that the move from conventional AI to agentic systems was a big jump in complexity, requiring new architectural frameworks and deeper understanding of emergent system behaviour to ensure stability and reliability in production. Despite the difficulties, agentic AI was going to change the financial industry. The trajectory was towards hyper-personalised, proactive, and deeply integrated financial services. O. Onabowale (2025) observed that agentic systems will go beyond executing simple tasks to be autonomous financial advisors for individuals and corporations, managing investments, cash flow, and providing strategic advice in real-time based on a full picture of a client’s financial situation and goals. This will democratise access to sophisticated financial management tools previously only available to high-net-worth individuals. In capital markets, the move from algorithmic to agentic trading will continue, with agents developing and executing new strategies, adapting to market conditions, and even collaborating or competing with other agents. The integration of autonomous agents will be the defining characteristic of the next generation of financial infrastructure.

Conclusions

The analysis determined that the shift from task-specific automation to goal-oriented autonomy differentiated agentic Artificial Intelligence from conventional Artificial Intelligence through proactive, adaptive, and independent decision-making. The use cases across financial and banking operations – from autonomous trading and dynamic risk management to personalised customer service and regulatory compliance – showed the potential of this technology. Agentic Artificial Intelligence will deliver not just incremental efficiency but fundamental changes to business models, value chains, and competitive landscapes. Regulatory frameworks were struggling to keep up with technology and creating uncertainty around accountability, transparency, and liability. The “black box” nature of complex models was a direct challenge to the principles of explainability and fairness, which were the foundation of trust in financial services. Integrating these systems with legacy infrastructure was a technical and financial barrier for many institutions. Most importantly the ethical dimensions of deploying autonomous systems – algorithmic bias, human oversight, building trustworthy Artificial Intelligence – demand careful and proactive governance. In the future, agentic Artificial Intelligence in finance will be an increasingly interconnected and intelligent ecosystem. The opportunities are huge – from hyper personalisation of financial services to more resilient and adaptive risk management and compliance functions. As financial institutions and FinTechs

develop and deploy more sophisticated agents, the industry will get closer to an era of autonomous financial services. Future research should focus on the technical mechanisms required to ensure interoperability between heterogeneous agentic systems across different financial institutions. Additionally, empirical studies are needed to quantify the systemic risks associated with high-frequency autonomous interactions in volatile markets.

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Conflict of Interest

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Агентний штучний інтелект у фінансово-банківських операціях: комплексний огляд

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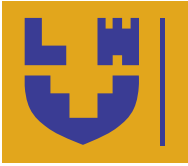
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Анотація. Метою дослідження був огляд академічної та галузевої літератури з метою уточнення концепції агентного штучного інтелекту, пояснення принципів його архітектурного функціонування та вивчення сфер застосування у фінансовому й банківському секторах. Зростаюче використання штучного інтелекту у сфері фінансових послуг сприяло переходу до етапу фінансової автоматизації, що ґрунтується не на правилах, а на системах, здатних міркувати, адаптуватися та діяти автономно й цілеспрямовано. Цей перехід призвів до появи того, що у сучасному світі називають агентним штучним інтелектом – категорією інтелектуальних систем, які функціонують незалежно, чого бракує традиційним застосуванням штучного інтелекту. Дослідження базувалося на методології систематичного огляду, яка узагальнила докази щодо використання агентного штучного інтелекту в автономній торгівлі, динамічній оцінці ризиків, алгоритмічному андеррайтингу, виявленні шахрайства, персоналізованій взаємодії з клієнтами та забезпеченні регуляторної відповідності. Як показав аналіз дослідження, такі системи підвищували операційну проактивність, ситуаційну обізнаність і здатність до багатокрокового ухвалення рішень, що дозволило фінансовим установам бути більш адаптивними до складних і швидкозмінних умов. Крім того, огляд засвідчив наявність постійних проблем, пов'язаних із пояснюваністю, відповідальністю, інтеграцією із застарілими інфраструктурами, етичним захистом і готовністю до регуляторних викликів. Результати засвідчили про те, що агентний штучний інтелект мав потенціал трансформувати операційну та стратегічну діяльність у фінансовому секторі, однак лише за умов відповідального управління та суворого нагляду його переваги могли бути реалізовані на практиці. Внеском цього огляду в наукову літературу стала інтегрована оцінка сучасних тенденцій на основі доказів, а також визначення ключових можливостей і обмежень, які формуватимуть майбутнє автономних інтелектуальних систем у сфері фінансових послуг

Ключові слова: штучні агенти; автономні фінанси; цифровий банкінг; фінансові інновації; фінансовий алгоритм



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Monetary policy transmission mechanisms and financial inclusion in West Africa countries

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Abstract. The purpose of the study was to examine the influence of monetary policy on financial inclusion in sixteen West African countries using panel data from the International Monetary Fund database covering 2010-2021. Financial inclusion was measured through a composite index generated via principal component analysis, incorporating indicators of financial institution penetration, availability, and usage. As a result, the following indicators were determined: money supply (MS, $\beta = 2.948901$, $p < 0.01$), open market operations (OMO, $\beta = 0.011170$, $p < 0.01$), liquidity ratio (LIQR, $\beta = 1.591667$, $p < 0.01$), reserve money (RM, $\beta = 0.800120$, $p = 0.012$), and monetary policy rate (MPR, $\beta = 0.040445$, $p < 0.01$). Cash reserve ratio (CRR, $\beta = -0.18154$, $p = 0.637$) and inflation (INF, $\beta = -0.001634$, $p = 0.914$) were not statistically significant. The model explained about 68% of the variation in financial inclusion ($R^2 = 0.6834$). The findings revealed that money supply significantly and positively influenced financial inclusion, showing that liquidity expansion increased banks' lending capacity and supported wider outreach. Open market operations also had a strong positive effect, as effective liquidity management fosters stability and encourages greater access to financial services. The bank liquidity ratio positively impacted inclusion by strengthening depositor confidence and enhancing banks' resilience. Reserve money and monetary policy contributed positively and significantly to enhancing financial inclusion. The cash reserve ratio, and inflation showed no significant impact, suggesting that their influence was indirect or constrained by structural financial limitations in the region. The study concluded that liquidity-enhancing monetary policies were critical for improving financial inclusion in West Africa. It was recommended expanding money supply, strengthening open market operations, enforcing robust bank liquidity ratios, and adopting cautious interest rate policies, supported by digital financial services and financial literacy initiatives

Keywords: cash reserve ratio; open market operations; liquidity ratio; money supply; reserve money

Introduction

Financial inclusion in West Africa had grown, motivated by the growth of mobile and digital banking services. The introduction and rapid adoption of mobile money platforms had enabled millions of individuals was left out of the structured financial system in order to obtain essential financial services such as payments, savings,

and credit. A. Khan *et al.* (2023) explained that development had positioned West Africa as a leading region in the global mobile money landscape, with the continent as a whole accounting for nearly half of mobile banking services worldwide. Nevertheless, according to World Bank Group (n.d.b) progress remained uneven. While

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countries such as Kenya and Ghana had recorded remarkable advances, others, including Niger and Guinea, still exhibit low account ownership rates of 14% and 23% respectively. Across the West African Economic and Monetary Union region, only 41% of adults own a mobile money account or a bank account, leaving an estimated 130 million adults without formal access to finance.

M.U. Arshad *et al.* (2021) pointed that the interaction between financial inclusion and monetary policy was increasingly recognised as central to bridging these gaps. Monetary policy had a significant impact on improving financial inclusion by influencing the cost, availability, and accessibility of financial services. R. Kumar (2022) mentioned that monetary policy instruments including the monetary policy rate, cash reserve ratio (CRR), liquidity ratio, and open market operations (OMO) directly influenced credit availability, lending behaviour, and access to financial services. For instance, D.W. Adams (2022) identified that high policy rates may incentivise bank expansion but simultaneously raised the cost of borrowing, discouraging low-income participation in formal credit markets. K. Iddrisu *et al.* (2025) noted that stringent liquidity and reserve requirements constrained banks' lending capacity, disproportionately affecting small businesses and rural households already at the margins of the financial system. Moreover, Y. Alhassan *et al.* (2025) argued that OMOs were frequently targeted at large commercial banks, while excluding microfinance institutions and fintech providers that were closest to financially excluded groups.

The effectiveness of monetary policy in promoting financial inclusion depended not only on its design but also on the strength of its transmission mechanisms, which remained weak across much of West Africa due to underdeveloped financial infrastructure. According to A.R. Olajide *et al.* (2022), rising policy rates, as evidenced by the collapse of several U.S. banks during the 2023 banking crisis, underscored the risks of poorly calibrated policies that undermined both financial stability and inclusion. R. Kumar & D.C. Pathak (2022) argued that, when policy rates were used as benchmarks for pricing, the banks raised the price of financial services, reduced credit demand, and narrowed the pool of beneficiaries. This dual effect reduced both the supply and demand for financial services, further excluding vulnerable groups. While central banks in West Africa focused on inflation control and price stability, the broader implications of monetary policy for inclusive finance required urgent attention. Aligning monetary policy with financial inclusion goals was crucial for equitable economic growth and poverty reduction. However, studies analysing the link between monetary policy mechanisms, particularly reserve money and policy rates, and financial inclusion in West Africa were scarce. E.J. Tonuchi *et al.* (2021) investigated the connection between monetary policy and financial inclusion in West Africa, but considered financial inclusion as an independent variable influencing

inflation, interest rate transmission, and financial development. The purpose of study was to analyse financial inclusion as a dependent variable, providing empirical insights for academics, policymakers, and regulators, offering practical guidance on structuring monetary policies to promote inclusive economic growth.

Literature Review

International Monetary Fund (n.d.) defined monetary policy as the method, by which a country's central bank or monetary authority regulated the money supply, frequently focusing on interest rates to maintain stability of prices and confidence in the currency. I.T. Aliu (2022) mentioned that monetary policy involved government measures to influence the monetary sector, with most authorities seeking to control money supply growth to curb inflation and support economic activity. While objectives differed across countries, it generally revolved around price stability and broader macroeconomic goals, with central banks like the Central Bank of Nigeria using money supply control as a key tool. According to V. Marhasova *et al.* (2020), monetary policy instruments varied across countries depending on the level of economic and financial sector development, but commonly included reserve requirements, open market activities, and changes in interest rates, central bank lending, direct credit controls, moral suasion, exchange rate policy, and prudential guidelines. M. Basheer *et al.* (2022) argued that reserve requirements oblige banks must retain a portion of their funds as cash or with the central bank, thereby influencing their lending capacity. According to A. Altunyan *et al.* (2020), open market operations involved the purchasing or selling of treasury bills and other securities to regulate bank reserves and money supply, while central bank lending, often through the monetary policy rate (MPR), affects credit availability, savings, and investment, thereby shaping economic growth. Other instruments included direct credit controls, which set loan ceilings, sectoral allocations, or interest rate caps to guide investment moral suasion, where regulators persuaded banks to align credit and savings policies with national objectives. Collectively, these instruments allowed central banks to influence credit, investment, and economic activity, finding a balance between growth and financial stability.

P.K. Ozili (2020) opined that many countries had made financial access a major policy priority. When well designed, such efforts can reduce poverty, stimulate entrepreneurship, and foster shared prosperity, but when poorly structured they may expose vulnerable groups to risks such as over-indebtedness, thereby worsening inequality. According to O. Adeola & O. Evans (2017), in Africa, particularly in Nigeria, expanding financial access was viewed as a pathway to economic diversification, poverty reduction, and improved living standards. Despite its recognised importance, financial inclusion continued to be limited by a variety of

institutional, structural, demand-related, and educational obstacles. K. Mutsonziwa & A. Fanta (2019) noted that weak financial infrastructure, limited branch networks, poor regulation, and low contract enforceability leave large groups excluded. P. Khera *et al.* (2022) mentioned that institutional factors such as unemployment, low income, absence of identification, restrictive credit-scoring systems, and stringent capital requirements further limit outreach, while financial firms often perceived small or remote markets as unprofitable. Measuring the extent of inclusion had therefore become central to policy debates. While early frameworks focused mainly on deposits, loans, and payments, later studies emphasised multidimensional indicators combining access, usage, and penetration approaches. By including mobile accounts, transactions, and agent outlets as a separate dimension, these approaches provided a more comprehensive picture of evolving financial landscapes and align more closely with current policy priorities.

Materials and Methods

The study examined data from 2010 to 2021, identifying three key shifts in the relationship between monetary policy and financial inclusion in West Africa. The first shift in 2014-2015 followed the oil price crash, leading to economic instability. In response, monetary authorities adjusted interest rates, reserve ratios, and liquidity policies, prompting banks to focus on digital and retail banking. The second shift in 2016-2017 was driven by regulatory reforms and Central Bank of West African States (n.d.) promotion of digital finance, which expanded mobile money and digital banking, enhancing the impact of liquidity tools on financial inclusion. The third shift in 2020 was triggered by the COVID-19 pandemic, which accelerated digital payments through accommodative policies. World Bank Group (n.d.a; n.d.b), and International Monetary Fund (n.d.) data of 16 West African countries (Benin, Burkina Faso, Cabo Verde, Côte d'Ivoire, Gambia, Mauritania, Ghana, Guinea, Niger, Togo, Guinea-Bissau, Liberia, Mali, Nigeria, Senegal, and Sierra Leone) were analysed using an ex post facto research design. The study adapted and modified the model of E.B. Anarfo *et al.* (2019). The model was stated as:

$$FINC_{it} = \beta_0 + \beta_1 CRR_{it} + \beta_2 M2_{it} + \beta_3 OMO_{it} + \beta_4 LQR_{it} + \mu_{it'} \quad (1)$$

where, FINC – financial inclusion, CRR – cash reserve ratio, M2 – broad money supply, OMO – open market operation, LQR – liquidity ratio, μ_{it} – random error term, apriori expectation, $\beta_1 < 0$, $\beta_2 > 0$, $\beta_3 > 0$, $\beta_4 > 0$ – estimation criteria.

Reserve money (RM), monetary policy rate (MPR) were added to strengthen the explanatory representation including inflation (INF) as a macroeconomic control. Here were the model's specifications:

$$FINC_{it} = \beta_0 + \beta_1 CRR_{it} + \beta_2 M2_{it} + \beta_3 OMO_{it} + \beta_4 LQR_{it} + \beta_5 RM_{it} + \beta_6 MPR_{it} + \beta_7 INF_{it} + \mu_{it'} \quad (2)$$

where, FINC – financial inclusion, CRR – cash reserve ratio, M2 – broad money supply, OMO – open market operation, LQR – liquidity ratio, μ_{it} – random error term, apriori expectation, RM – reserve money, MPR – monetary policy rate, INF – inflation, $\beta_1 < 0$, $\beta_2 > 0$, $\beta_3 > 0$, $\beta_4 > 0$, $\beta_5 > 0$, $\beta_6 < 0$, $\beta_7 < 0$ – estimation criteria.

This study adopted principal component analysis (PCA), which was also conducted to determine an index for financial inclusion. For regression analysis, R-squared, F-statistic, t-test were useful for model estimation. R_2 was a measure of the regression analysis's overall explanatory power. The model's overall significance was assessed using the F-statistic, and the t-test assessed the overall statistical significance of the model. The study applied statistical methods that were both descriptive and inferential. Descriptive statistics (mean, standard deviation, minimum, and maximum) summarised the data, while variance inflation factor (VIF) tested for multicollinearity and pairwise correlation assessed relationships between variables. A composite financial inclusion index was constructed using PCA, which consolidated multiple indicators such as access to banking, digital usage, and credit penetration into a single unbiased measure (Kherif & Latypova, 2020). For inferential analysis, the effects of monetary policy channels; cash reserve ratio, open market operations, liquidity ratio, money supply, reserve money, and monetary policy rate on financial inclusion were estimated using ordinary least squares (OLS), followed by fixed and random effects models to account for unobserved heterogeneity. The Hausman test guided model selection, before estimation, panel unit root properties were assessed using the Levin Lin Chu test, the Harris Tzavalis test, and the Fisher type of Phillips Perron test to ensure the stationarity of the variables. Pair wise correlation analysis was conducted to check for potential multicollinearity among explanatory variables. The Breusch-Pagan LM test was used to determine whether panel effects were present, thereby supporting the selection of appropriate panel models. The generalised method of moments (GMM) was applied, using lagged explanatory variables as instruments. GMM's capacity to handle dynamic relationships and simultaneity bias strengthened the reliability of the findings on monetary policy's influence on financial inclusion in West Africa. The limitation of this study arose from the context-dependent nature of the effectiveness of monetary policy tools, which made it challenging to generalise the findings across different periods or regions.

Results and Discussion

The analysed research data reported the mean, standard deviation, minimum, and maximum values of all variables, providing an overview of their central tendencies and dispersion. The FINC, derived from principal component analysis of penetration, availability, and usage indicators, recorded a mean of 0.3525 and a standard

deviation of 1.2013, signifying low average inclusion and considerable dispersion. The minimum value (0.000) confirmed that some countries still had extremely limited inclusion, while the maximum (16.6526) suggested that others performed relatively well during the study period. The CRR averaged 17.2924%, with a low standard deviation (0.5538), reflecting stable liquidity control, though the range from 7.4596% to 35.9750% showed

occasional strong interventions. MS averaged 15.6611%, with a higher variability (SD = 1.4681) and a wide range (2.6117-41.6622), indicating active liquidity management. OMO had a mean of 21.1597 and a large standard deviation (17.8084), revealing substantial fluctuations in the use of this policy tool. Table 1 showed the summary of dataset in the descriptive statistics that summarised the characteristics of the dataset used in this study.

Table 1. Summary statistics

| Variable | Observations | Mean | Standard deviation | Minimum | Maximum |
|----------|--------------|----------|--------------------|-----------|----------|
| FINC | 192 | 0.3525 | 1.2013 | 0.0000 | 16.6526 |
| CRR | 192 | 17.2924 | 0.5538 | 7.4596 | 35.9750 |
| MS | 192 | 15.6611 | 1.4681 | 2.6117 | 41.6622 |
| OMO | 192 | 21.1597 | 17.8084 | 9.4988 | 33.0476 |
| LIQR | 192 | 56.8223 | 3.4356 | 17.8074 | 78.3409 |
| RM | 192 | 9.6300 | 0.3466 | 1.2891 | 25.2688 |
| INF | 192 | 12.94439 | 13.08138 | -1.267686 | 65.7418 |
| MPR | 192 | 18.95445 | 8.99935 | 5.94846 | 41.73296 |

Note: FINC – financial inclusion, CRR – cash reserve ratio, MS – broad money supply, OMO – open market operation, LIQR – liquidity ratio, RM – reserve money, MPR – monetary policy rate, INF – inflation

Source: World Bank Group (n.d.a; n.d.b)

The liquidity ratio averaged 56.8223, with moderate variability (SD = 3.4356) but a broad range (17.8074-78.3409), reflecting shifts between relaxed and stringent liquidity requirements. Reserve money (RM) was relatively stable (mean = 9.6300; SD = 0.3466) despite an extensive range (1.2891-25.2688), suggesting occasional sharp adjustments. Inflation averaged 12.94439, with very high volatility (SD = 13.08138), ranging from -1.267686% (deflation) to 65.7418% (hyperinflation episodes). The monetary policy rate (MPR) averaged 18.95445%, with a high standard deviation (8.99935) and a range from 5.94846%

to 41.73296%, indicating shifts between accommodative and restrictive policy stances. Overall, these statistics depicted a region with persistently low financial inclusion, moderate stability in some policy variables (CRR, RM), but high variability in others (OMO, inflation, MPR), reflecting active and sometimes aggressive monetary management in response to diverse macroeconomic conditions. Multicollinearity among the variables was checked with both pair-wise correlation and variance inflation factor. The correlational matrix of each pair of independent variables was shown in Table 2.

Table 2. Pair-wise correlation

| Variable | FINC | CRR | MS | OMO | LIQR | RM | INF | MPR |
|----------|---------|--------|--------|--------|--------|--------|--------|--------|
| FINC | 1.0000 | | | | | | | |
| CRR | 0.0126 | 1.0000 | | | | | | |
| MS | 0.1219 | 0.3210 | 1.0000 | | | | | |
| OMO | 0.0921 | 0.1132 | 0.4391 | 1.0000 | | | | |
| LIQR | -0.1156 | 0.2781 | 0.3330 | 0.0019 | 1.0000 | | | |
| RM | 0.0596 | 0.0218 | 0.0112 | 0.0120 | 0.5611 | 1.0000 | | |
| INF | 0.4119 | 0.5329 | 0.2270 | 0.0115 | 0.0220 | 0.0591 | 1.0000 | |
| MPR | 0.0147 | 0.1101 | 0.4900 | 0.3219 | 0.3520 | 0.1791 | 0.2431 | 1.0000 |

Note: FINC – financial inclusion, CRR – cash reserve ratio, MS – broad money supply, OMO – open market operation, LIQR – liquidity ratio, RM – reserve money, MPR – monetary policy rate, INF – inflation

Source: World Bank Group (n.d.a; n.d.b)

D.N. Gujarati & D.C. Porter (2009) stated that, when the correlation coefficient was more than 0.8, the relationship between two independent variables became problematic. To put it another way, a multicollinearity problem arose when a pair of explanatory variables had a strong correlation of more than 80%. Regression analysis results that were tainted by multicollinearity

were typically untrustworthy. In this study, there would be no multicollinearity issues when using the variables in the regression model. The regression model was then created to ascertain the impact of the explanatory variables as the test result demonstrated the lack of multicollinearity. The VIF was used to further explore the likelihood of multicollinearity among the regressors (Table 3).

Table 3. Results of use of VIF

| Variable | VIF | 1/VIF |
|-----------------|-------------|----------|
| FINC | 1.27 | 0.787402 |
| CRR | 2.70 | 0.37037 |
| MS | 1.99 | 0.502513 |
| OMO | 2.25 | 0.444444 |
| LIQR | 1.79 | 0.558659 |
| RM | 2.30 | 0.434783 |
| INF | 1.99 | 0.502513 |
| MPR | 1.65 | 0.606061 |
| Mean VIF | 1.99 | |

Note: FINC – financial inclusion, CRR – cash reserve ratio, MS – broad money supply, OMO – open market operation, LQR – liquidity ratio, RM – reserve money, MPR – monetary policy rate, INF – inflation

Source: World Bank Group (n.d.a; n.d.b)

The VIF and its inverse, also known as tolerance, for each independent variable was shown in Table 3. Thus, a variable was extremely collinear if its VIF was more than 5, and vice versa. According to the data, every variable had a VIF of less than five. This implied that it was not

collinear. To establish stationarity for these variables, unit root test was conducted, as shown in Table 4, following three procedures, which included the Levin-Lin-Chu test, Harris-Tzavalis test, and Fisher-type of Philip-Perron test.

Table 4. Results of unit root tests

| Variable | Levin-Lin-Chu | | Harris-Tzavalis | | Fisher-type Phillip-Perron | | Stationarity Order of I |
|----------|---------------|---------|-----------------|---------|----------------------------|---------|-------------------------------|
| | Statistics | p-value | Statistics | p-value | Statistics | p-value | |
| FINC | 6.29 | 0.001 | -7.40 | 0.000 | 10.01 | 0.000 | At level |
| CRR | -8.43 | 0.000 | -5.12 | 0.000 | 3.04 | 0.041 | At level |
| MS | -3.11 | 0.038 | 5.39 | 0.000 | 3.62 | 0.010 | At 1 st difference |
| OMO | 9.33 | 0.000 | 8.13 | 0.000 | 7.44 | 0.000 | At 1 st difference |
| LIQR | 3.90 | 0.010 | 11.50 | 0.000 | 3.00 | 0.0431 | At level |
| RM | 5.51 | 0.000 | 7.32 | 0.000 | 8.71 | 0.000 | At level |
| INF | 11.92 | 0.000 | 14.55 | 0.000 | 3.09 | 0.0447 | At 1 st difference |
| MPR | 7.11 | 0.000 | 19.00 | 0.000 | 12.21 | 0.000 | At level |

Note: FINC – financial inclusion, CRR – cash reserve ratio, MS – broad money supply, OMO – open market operation, LQR – liquidity ratio, RM – reserve money, MPR – monetary policy rate, INF – inflation

Source: World Bank Group (n.d.a; n.d.b)

Since the null hypothesis in these tests assumed the presence of a unit root, significant test statistics showed that the variables were stationary meaning their mean and variance remained stable over time. The confirmation of stationarity implied that the data series do not exhibit random walks or persistent trends that could distort regression results. This stability strengthened the reliability of the estimated models, allowing meaningful interpretation of how monetary policy tools influenced financial inclusion. In the context of West Africa,

stationary monetary indicators such as money supply, liquidity ratio, and policy rate suggested that the region's monetary environment had achieved a degree of consistency, which was crucial for assessing policy effectiveness. Likewise, a stationary financial inclusion index indicated that changes in inclusion levels were driven by policy adjustments and structural reforms rather than random fluctuations. The results of the Breusch-Pagan LM test, which compared the simple Pooled OLS model with the random-effects estimator, were presented in Table 5.

Table 5. Results of Breusch-Pagan LM test

| Breusch-Pagan LM | Statistics | Degrees of Freedom | Probability value |
|------------------|------------|--------------------|-------------------|
| Values | 19.233 | 190 | 0.002 |

Source: World Bank Group (n.d.a; n.d.b)

The LM statistic produced a p-value of 0.002, which was below the 0.05 significance threshold. This led to the rejection of the null hypothesis that the variance across entities was zero, confirming the presence of significant individual effects among the West African countries.

In other words, the differences in financial inclusion and monetary policy outcomes across these countries were not merely due to random variation but were systematically influenced by country-specific characteristics by regulatory quality, financial infrastructure, and

economic structure. Consequently, the Pooled OLS model, which assumed homogeneity across cross-sections, was unsuitable for this dataset. This result justified the use of panel estimators that can account for such heterogeneity. Therefore, to identify the most appropriate

specification, the study proceeded with the Hausman test to distinguish whether the unobserved effects were correlated with the explanatory variables, thereby guiding the choice between fixed-effects and random-effects models (Table 6).

Table 6. Results of Hausman test

| Test summary | Chi-square statistic | Chi-square degrees of freedom | Probability value |
|----------------------|----------------------|-------------------------------|-------------------|
| Cross-section random | 146.425 | 191 | 0.0000 |

Source: World Bank Group (n.d.a; n.d.b)

Thus, the estimate of Hausman test (146.425) was high and significant, its calculated p-value (0.0000) was also lower than the significance level of 5%. Therefore, the null hypothesis that the discrepancies in the estimated parameters produced by the two estimation procedures were not systematic must be rejected. Put another way, the fixed effects model was more

suitable for the study since the null hypothesis was rejected because the p-value was less than 0.05. The fixed effects technique was consequently used for this investigation because it yields superior results for the model. Pooled OLS, fixed effect models, and random effect models were used to estimate the regression models in Table 7.

Table 7. Summary of model estimation

| Variable | Pooled OLS coefficient (p-value) | Fixed effect coefficient (p-value) | Random effect coefficient (p-value) | System GMM coefficient (p-value) |
|-------------------------|----------------------------------|------------------------------------|-------------------------------------|-----------------------------------|
| C | 5.124295 (0.000) *** | 7.43042 (0.000) *** | -6.848051 (0.3296) | - |
| CRR | -0.1336984 (0.554) | -0.18154 (0.637) | -0.114936 (0.686) | 0.158179 (0.071) |
| MS | 2.787544 (0.000) *** | 2.948901 (0.000) *** | 3.07944 (0.000) *** | 0.561400 (0.011) ** |
| OMO | -0.072400 (0.000) *** | 0.011170 (0.000) *** | 0.091771 (0.000) *** | 0.110112 (0.000) *** |
| LIQR | 0.661459 (0.138) | 1.591667 (0.008) *** | 1.064279 (0.037) ** | 0.179036 (0.001) *** |
| RM | 0.602888 (0.227) | 0.800120 (0.012) ** | -0.602402 (0.257) | -0.257014 (0.252) |
| INF | 0.000983 (0.870) | -0.001634 (0.914) | 0.000404 (0.961) | -0.009507 (0.639) |
| MPR | 0.033017 (0.000) *** | 0.040445 (0.000) *** | 0.038614 (0.000) *** | -0.404670 (0.039) ** |
| R ² | 0.6298 | 0.6834 | 0.6782 | - |
| Adjusted R ² | 0.6043 | 0.6464 | 0.63764 | - |
| F-statistic | 22.930 (0.000) | 22.5900 (0.000) | 9.490432 (0.000) | Wald $\chi^2(8) = 392.37 (0.000)$ |
| DW | 1.9031 | 2.4058 | 2.0370 | - |
| AR(1) | - | - | - | -0.31 (0.758) |
| AR(2) | - | - | - | -0.66 (0.508) |
| Sargan test | - | - | - | 1.76 (0.8290) |

Note: C – constant term, CRR – cash reserve ratio, M2 – broad money supply, OMO – open market operation, LIQR – liquidity ratio, RM – reserve money, MPR – monetary policy rate, INF – inflation, R² – coefficient of determination, DW – Durbin-Watson statistic, AR(1) – Arellano-Bond test for first-order serial correlation, AR(2) – Arellano-Bond test for second-order serial correlation

Source: World Bank Group (n.d.a; n.d.b)

This multi-model approach controlled for unobserved heterogeneity, serial correlation, and endogeneity. Results indicated that the CRR exhibited a negative and insignificant effect in static models but turned positive in the dynamic specification, suggesting potential stability gains for inclusion, though not statistically robust. MS consistently showed a strong and significant positive effect across all estimations, confirming its role in enhancing liquidity and credit access. OMO shifted from negative in OLS to positive and significant in FE (fixed effects), RE (random effects), and GMM, implying that, when heterogeneity was addressed, active OMO supported inclusion through liquidity management. The LIQR was significant and positive in FE, RE, and GMM, indicating that stronger bank capitalisation fostered

broader access. RM yielded mixed results, positive and significant in FE but negative or insignificant, elsewhere suggesting its effectiveness depended on the efficiency of credit transmission channels. INF remained insignificant in all models, while the MPR was positive and significant in static estimations but negative and significant in GMM, reflecting a trade-off between short-run savings attraction and long-run credit constraints. Model diagnostics reported R² values between 62.98% and 68.34% for static models, with significant F-statistics, while GMM diagnostics confirmed the absence of first- and second-order serial correlation (AR(1), p = 0.758; AR(2), p = 0.508) and instrument validity (Sargan test, p = 0.8290). Overall, MS, OMO, and LIQR emerged as consistent and effective policy tools for enhancing financial inclusion in West Africa.

The results indicated that OMO had a significant positive relationship with financial inclusion, suggesting that effective liquidity management through the buying and selling of government securities can deepen financial markets and expand access to financial services. In the West African context, where liquidity constraints persist, well-implemented OMO can encourage banks to extend credit, particularly to underserved populations. This finding aligned with D.O. Olayungbo & B.A. Iqbal (2021), though O.F. Ngaikedi *et al.* (2023) caution that without complementary institutional reforms, the impact of OMO may be limited. Similarly, the LIQR showed a significant positive effect, implying that higher bank liquidity supported confidence, deposit mobilisation, and credit extension. This supported C.K. Adjasi & C.A. Yartey (2007) but contrasted with A.R. Olajide *et al.* (2022), who found the effect to be statistically insignificant, underscoring the need for targeted inclusion programmes alongside liquidity improvements. RM exhibited a negative but statistically insignificant relationship with financial inclusion, indicating that expansion of the monetary base alone does not guarantee broader access to formal financial services unless paired with structural reforms, as emphasised by S. Ben Naceur *et al.* (2020). Consistent with this, studies such as by E.J. Tonuchi *et al.* (2021) and A.R. Olajide *et al.* (2022) found RM's influence weak or inconsistent. INF also showed an insignificant positive effect, suggesting that price changes, within the observed range, do not directly impact inclusion, though other studies document significant negative effects, particularly in contexts of higher inflation volatility. MPR showed a significant positive relationship with financial inclusion, potentially reflecting monetary tightening as a signal of macroeconomic stability, which can attract engagement with formal finance. Findings suggested that, while tools like OMO, LIQR, and MPR can foster inclusion, measures such as RM expansion and inflation control alone were insufficient. A holistic policy mix that integrated monetary tools with targeted financial inclusion strategies was therefore essential for sustainable gains in West Africa.

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Conclusions

The results of this study revealed that monetary policy variables significantly influenced the depth and outreach of financial inclusion within the West Africa. The fixed effects model was selected based on the Hausman test ($\chi^2 = 146.425$, $p < 0.01$), and the results showed that money supply ($\beta = 2.948901$, $p < 0.01$) had the strongest positive effect, indicating that liquidity expansion and increased credit availability were crucial for deepening formal financial participation. Open market operations ($\beta = 0.011170$, $p < 0.01$), liquidity ratio ($\beta = 1.591667$, $p < 0.01$), and reserve money ($\beta = 0.800120$, $p = 0.012$) also had significant positive impacts, highlighting the importance of effective liquidity management. In addition, monetary policy rate ($\beta = 0.040445$, $p < 0.01$) showed a small positive effect in the fixed effects model, suggesting that moderate interest rate adjustments may not constrain access to financial services in the short term. In contrast, cash reserve ratio ($\beta = -0.18154$, $p = 0.637$) and inflation (INF, $\beta = -0.001634$, $p = 0.914$) were not statistically significant, implying limited direct influence on financial inclusion outcomes. The study concluded that expansionary monetary instruments, particularly money supply growth, active open market operations, and sound liquidity management, were the most effective policy levers for improving financial inclusion in West Africa. Policymakers should adopt liquidity-supportive measures alongside moderate interest rate regimes, complemented by targeted interventions such as digital finance expansion, microfinance development, and financial literacy initiatives. Future research should disaggregate these effects at the country level to better understand the structural and institutional factors that shape inclusive finance in the region.

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Conflict of Interest

None.

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Механізми трансмісії монетарної політики та фінансова інклюзія в країнах Західної Африки

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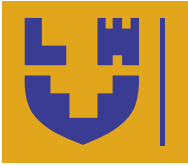
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Анотація. Метою дослідження було вивчити вплив монетарної політики на фінансову інклюзію у шістнадцяти країнах Західної Африки, використовуючи панельні дані з бази даних Міжнародного валютного фонду за період 2010-2021 років. Фінансова інклюзія вимірювалася за допомогою складного індексу, створеного методом головних компонентів, що включав показники проникнення фінансових установ, доступності та використання. У результаті були визначені такі показники: грошова маса (MS , $\beta = 2,948901$, $p < 0,01$), операції на відкритому ринку (OMO , $\beta = 0,011170$, $p < 0,01$), ліквідність банківського сектору ($LIQR$, $\beta = 1,591667$, $p < 0,01$), резервні гроші (RM , $\beta = 0,800120$, $p = 0,012$) та облікова ставка (MPR , $\beta = 0,040445$, $p < 0,01$). Коефіцієнт обов'язкових резервів (CRR , $\beta = -0,18154$, $p = 0,637$) та інфляція (INF , $\beta = -0,001634$, $p = 0,914$) не мали статистично значущого впливу. Модель пояснила близько 68 % змін у фінансовій інклюзії ($R^2 = 0,6834$). Результати показали, що грошова маса значно та позитивно впливала на фінансову інклюзію, що свідчить про те, що розширення ліквідності збільшувало кредитну спроможність банків і сприяло більш широкому охопленню. Операції на відкритому ринку також мали сильний позитивний ефект, оскільки ефективне управління ліквідністю сприяло стабільності та стимулювало доступ до фінансових послуг. Ліквідність банківського сектору позитивно впливала на інклюзію, зміцнюючи довіру до депозитарних установ і підвищуючи стійкість банків. Резервні гроші та монетарна політика також позитивно та значущо впливали на фінансову інклюзію. Коефіцієнт обов'язкових резервів і інфляція не мали значущого впливу, що вказувало на їх опосередкований вплив або обмеження через структурні фінансові проблеми в регіоні. Було зроблено висновок про те, що монетарні політики, що сприяли ліквідності, стали критично важливими для покращення фінансової інклюзії в Західній Африці. Було рекомендовано розширення грошової маси, зміцнення операцій на відкритому ринку, посилення банківських ліквідних показників та ухвалення обережної політики щодо облікових ставок, підтримуваної цифровими фінансовими послугами та ініціативами з підвищення фінансової грамотності

Ключові слова: коефіцієнт обов'язкових резервів; операції на відкритому ринку; ліквідність банківського сектору; грошова маса; резервні гроші



Methodology for assessing the impact of management decisions on the financial and economic security of an enterprise

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Abstract. Ensuring the financial and economic security of enterprises in the current conditions of globalisation, technological changes, and digitalisation has become important for maintaining their sustainability, efficiency, and competitiveness. The purpose of the study was to develop a methodology for assessing the impact of management decisions on the financial and economic security of an enterprise to increase its sustainability and efficiency. The paper offers a methodology that integrates strategic, financial, and budgetary, investment, digitalisation, organisational, personnel, and risk management solutions, along with control over costs and resources. The methodology combined components that provided a comprehensive assessment of the effectiveness of management's actions, allowed structuring information and forming an integral index of the impact of management decisions. This index correlated with the integrated financial and economic security indicator (FEBS), which reflected the level of stability, solvency, innovation, and adaptability of the enterprise. The application of the methodology on the example of LLC "Agroplus 2006" demonstrated that the implementation of a coordinated set of management solutions – from digitalisation and increasing management transparency to optimising the financial structure, improving operational indicators, and strengthening the risk management system – provided a substantial increase in FEBS, strengthened financial stability, and contributed to the long-term development of the enterprise. It was determined that digitalisation initiatives provided increased transparency in decision-making, investment measures strengthened resource potential, and management practices for cost optimisation and cost control contributed to reducing unproductive costs and increasing margins. As a result of the analysis, the FEBS indicator was 0.3894, which corresponded to the lower threshold, and after the implementation of management decisions, it increased to ≈ 0.5945 and moved to the medium level of security. The greatest impact on FEBS growth was provided by digitalisation (the Digital Index increased from 0.4 to 0.75) and enhanced operational efficiency, in particular, an increase in EBITDA margin (to 0.5667). The use of the methodology allowed identifying critical areas of management, assessing the sensitivity of FEBS indicators to external and internal risks, and predicting the consequences of alternative management strategies. The proposed approach contributed to the integration of modern management practices, digital technologies, and analytical methods into the decision-making process, providing a comprehensive assessment of financial and economic security and increasing the efficiency of enterprise management in difficult and dynamic market conditions

Keywords: analytical support; management; integrated security indicator; accounting information; financial statements

Introduction

The current state of the problem of assessing the impact of management decisions on financial and economic security of the enterprise is relevant in the world scientific and

practical literature, as globalisation, rapid technological changes, increased uncertainty of the external environment, and digitalisation put forward new requirements

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for management activities. Businesses are constantly facing complex internal and external threats, including financial, information, cyber, and strategic risks. Research proves that management decisions such as strategic planning, investment policy, cost structure, digitalisation, and riskmanagement directly affect the financiaeconomic security of the enterprise, forming its financial indicators, sustainability, and development potential. In the study by T. Simkova & Yu. Kopcha (2025), the implementation of management decisions with an emphasis on business diversification, innovation, and building an adaptive risk management system has become a strategic imperative for strengthening the financial and economic security of the enterprise. O. Dubynska (2022) noted that the methodology for assessing the impact of management decisions on the financial and economic security of an enterprise should be based on a systematic analysis of indicators of its financial condition since they reflect the effectiveness of risk management, adaptation to uncertainty and the ability of an enterprise to maintain stability and development in the long term.

H. Kang & H.J. Na (2024) emphasised that an effective methodology for assessing the impact of management decisions on the financial and economic security of an enterprise should be based on a systematic analysis of the company's strategic guidelines since the choice of management priorities – financial, client, internal process, or focused on training and growth – directly determines the profitability, stability, and development potential of the enterprise, thereby forming the level of its financial stability and economic security. O. Sereida (2024) noted that in the conditions of economic instability and increasing risks, the key factor in ensuring financial-economic security of the enterprise was the introduction of an effective financial controlling system, increasing the validity of management decisions and ensuring the stability of business entities to external and internal threats. A. Cherep *et al.* (2020) stressed that such a methodology should be based on an integral approach that combines expert assessment of key financial indicators, regression analysis, and data normalisation since it is this model that allows comprehensively determining the level of resilience of an enterprise to internal and external threats, identifying reserves for improving financial stability, and predicting the potential for its further development. As noted by O. Sova *et al.* (2021), financial and economic security has become a multidimensional category, encompassing both financial sustainability and adaptive risk management mechanisms that have enabled the enterprise to maintain a balance between profitability and risk in the long term. According to O. Tkachenko *et al.* (2024), the financial-economic security of an enterprise was the result of the integration of financial, organisational, and managerial processes that determined its ability to resist threats and maintain operational efficiency. It was formed under the influence of purposeful management decisions that provided a

balance between financial results, resource base, and strategic development guidelines.

The study aimed to develop a methodology for assessing the impact of management decisions on financiaeconomic security of the enterprise, which would integrate modern challenges, internal and external risk factors, and features of management processes. The following tasks were set to achieve this goal: 1) analyse theoretical approaches to the categories “management decision” and “financiaeconomic security of the enterprise”; 2) develop a model for assessing the impact of management decisions on the economic security of the enterprise through integrated indicators, apply the methodology in practice of a specific enterprise; 3) formulate recommendations for management practice on integrating the impact assessment of management decisions into the financiaeconomic security of the enterprise. The scientific novelty of the work consists in substantiating the proposed methodological model, which will allow linking specific management decisions with the level of financiaeconomic security of the enterprise.

Materials and Methods

The study aimed to develop a methodology for assessing the impact of management decisions on the financial and economic security of the enterprise. The material base was financial and economic indicators (stability, liquidity, profitability, business activity, innovation) of the Enterprise LLC “Agro Plus 2006” (n.d.), data on management practices, digitalisation, risk management, and investment processes. The study was conducted in several stages. The first stage included the classification of management decisions: strategic, financial, and budgetary, investment, digitalisation, organisational and managerial, risk management, and cost and pricing decisions. The calculation of the Integrated Security Score (FEBS – Financial and Economic Security Score) had the form of a function:

$$FEBS = f(U, F, R, E), \quad (1)$$

where U – quality of management decisions (strategic, financial, innovative, digital); F – financial parameters (liquidity, profitability, autonomy); R – level of risks (external and internal); E – efficiency of adaptation processes (flexibility of management, human resources, innovation).

For each type of management decision, indicators were determined that reflected its impact on financial and economic security, in particular, profitability, liquidity, digital transparency, and the risk tolerance index. For each indicator, linear normalisation was applied using the formula:

$$Z_{ij} = \frac{X_{ij} - X_j^{\min}}{X_j^{\max} - X_j^{\min}}, \quad (2)$$

where Z_{ij} – normalised indicator value j for the company i ; X_{ij} – actual value; – minimum and maximum limit values.

For indicators of the “minimising type”, the formula was used:

$$Z_{ij} = \frac{x_j^{\max} - x_{ij}}{x_j^{\max} - x_j^{\min}} \quad (3)$$

For each block of management decisions, the following formula was used:

$$I_k = \sum_{j=1}^m a_{kj} Z_{kj} \quad (4)$$

where I_k – partial block management index k ; a_{kj} – weighting coefficients of indicators j within the block k ; Z_{kj} – normalised values of indicators.

The second stage involved the rationing and integration of indicators using methods of linear and nonlinear transformation, weighting coefficients and expert evaluation, which allowed calculating partial indices and an integral index of the impact of management decisions (I_U). During the third stage, the correlation of the integral index of the impact of management decisions was conducted (I_U):

$$I_U = w_s I_s + w_f I_f + w_i I_i + w_c I_c + w_o I_o + w_r I_r + w_y I_y \quad (5)$$

where w_x – weight coefficients of significance of the corresponding areas of management.

Thus, in the course of the study, a logical transition was used from formalised procedures for calculating indices to their analytical interpretation of the research results. It was planned to compare the integral index of the impact of management decisions with the indicator of financial and economic security using correlation and regression analysis, and assessment of the model's sensitivity to changes in weight coefficients and key parameters. This helped establish a functional link between

the quality of management decisions in the strategic, financial-budgetary, investment, digital, organisational, risk and cost spheres, and the level of economic security of the enterprise. The methodology provided a comprehensive quantitative-qualitative assessment of management practices, accounting for external challenges and internal limitations, and formed the basis for a structural and logical model for analysing management effectiveness. The calculated indicators served as a basis for identifying critical risk zones and justifying recommendations for strengthening the financial and economic security of an enterprise in an unstable environment.

Results and Discussion

In the process of evaluating the impact of management decisions on the financial and economic security of an enterprise, it has become important to systematise and classify the main types of decisions that determine the stability and sustainability of the business entity's activities. It is advisable to distinguish categories of decisions based on their functional and strategic characteristics to ensure a comprehensive approach to assessing the impact of management actions, considering which aspects of financial and economic security they directly affect. This approach allows both assessing the effectiveness of management decisions in a structured way and identifying priority areas for improving financial stability, minimising risks, and increasing the company's adaptability to changes in the external environment. Table 1 shows the key types of management decisions that strongly affect the level of financial and economic security of the enterprise, indicating the content of their impact and expected implementation results.

Table 1. Main types of management decisions that affect the level of financial-economic security of the enterprise

| Type of management decision | Content and features of the impact on financial and economic security | Expected implementation result |
|--|--|--|
| Strategic decisions | Determine the directions of enterprise development, form a security policy, risk management strategy, financial strategy, and diversification policy | Improving long-term sustainability, minimising strategic risks |
| Financial and budgetary solutions | They are aimed at optimising the cost structure, managing liquidity, forming reserves and financial flows | Ensuring solvency, reducing financial threats, and improving resource efficiency |
| Investment solutions | Related to the choice of investment directions, the evaluation of the effectiveness of investment projects, and asset management | Strengthening the resource potential, increasing the cost of the enterprise, increasing investment attractiveness |
| Digitalisation solutions | They provide for the introduction of IT systems, big data analytics, financial controlling, and cyber defence systems | Improving the transparency of management, efficiency of decisions, and protection of information flows |
| Organisational and managerial decisions | Aimed at improving the management structure, personnel policy, motivation and control system | Improving the efficiency of management processes, consistency of actions of divisions, and reducing internal risks |
| Risk management solutions | They include the development of policies for identifying, assessing, and minimising various types of risks (financial, industrial, and market) | Formation of an adaptive threat response system, maintaining the stability of financial indicators |
| Decisions regarding costs and production costs | Related to cost control, resource utilisation optimisation, and critical break-even points | Increase margins, reduce unproductive costs, and strengthen financial balance |

Source: based on V. Baidala & A. Yakymovska (2023), N. Petrukha et al. (2025)

The relationship between the nature of management actions and their impact on strategic stability, financial stability, resource availability, and adaptability of the enterprise to changes in the external environment is key to evaluating the effectiveness of management. The categories of decisions-strategic, financial and budgetary, investment, digitalisation, organisational, and managerial, risk management and cost and cost decisions-cover the main areas of management activity that determine the ability of an enterprise to maintain financial and economic security. Specific management practices are transformed into practical results that increase long-term sustainability, optimise resource usage, minimise risks, and ensure balanced enterprise development. This analytical approach creates the basis for developing a methodology for quantifying the impact of management decisions on financial and economic security and allows systematising management information for making informed decisions in practice. In today's environment, the effectiveness of business entities is determined not only by traditional measures of profitability or return on investment but also by an organisation's ability to adapt quickly to change, minimise the impact of adverse factors, and make sound management decisions in the face of uncertainty. It is important to form a systematic approach to assessing the impact of management decisions on financial and economic security, which would allow integrating the results of strategic planning, financial management, risk management, and digital transformations of the enterprise. A special role in this process is played by accounting information and financial statements prepared in accordance with International financial reporting standards, which provides a reliable basis for making managerial decisions and supports the transparency of the company's financial activities.

From the standpoint of understanding the nature of managerial actions, I. Demko (2025) noted that management decisions played a central role in the overall management system of the enterprise, directly shaping its ability to respond to modern challenges in a timely and effective manner. This confirmed the view that a

high-quality decision-making process has become a fundamental tool for ensuring the viability and economic stability of a business entity. Considering digitalisation solutions as a modern security element, M.I. Ononiwu *et al.* (2024) underlined that digital business transformation has become critical to significantly increasing organisational flexibility. Due to the introduction of digital innovations, enterprises were able to adapt much faster to the unstable market environment, which made them a determining factor in strengthening financial and economic security. T. Bondaruk *et al.* (2022) and H. Jiao *et al.* (2025) noted that it is management decisions that determine the level of stability, solvency, and investment attractiveness of an enterprise, in addition to its ability to develop for a long time and counteract crisis phenomena. Assessing the impact of such decisions requires a comprehensive approach that accounts for external challenges, internal risks, and features of management processes, and also allows forming integrated indicators of financial-economic security for comparative analysis and monitoring of the effectiveness of management actions. In this aspect, the development of a model for assessing the impact of management decisions is an important tool not only for scientific analysis but also for the practical activities of managers since it allows determining the most effective areas of strategic and tactical management, assessing the consequences of implemented decisions, and predicting threats and opportunities to improve the stability and development of the enterprise. This approach creates prerequisites for integrating modern digitalisation challenges, global economic transformations, and environmental risks into the decision-making system, while providing a comprehensive assessment of the effectiveness of management actions and their impact on the level of financial and economic security, which is the basis for building competitive business models in modern conditions. It is worth considering a structural and logical model for assessing the effectiveness of management actions and their impact on the level of financial and economic security (Table 2).

Table 2. Structural and logical model for evaluating the effectiveness of management actions

| Block | Content | Key indicators/parameters | Evaluation methods |
|---|--|--|--|
| Input block: external calls | Geopolitical situation, military risks, inflation, energy fluctuations, legislative changes, market digitalisation | Business Climate Index, Inflation Expectations Index, Digital Readiness Index | Scenario analysis, SWOT assessment of the external environment |
| Management decisions (core of the model) | Determine the strategic course and resources of the enterprise | Decisions on: 1) development strategy, 2) budgeting, 3) risk management, 4) digitalisation, 5) investment, 6) personnel policy | Expert evaluation, analytical hierarchy method, content analysis of management documents |
| Internal factors of financial and economic security | Indicators of sustainability, liquidity, profitability, business activity, innovation | Financial stability ratio, ROI, EBITDA margin, autonomy ratio, digital maturity index | Data normalisation, integral evaluation |
| Integrated security indicator (FEBS) | Combines the results of management, financial, and risk indicators | $FEBS = \sum(W_i \times X_i)$, where W_i - weight, X_i - normalised indicator | Weighted average method, regression analysis |

Table 2, Continued

| Block | Content | Key indicators/parameters | Evaluation methods |
|---------------------------------|---|---|---|
| Output block: impact assessment | Determination of the level of financial and economic security and the effectiveness of management decisions | Threshold levels: low (<0.4), medium (0.4-0.7), high (>0.7) | Dynamic comparison, benchmarking, time monitoring |

Note: ROI – Return on Investment; EVITDA margin – profitability of operating activities in the company's revenue (operating marginality)

Source: based on I. Litvin et al. (2022), A. Zhurakovska et al. (2024), M.N. Ngoc et al. (2025), OECD (2025)

The methodology for assessing the impact of managerial decisions on the financial and economic security of the enterprise is based on the integration of a structural and logical approach, a system of indicators of management performance and modern methods of quantitative analysis, which allows comprehensively reflecting the relationship between the quality of managerial actions and the level of economic security of the enterprise. Its conceptual basis is the assumption that management decisions made in key areas of activity – strategic, financial and budgetary, investment, digitalisation, organisational and personnel, risk management, and expenditure – form multidirectional effects that together determine the ability of an enterprise to resist external and internal threats, maintain stability, and ensure development. For example, as a result of data analysis by LLC “Agro Plus 2006” (n.d.), the basic integral indicator of FEBS was 0.3894, and after the implementation of management decisions, it increased to 0.595. The applied methodology provided for several consecutive stages – at the first stage, management decisions were identified and structured by type in accordance with the content of management activities. For each type, a set of quantitative and qualitative indicators was determined that reflected the effectiveness of implemented management practices. This approach enabled correctly assessing both direct financial results (profitability, liquidity, turnover, cost of capital) and indirect ones – organisational coherence, digital maturity, risk tolerance, and innovation.

The second stage consisted of normalising indicators using linear and nonlinear transformation methods, which allowed them to be brought to a single scale and eliminated the influence of different units of measurement. Normalised values were integrated into group indices using weighting coefficients determined by the expert evaluation method or analytical hierarchy. Thus, partial indices of the effectiveness of management decisions in each area of management were formed: strategic (I_s), financial (I_f), investment (I_i), digital (I_d), organisational (I_o), risk (I_r), loss (I_v). In the third stage, an integral index of the impact of management decisions was introduced (and_{ij}), which reflected the generalised performance of management. It was formed as an aggregated value of group indices using a weighted multivariate model. The fourth stage provided for the correlation of the integral index of management decisions

with the index of financial and economic security (I_{FEBS}). For the latter, a system of indicators was used, covering the assessment of financial stability, solvency, business activity, profitability, investment attractiveness, risk tolerance, and adaptability of the enterprise. The final FEBS index was defined as an integrated assessment of normalised indicators, accounting for their impact on the economic security of the enterprise. The fifth stage of the methodology involved establishing a functional relationship between the quality of management decisions and the level of financial and economic security using regression modelling. This helped not only to quantify the extent of each management unit's impact but also to identify the most critical areas of management that required improvement. If the model is applied in dynamics, it is possible to predict changes in financial and economic security depending on alternative management scenarios. During the final stage, the results were interpreted, and recommendations were developed for optimising management decisions in order to strengthen the financial and economic security of the enterprise. A special feature of the methodology was its adaptability to various sectors of the economy and the ability to integrate specific indicators inherent in a particular production environment. This has made it a universal decision-making tool for businesses operating in the face of growing volatility, market volatility, and growing resource constraints.

Practical use of the developed structural-logical model for assessing the impact of management decisions on financial and economic security has become especially important for agricultural enterprises of Ukraine, which operate in conditions of major market fluctuations, military threats, logistical restrictions, instability of state policy, and high resource intensity of production. The agricultural sector is closely dependent on natural and climatic factors, seasonality, the level of technological support, availability of credit resources, and the global environment, which increases the impact of management decisions on its financial stability and economic prospects. The agricultural enterprise LLC “Agro Plus 2006” (n.d.) was selected for the study. The financial-economic condition of the enterprise as of February 2026 was characterised by a successful transition from a critical risk zone to a stable medium level of security. The qualitative transformation of the company's financial condition was confirmed by the positive

dynamics of fundamental indicators: absolute liquidity increased from 0.08 to 0.14, minimising the risks of sudden insolvency; the autonomy coefficient increased from 0.33 to 0.42, which indicated the strengthening of financial sovereignty and an increase in the share of equity; business activity accelerated from 0.75 to 0.92 revolutions per year, reflecting a higher efficiency of resource use.

The synergy of external risks caused by military instability and logistical gaps, combined with high debt dependence, has put destructive pressure on the financial stability of LLC "Agro Plus 2006" (n.d.), which led to a critical decline in the security index to 0.3894 and made the company vulnerable to market changes. Improving the financial security of this agricultural enterprise was achieved through the introduction of Integrated resource monitoring systems, which helped overcome information silos and minimise internal risks. In addition, measures were taken to restructure the company's debt and strictly optimise operating expenses. This successfully contributed to the growth of business profitability

and ensured its independence from the volatility of the foreign market. In addition, these steps were reinforced by the introduction of proactive risk management, which transformed the enterprise security system from a simple hazard response to a dynamic framework for strategic forecasting. Considering this, the model allowed determining the current level of security and assessing how much the quality of decisions in the strategic, financial, investment, digital, organisational spheres and in risk management contributes to strengthening or weakening the economic stability of the enterprise. The methodology provides an opportunity for a comprehensive quantitative assessment of how management actions affect the economic security of the enterprise, allows structuring data, justifying management decisions, and forming a strategically oriented policy of financial and economic development (Table 3). Its application creates the basis for building personalised models for monitoring FEBS, comparative analysis of enterprises, and forming recommendations for improving management efficiency in the face of modern challenges.

Table 3. Structured initial data and calculations of the model for assessing the impact of management decisions on the financial and economic security of LLC "Agroplus 2006"

| Indicator | Normalisation range | Base value | Normalised (basic) | Weight | Contribution (basic) | Value after measures | Normalised (after) | Contribution (after) |
|-----------------|---------------------|------------|--------------------|--------|----------------------|----------------------|--------------------|----------------------|
| Current Ratio | 0.5-2.5 | 1.2 | 0.35 | 0.2 | 0.07 | 1.6 | 0.55 | 0.11 |
| ROA (%) | -2-12 | 3 | 0.3571 | 0.2 | 0.0714 | 5 | 0.5 | 0.1 |
| EBITDA (%) | -5-25 | 8 | 0.4333 | 0.18 | 0.078 | 12 | 0.5667 | 0.102 |
| D/E (inverted) | 0-3 (inversion) | 2 | 0.3333 | 0.15 | 0.05 | 1.4 | 0.5333 | 0.08 |
| Digital (0-1) | 0-1 | 0.4 | 0.4 | 0.15 | 0.06 | 0.75 | 0.75 | 0.1125 |
| Risk (0-1) | 0-1 | 0.5 | 0.5 | 0.12 | 0.06 | 0.75 | 0.75 | 0.09 |
| Integrated FEBS | | | | | 0.3894 | | | 0.5945 |

Note: Current Ratio (CR) – liquidity; ROA – return on assets; EBITDA – operating profitability; D/E (inverted) – financial leverage; Digital – digitalisation level; Risk – risk level; Integral FEBS – indicator of financial and economic risks

Source: LLC "Agro Plus 2006" (n.d.)

The integral indicator of FEBS in the base state is approximately 0.3894, which places the enterprise within the lower threshold (just below the "average" interval), while after the implementation of a set of management solutions, FEBS increases to ≈0.5945 and belongs to the "average" level of security. The absolute increase in FEBS is +0.2051 (≈0.206), which in relative units gives an improvement of ≈ 53% from the initial level (0.206/0.389 ≈ 0.529). The greatest contribution to the increase in FEBS was made by digitalisation initiatives (growth of the Digital Index from 0.4 to 0.75) and improving the efficiency of operating indicators (growth of EBITDA margin). The D/E reduction also significantly improved financial stability, as it reduced the financial burden. These data showed that a coordinated package of management decisions – a combination of investment changes, digitalisation, budget discipline, and

strengthening risk management – can lead to an increase in the integral level of financial and economic security of an agricultural enterprise. Managers should focus on measures that simultaneously increase operational efficiency (EBITDA), liquidity and digital transparency, and reduce external dependence through debt burden management and risk diversification. The integrated approach has become the most comprehensive, as it allows assessing the financial and economic security of an enterprise through a combination of strategic, organisational, resource, and risk management aspects. This approach creates the basis for a systematic analysis of the impact of management decisions on the stability of the enterprise's functioning and its ability to counteract external and internal threats. For effective practical implementation, it has become essential to use reliable accounting data and to prepare financial statements

in accordance with International Financial Reporting Standards (IFRS..., 2013). This allowed automating data collection and normalisation, regularly reviewing the weights of indicators in accordance with the changed enterprise strategy, and conducting scenario analysis to assess the sensitivity of FEBS to remote shocks, ensuring transparency and validity of management decisions.

The categories "management decision" and "financial-economic security of the enterprise" occupy a central place in the modern theory of management since the sustainability of the enterprise in a dynamic environment is implemented through the process of making managerial decisions strategic and operational. In the theoretical aspect of the concept of "management decision" it is interpreted as a conscious choice by the head or management body of a certain alternative to actions aimed at achieving certain goals of the enterprise in the conditions of existing resource, time, and information restrictions. According to F. de Andreis (2020) and M. Kobiyh & A. El Amri (2024), the classical approach considered management decision as a rational process of choosing the optimal action among possible options based on information analysis and predicting consequences. In the modern scientific tradition, according to A.-M. Kanzola *et al.* (2024), management decision is interpreted more broadly – as a complex process that combines analytical, cognitive, and intuitive components, reflecting both formalised assessment methods and behavioural factors that determine management performance in real-world conditions of risk and uncertainty. From the point of view of modern management science, decision-making is an integral part of strategic and operational management. G. Deep (2023) states that it is the type of management decision that determines the nature of the impact on the economic stability of the enterprise: strategic decisions form a long-term development trajectory, and tactical – adaptation to changes in the current environment. In addition, management decisions are systemic in nature, as their effect extends to the financial, production, marketing, personnel and innovation subsystems of the enterprise. In parallel with this, the category "financial-economic security of the enterprise" is defined as the state of protection of its financial and economic activities from the destructive influences of internal and external factors, which ensures the stability of functioning, solvency and development potential.

Researchers M.S. Emblemståg & J. Emblemståg (2025) interpreted enterprise security from the standpoint of a systematic approach, as a result of the interaction of subsystems – strategic, financial, information, production; attention was focused on the complexity of risk management. The authors also emphasised the role of digital technologies, big data analytics, and financial controlling in building an effective security system that can quickly respond to changes in the external environment. K. Pavlov *et al.* (2022) and A. Kores (2024) viewed financial and economic security

as a set of managerial functions (planning, monitoring, control) aimed at preventing crisis phenomena and maintaining the stability of the financial system of an enterprise. Ye. Chaikovskiy (2024) stressed the influence of external regulatory, legal, and socio-economic factors on the formation of the financial security policy of an enterprise through the prism of an institutional approach. An integral approach to determining the financial and economic security of an enterprise, according to Z. Shylo (2022) and S. Onyshchenko *et al.* (2023), provided for a comprehensive security assessment based on a combination of quantitative and qualitative indicators reflecting the effectiveness of management decisions. The presented theoretical approaches have demonstrated that the modern concept of financial and economic security of an enterprise has been transformed from a passive model of resource protection into a dynamic adaptive management system. A synthesis of resource-based, functional and systems perspectives has shown that security is not merely a static set of financial indicators, but rather the ability of management to make informed decisions in conditions of high uncertainty. In this context, innovative digital and integrated approaches have gained particular weight, which emphasised that the effectiveness of the security system directly depends on the quality of information support and the depth of analytical support for management processes. This created a solid theoretical foundation for rethinking the role of the manager as the main architect of the organisation's security space. Therefore, the methodology for assessing the impact of management decisions should go beyond purely mathematical calculations, integrating institutional factors and the flexibility of digital tools. Accounting for the complexity of interaction between internal subsystems allows considering each management decision as a strategic impulse that either strengthens the viability of the enterprise or creates hidden vulnerability zones. Therefore, financial-economic security has become an integral attribute of managerial professionalism, and its provision requires holistic tools that can harmonise quantitative results of activities with qualitative parameters of sustainable development.

Conclusions

The study showed that in the context of increasing economic turbulence, digitalisation and increasing risks, management decisions play a key role in ensuring the financial and economic security of the enterprise. Their impact was manifested through financial results, the formation of strategic sustainability, the efficiency of resource provision, and the ability of the enterprise to adapt to a dynamic external environment. The proposed structural and logical model for assessing the impact of management decisions integrated financial parameters, risks, quality of management actions, and adaptability of the management system. Its application allowed

quantifying the relationship between management actions and the level of financial and economic security.

The use of the model on the example of data analysis of LLC "Agroplus 2006" showed its effectiveness: the basic level of FEBS was 0.3894, and after the introduction of digital, budget, risk management and cost solutions, the integral indicator increased to 0.5945, which indicated a substantial strengthening of the economic stability of the enterprise. This 53% improvement proved that the company's security was not the result of market conditions, but rather a direct consequence of conscious and coordinated management steps. The key drivers of this process were the digital modernisation of business processes and the focus on the operational health of the business entity, which was reflected in the growth of EBITDA margin to 12%. Due to a balanced decision to reduce debt dependence (the D/E ratio decreased from 2 to 1.4), management not only succeeded in protecting the company from external risks but also in strengthening its internal capacity for future growth. The results confirmed the thesis that business

sustainability is formed by integrating digital innovation, budget discipline, and adaptive risk management within a single strategic model. The versatility of the model and the possibility of its adaptation to different industries were also confirmed. Combined with analytical tools, the model has laid the groundwork for enhancing the transparency, adaptability and efficiency of management processes. Prospects for further research lie in analysing the development of sector-specific models of financial and economic security, as the structure of risks and resource constraints varies significantly depending on the type of economic activity.

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Conflict of Interest

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Методика оцінювання впливу управлінських рішень на фінансово-економічну безпеку підприємствах

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Аспірант

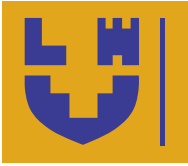
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Анотація. Забезпечення фінансово-економічної безпеки підприємств у сучасних умовах глобалізації, технологічних змін та цифровізації стало важливим для підтримки їхньої стійкості, ефективності та конкурентоспроможності. Мета дослідження полягала у розробці методики оцінювання впливу управлінських рішень на фінансово-економічну безпеку підприємства для підвищення його стійкості та ефективності. У статті запропоновано методику, яка інтегрувала стратегічні, фінансово-бюджетні, інвестиційні, цифровізаційні, організаційно-кадрові та ризик-менеджментові рішення, а також контроль за витратами та ресурсами. Методика поєднувала компоненти, що забезпечували комплексну оцінку ефективності дій керівництва, дозволяли структурувати інформацію та формувати інтегральний індекс впливу управлінських рішень. Цей індекс корелював з інтегрованим показником фінансово-економічної безпеки (FEBS), що відображав рівень стабільності, платоспроможності, інноваційності та адаптивності підприємства. Застосування методики на прикладі ТОВ «АгроПлюс 2006» продемонструвало, що впровадження скоординованого комплексу управлінських рішень – від цифровізації та підвищення прозорості управління до оптимізації фінансової структури, поліпшення операційних показників і зміцнення системи ризик-менеджменту – забезпечило значне підвищення FEBS, зміцнило фінансову стійкість та сприяло довгостроковому розвитку підприємства. Було визначено, що цифровізаційні ініціативи забезпечили підвищення прозорості прийняття рішень, інвестиційні заходи зміцнили ресурсний потенціал, а управлінські практики щодо оптимізації витрат і контролю за собівартістю сприяли зниженню непродуктивних витрат і підвищенню маржинальності. У результаті аналізу показник FEBS становив 0,3894, що відповідало нижньому порогу, а після впровадження управлінських рішень він зріс до $\approx 0,5945$ і перейшов до середнього рівня безпеки. Найбільший вплив на зростання FEBS забезпечили цифровізація (індекс Digital зріс з 0,4 до 0,75) та підвищення операційної ефективності, зокрема зростання EBITDA-маржі (до 0,5667). Застосування методики дозволило ідентифікувати критичні сфери управління, оцінити чутливість показників FEBS до зовнішніх і внутрішніх ризиків, а також прогнозувати наслідки альтернативних управлінських стратегій. Запропонований підхід сприяв інтеграції сучасних управлінських практик, цифрових технологій та аналітичних методів у процес прийняття рішень, забезпечуючи комплексну оцінку фінансово-економічної безпеки та підвищуючи ефективність управління підприємством у складних і динамічних умовах ринку

Ключові слова: аналітичне забезпечення; менеджмент; інтегрований показник безпеки; облікова інформація; фінансова звітність



Adoption and optimisation of investment decisions in enterprise management

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Abstract. This article aimed to substantiate approaches to the adoption and optimisation of investment decisions as a part of an enterprise management system. The methodology employed the methods of theoretical generalisation, as well as financial-statistical and comparative analyses using official financial reports and open data of companies for 2022-2025. The results of the study revealed that the investment activity of Metinvest in 2022-2025 developed in the context of decreased production potential and wartime risks. This caused a decrease in capital expenditures from USD 354 million in 2022 to USD 235 million in 2024, as well as a phased implementation of investment projects from a strategic perspective. The net debt-to-earnings before interest, taxes, depreciation and amortisation ratio increased from 0.9 in 2022 to 1.9 in the first half of 2025, which limited the investment activity. By contrast, the investment strategy of EPAM in 2022-2025 prioritised the development of intangible assets, technological platforms and human capital. This approach was accompanied by the stabilisation of revenue at USD 4.73 billion in 2024, an increase in headcount to 62.35 thousand employees in 2025, and an improvement in earnings per share under generally accepted accounting principles from USD 7.06 in 2023 to USD 7.84 in 2024. The results obtained indicated that the effectiveness of investment decisions was determined by industry-specific characteristics, asset structure, and the nature of financial and external risks, while the optimisation of investment required the alignment of financial constraints with the strategic development objectives of enterprises. The practical significance of the study lies in the possibility of applying its findings by enterprise executives and financial managers to substantiate investment decisions and to align them with strategic development goals under conditions of financial constraints

Keywords: strategic planning; risk; capital; efficiency; resources

Introduction

Limitedness of financial resources, and an increase in the cost of capital complicated the process of making investment decisions at the enterprise level. Managerial mistakes in choosing investment projects, their timing, and sources of financing led to inefficient allocation of resources and a decrease in financial performance. The limitedness of financial resources, the growth of the debt burden, and the need for an instant response to financial threats further complicated the justification of directions of capital allocation in the practice of enterprise management. O. Kuzmin & O. Yurinetz (2021)

investigated the use of investment tools within the framework of crisis management and paid attention to the combination of capital investments that were directed to debt repayment with the implementation of profitable investment projects. This resulted in the development of an economic and mathematical model of capital allocation optimisation, which took into account the discount rate, debt repayment time, and expected financial receipts. This made it possible to formalise the choice of investment alternatives in the context of time and resource constraints.

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The contradiction between the strategic plans of an enterprise and the realisation of investment decisions made it difficult to match the time, financial, and efficiency parameters of capital investments. In this context, L. Halko (2021) examined the integration of strategic, tactical, and operational management decisions in the organisation of investment activity, defined the content of investment strategy and investment policy, and synthesised approaches to the formation and balancing of an investment portfolio with due regard to return requirements, liquidity, and acceptable risk levels. As a result, investment process management tools were systematised and the evidence of the necessity to coordinate the actions of managers at various levels to ensure the achievement of the planned results. The contradiction between the lack of harmony of financial, managerial, and investment indicators made it difficult to choose an investment decision at the level of an enterprise, which was substantiated, and necessitated the need to formalise the approaches to the assessment of investment attractiveness. D. Khoma *et al.* (2025) considered the investment attractiveness of an enterprise as a criterion for making management decisions. The authors developed an integrated method of evaluation, using the indicators of the condition of assets, financial stability, liquidity, profitability, and business activity, as well as a rating-based summarisation of the analytical results. The research presented the results of the possibility of using an integrated indicator for the comparative assessment of an enterprise and developing recommendations to increase investment attractiveness. In the article of L. Ryaboshtan (2024), investment controlling was considered as a part of the enterprise management system; the organisational and economic mechanism of investment controlling was substantiated, its structural elements and functions were defined, and the role of controlling in coordinating the planning, monitoring, and analysis of investment activity was proven. The results obtained made it possible to systematise the toolkit of investment controlling and to demonstrate its importance for enhancing the soundness of managerial decision-making and reducing investment risks.

N. Skopenko & V. Rezyk (2024) clarified the economic content of investment risks, proposed a classification of the latter, and summarised the principles and methods of management, including diversification, insurance, hedging, scenario analysis, and methods of quantitative assessment. The results enabled the formation of a complete idea of the toolkit for managing investment risks and its role in improving the substantiation of investment decisions. The management of innovation and investment security, as well as the assessment of existing projects, was a focus of B. Kosovych *et al.* (2025), who proposed a scenario-stochastic model that included a Monte Carlo simulation, an autoregressive index of dynamism of the external environment, and a calculation of the net present value with a variable discount

rate depending on turbulence. The research results allowed quantitatively evaluating the innovation portfolio implementation feasibility, comparing the alternative combinations of projects by their expected effectiveness and risk level, and formulating the rules for managerial decisionmaking under the given risk constraints. Insufficient systematisation of strategic investment guidelines and the difficulty of aligning investment decisions with long-term development objectives complicated the assurance of enterprise sustainability and competitiveness. D. Donets (2024) focused on the formation of investment strategies as a key instrument of enterprise development, identified the main factors influencing the effectiveness of investment activity, synthesised criteria for selecting investment projects, and substantiated the importance of combining profitability, risk, liquidity, and implementation timelines in managerial decision-making. The findings made it possible to reveal the role of investment strategy in stimulating technological renewal, improving financial performance, and supporting organisational change within the enterprise. V. Zelenyak *et al.* (2024) represented the investment activity of the enterprise as an element of the management system and clarified its economic content and investment activity, systematised the classification features of investments, and identified the main functions and tools for managing investments, such as planning, organisation, motivation, accounting, analysis, control, and coordination. The obtained results provided a comprehensive description of the investment management mechanism and demonstrated its role in ensuring the reproduction of resources and maintaining the economic stability of the enterprise. However, this study did not consider the issues of integration of investment tools, risk management methods, and control with strategic planning, as well as formalised evaluation and optimisation of alternative investment decisions. This article aimed to develop theoretically substantiated recommendations for improving the technology of making investment decisions in the system of enterprise management in the context of financial constraints, risks and priorities of strategic development. To achieve this aim, the study solved the following objectives: 1) systematisation of theoretical approaches to forming managerial decisions in the investment activities of an enterprise; 2) analysis and comparison of alternative investment directions based on financial and statistical performance and risk indicators, on the example of enterprises of different sectors of the economy.

Materials and Methods

The study used a theoretical and empirical method and was performed for the period from 2022 to 2025, which was chosen in connection with the significant changes in the conditions of investment activities of enterprises caused by macroeconomic instability, risks of Russian-Ukrainian war and changes in access to sources of financing. In the study, the sources of financing

investment activities of an enterprise were considered. The enterprises' own funds were investigated using the method of theoretical generalisation to determine their role in financing investment projects and ensuring the financial independence of managerial decisions, using the results of the research of O. Prokopenko *et al.* (2025). Credit financing was examined through the case of the Affordable Loans 5-7-9% Programme, using institutional analysis to assess interest rate compensation mechanisms and their impact on the accessibility of borrowed capital for investment purposes.

Foreign investment was analysed using comparative and descriptive methods to determine the role of international financial institutions in financing strategic and technologically complex investment projects, in particular the World Bank Group (n.d.) and the European Bank for Reconstruction and Development (n.d.). The U.S. Agency for International Development (USAID) (n.d.) was examined separately using institutional analysis to assess its role in supporting innovative, industrial, and recovery-oriented investments. The sources of grant financing were studied using systematisation and comparative analysis to determine the spheres of use of non-repayable funds in financing investment projects, such as EU4Business, Horizon Europe and the state programme eRobota. Investment risks and macroeconomic factors of influence, in particular financial, currency, legal, technological and geopolitical risks, were studied using classification and theoretical generalisation to form a systematic risk characteristic of the investment decision-making environment, using the results of the research of A. Nechyporenko (2023), L. Mensah *et al.* (2025), and O. Ibrahimov *et al.* (2025). Corporate governance was considered as a tool for risk reduction and for enhancing the soundness of investment decisions through conceptual analysis, drawing on M. Banda & A. Mwangi (2023). The regulatory framework for risk management was examined by means of regulatory analysis of the standards of the DSTU ISO 31000:2018 (2018) and Society of Corporate Compliance and Ethics & Health Care Compliance Association (2020).

The empirical part of the research was based on the case study of the investment strategies and investment decision-making processes of the Metinvest and EPAM, which were chosen on the basis of differences in sectoral affiliation, asset structure and the nature of investment risks. In particular, for Metinvest, a financial and economic analysis of the directions of investment strategy was carried out, taking into account the activity of Private Joint-Stock Company Kamet-Steel (2024) and Zaporizhstal (n.d.), investments in energy security in 2024-2025 and investments in 2026. Investments of Metinvest (2024b) in environmental technologies were considered separately on the basis of corporate sources. Then, the key financial and investment indicators of Metinvest for 2022-2025 (for 2025, the data for the first six months of the year) were considered, including

earnings before interest, taxes, depreciation and amortisation, EBITDA margin, capital expenditure, and the net debt-to-EBITDA ratio. The analysis was carried out using financial and statistical methods to characterise the trends of financial performance and investment activity on the basis of official reports of Metinvest (2022; 2023; 2024). The data for 2025 were analysed separately using the official six-month financial statements of Metinvest (2025) in the context of assessing changes in financial constraints and investment decisions in 2025.

For EPAM, a structural and comparative analysis of investment directions was carried out, in particular, investments in the scaling of the DIAL 3.0 and EliteA platforms, investments in the acquisition of NEORIS, in order to characterise the priorities of technological development and growth strategy of the company. Investments of EPAM in the acquisition of First Derivative, geographic expansion (Pestel Analysis Example, 2025) and human capital, in particular, within the framework of the EPAM Campus programmes, were considered separately to assess the expansion of the market presence and formation of long-term human potential. The key financial and operating metrics of EPAM were considered, in particular, revenue (billions USD), year-on-year revenue change, earnings per share under generally accepted accounting principles (GAAP EPS) and non-GAAP EPS (USD), headcount (thousands of employees). The analysis was carried out using financial and statistical methods to identify the dynamics of performance as a result of investment decisions on the basis of official reports of the company EPAM Systems, Inc. (2023; 2024; 2025a). Separate analysis of data for the first three quarters of 2025 was carried out on the basis of the report of EPAM Systems, Inc. (2025b) to estimate changes in the dynamics of revenue, profitability and employment indicators. Comparative analysis of the investment strategies of Metinvest and EPAM was carried out in accordance with the following indicators: industry and business model; prevailing investment objects; investment horizons; sources of financing; the role of state and international programmes; the essence of the risks; approaches to risk management; the role of corporate governance; and strategic investment goals, which allowed the tracing of the features of investment decision-making, while taking into account sectoral peculiarities and asset structure.

Results

Financing of investments and risk management in the enterprise management system

The implementation of investment management decisions at the level of the enterprise directly depended on the existing financing system, which predetermined the ability to update the resource potential, technological modernisation, and adapted to changes in the external economic environment. The investment financing structure was not universal and depended on the scale of the project, the financial stability of the enterprise, riskiness,

and the availability of financial instruments on different capital markets, which justified the need for diversification of investment sources. Own funds of enterprises, namely retained profits, amortisation and internal accumulations, were the main and most independent source of investment financing. These funds were usually directed to phased modernisation of fixed assets, renewal of the equipment, and implementation of investment projects with a relatively short payback period. Own funds were often used as a mandatory co-financing component of state and international support programmes, which strengthened the responsibility of enterprises for investment results and decreases dependence on borrowed capital (Prokopenko *et al.*, 2025). Credit resources played a key role in cases, where internal financial resources were insufficient; credit resources became essential for investment activities. In the Ukrainian market, there was an institutional instrument for attracting credit financing for investments, such as the Affordable Loans 5-7-9% Programme, under which the state compensated interest rates on bank loans for purchasing fixed assets, modernising production and introducing technologies. Alongside that, businesses utilise investment loans from commercial and state-owned banks, leasing programmes to renew equipment, and targeted credit programmes for implementing energy-efficient and industrial projects. Using credit resources made it possible to speed up the implementation of investment decisions, but it also required effective debt burden and liquidity management.

Foreign investments – this was the main source of financing for large-scale and high-tech projects. Ukrainian businesses attracted resources from international financial organisations, including the World Bank Group (n.d.) and the European Bank for Reconstruction and Development (n.d.), which provided longterm lending, guarantees or participation in the capital of enterprises. Such investments not only bring money but also the transferred of management experience, new technologies, and world standards of corporate governance, which increased the investment attractiveness of enterprises. Grants and grant programmes had a special place in the structure of investment financing of enterprises. Among the most common grant instruments were international technical

assistance programmes and business development initiatives implemented with the involvement of international organisations and donors. In particular, the U.S. Agency for International Development (USAID) (n.d.) run grant programmes to support small and medium-sized enterprises, innovative projects, productivity improvements, and the implementation of technological solutions, including grants for the modernisation of production processes and the development of export potential.

Sources of grant financing included programmes of the European Union, in particular EU4Business and Horizon Europe, aimed at supporting innovations, digitalisation, energy efficiency and development of the ecosystem of entrepreneurship. Within these programmes, businesses can receive grants for research and development, implementation of new products, technologies and business models. Of particular note were grant tools implemented with the involvement of the World Bank Group (n.d.) and related funds that finance investment projects for rebuilding infrastructure, increasing energy efficiency and developing sustainable businesses, often in combination with concessional lending or technical assistance. Grants were used at the national level in state programmes of support of entrepreneurship, in particular, the programme eRobota, which provided irrevocable funds for opening or developing a business, purchasing equipment, and creating new jobs. At the same time, enterprises involve grant financing from international development finance institutions, in particular the German Society for International Cooperation, the Nordic Environment Finance Corporation, and the European Bank for Reconstruction and Development, which provided grants or combined financing for environmental, energy-saving and recovery investment projects. Investment risks and macroeconomic factors determined the conditions for the formation and implementation of an enterprise investment decision and directly influenced the expected results of investment activity. Considering these factors was an essential element of the managerial process, as investment activity was carried out in an environment of uncertainty encompassing both the internal operational parameters of the enterprise and external economic conditions. A systematisation of the main types of investment risks and external factors was presented in Table 1.

Table 1. Investment risks and macroeconomic influencing factors

| Type of risk/factor | Description |
|---------------------|--|
| Financial | Related to changes in the enterprise's financial indicators, the availability of financial resources, liquidity levels, and the ability to meet financial obligations during the implementation of investment projects |
| Currency | Arise when using foreign sources of financing, importing equipment, or exporting products, and are associated with fluctuations in exchange rates |
| Regulatory | Caused by changes in legislation, taxation, financing rules, and requirements for carrying out investment activity |
| Technological | Related to technology upgrades, the choice of technical solutions, the obsolescence of equipment, and the pace of technological change |
| Geopolitical | Determined by changes in international trade conditions, logistics, access to external markets, and capital flows |

Source: based on A. Nechyporenko (2023), L. Mensah *et al.* (2025), O. Ibrahimov *et al.* (2025)

This systematisation demonstrated that investment risks and macroeconomic factors created a complex environment for investment decision-making, in which different groups of risks affected various parameters of an enterprise's investment activity. Financial and currency risks directly influenced the value of investments and cash flow structure, while legal factors influenced the stability of the investment project implementation conditions. Technological and geopolitical factors, in their turn, impose long-term limitations and determine directions for adaptation of investment decisions. Taking into account the complex influence of these factors increased the consistency of investment projects with the financial potential of an enterprise and the external environment conditions. Corporate governance was considered as an institutional mechanism of risk reduction and the soundness of investment decisions. It provided the standardisation of management processes, the transparency of authority distribution, and the responsibility of governing bodies. In the investment practice, corporate governance quality determined the ability of an enterprise to coordinate the interests of owners, management and external investors, to integrate investment decisions into the general framework of strategic development. An important element of corporate governance was the reduction of agency risks caused by the discrepancy between the interests of capital owners and managers. A clearly defined functional distribution between the general meeting of shareholders, the supervisory board and the executive body, as well as standardised procedures for investment decisions approval, restricted the possibility of actions that were not consistent with the long-term goals of an enterprise. These approaches were consistent with the principles of corporate governance, which were recommended by the Organisation for Economic Co-operation and Development, and used as a criterion for evaluating the institutional environment of the management of enterprises (Banda & Mwange, 2023).

Corporate governance was interlinked with the performance of internal control and risk management systems. Incorporating investment decisions into the risk management system was consistent with the approaches proposed in the standards of the DSTU ISO 31000:2018 (2018) and Society of Corporate Compliance and Ethics & Health Care Compliance Association (2020), which provided for identifying, evaluating, and monitoring risks at all stages of the management cycle. The existence of boards of supervisors, audit committees, and services for internal control made it possible to carry out preliminary evaluation of investment projects, to analyse the potential deviation of actual from planned performance indicators, and to correct management decisions in connection with changes in the external environment (Rija & Rubino, 2018). The second area of influence of corporate governance on the soundness of investment decisions was associated with the

transparency of information provision. Ensuring the openness of financial and non-financial reporting, including within the Environmental, Social, and Governance (ESG) frameworks, reduced information asymmetry between the enterprise and potential investors, which contributed to a more objective evaluation of risks and expected returns on investments. For investors, the governance component (G) of the ESG model was an indicator of the quality of management processes and the achievement of the declared strategic goals (Hwang, 2024). In this way, corporate governance was used as an effective instrument for minimising investment risks and increasing the soundness of investment decisions. Its instrumental role was implemented in uniting the interests of stakeholders, integrating risk management into the process of making investment decisions, and observing international standards and financing programmes and the transparency and accountability of managerial decisions, which contributed to the formation of the institutional environment for investment activities of enterprises.

Investment strategies and decision-making processes in enterprises of various economic sectors

Metinvest's (n.d.) investment strategy was developed as a tool for production and corporate strategy implementation and was based on a combination of vertical integration, strengthening of positions in the strategic markets and implementation of the best business practices. The strategic goal of the company was to become a leading vertically integrated European steel producer with a stable profitability level that was less sensitive to fluctuations in the economic cycle, which, in its turn, predetermined the structure and priorities of investment activity. Vertical integration was the main emphasis of the investment strategy and was considered an instrument for ensuring production stability and self-financed development. The investments were channelled to the modernisation of production facilities, equipment renewal, cost reduction and energy saving. In the metallurgical segment, capital repairs and modernisation of blast furnaces, rolling mills and continuous casting machines were carried out at the enterprises Private Joint-Stock Company Kamet-Steel (2024), and Zaporizhstal (n.d.). Metallurgical capacities of the group reached about 75% of the pre-2022 level. Given the destruction of the plants in Mariupol, in 2024, Metinvest's metallurgical production amounted to about 35% to 40% of the pre-war indicators. Preparation was carried out for the next stages of technological transformations, in particular, the possible transition to modern technologies of electric steel production or Direct Reduced Iron in the framework of future "green" steel projects (Ivanova, 2024).

A separate area of investment activity was the issue of energy security. In 2024-2025, the company implemented a number of projects for the development of its own generation, in particular, gas generation and solar

power plants, cogeneration plants for the generation of electricity from industrial gases. These investments were aimed at decreasing dependence on external power supplies, minimising the risks of downtime and creating pre-conditions for achieving up to 50% energy self-sufficiency by 2030 (Prysyazhna, 2025). Against the background of energy insecurity, such projects have become the core of the investment portfolio. Medium-term investment projects of Metinvest (2025) were set for a time horizon of 3-5 years and provided for a phased increase in investment programmes depending on the adaptation to security and logistical constraints. The company has announced investment plans of about USD 500 million for 2026 to finance modernisation projects that can be implemented under the current wartime risks. Part of the projects announced after 2022, with a total investment volume of more than USD 900 million during the period of the full-scale war, were being implemented in the format of phased investments. This implied a division into separate phases with relatively moderate investment horizons, which allowed for adjusting the pace and volume of investments depending on the security situation and operating conditions.

Investments in environmental technologies constituted another structural block of the investment strategy. In 2024, environmental expenditures amounted to USD 170.5 million, of which USD 39.8 million was

allocated to capital investments (TSN.ua, 2025). Modernisation projects were implemented for dust and gas cleaning systems, the introduction of real-time emissions monitoring systems, as well as waste management and tailings thickening programmes at the mining and processing plants. These investments were directly related to preparing for the implementation of the Carbon Border Adjustment Mechanism, Emissions Trading System, Monitoring, Reporting and Verification requirements, and European Sustainability Reporting Standards, thus incorporating the environmental aspect into long-term management decisions (Metinvest, 2024). In addition to investments, the company used the tool of strategic partnership, which provided geographical and technological diversification. The most important example was Project Adria in Italy, which provided for the construction of a low-carbon steel plant with a capacity of 2.7 million tonnes per year in partnership with Danieili. The total volume of investments was more than EUR 2.5 billion, and the project implementation was scheduled after reducing the wartime risks, which indicated the postponement of long-term investments under the modern conditions. To give an idea of the scale of investment activity and the financial conditions for making decisions at Metinvest, it was useful to consider the dynamics of the main financial and investment indicators for 2022-2025 (Table 2).

Table 2. Distribution of cotton gene pool samples according to the duration of the growing season, days (2012-2016)

| Indicator | 2022 | 2023 | 2024 | 2025 (6 months) |
|----------------------------------|-------|------|------|-----------------|
| EBITDA, million USD | 1,873 | 861 | 957 | 339 |
| EBITDA margin, % | 23 | 12 | 12 | 10 |
| Capital investments, million USD | 354 | 284 | 235 | 91 |
| Net debt/EBITDA, million USD | 0.9 | 1.6 | 1.1 | 1.9 |

Source: based on Metinvest (2022; 2023; 2024; 2025)

The data showed that in 2022-2025, the investment activity of Metinvest was carried out in the context of declining operational financial results and a steady decrease in the volume of capital investments. In 2022, capital investments were USD 354 million; in 2024, they decreased to USD 235 million; in the first half of 2025, they totalled USD 91 million. This suggests a prioritisation of short- and medium-term investment projects. The dynamics of EBITDA and EBITDA margin after 2022 affected the ratio of debt burden and operational results. The net debt-to-EBITDA ratio in 2022 was 0.9, in 2023, 1.6, in 2024, 1.1, and at the end of the first half of 2025, 1.9. The investment decisions were made under these changing financial constraints, which explained the company's emphasis on phased and flexible investment programmes with manageable risk levels.

EPAM was a global provider of information technology and digital engineering services and consulting on software development, implementation of digital platforms, and support for information technology (IT) solutions for corporate clients. The business model

was based on a combination of engineering expertise, a network of global development centres, and a full-cycle service model with a focus on long-term partnership with clients, many of whom were represented among the Fortune Global 500 (Fortune, n.d.) companies. In the structure of EPAM assets, intangible resources prevailed, first of all, human capital, technological platforms, and intellectual property, which determined the content of the investment strategy. One of the priorities of the company's investments in 2023-2025 was the development of technological solutions in the field of artificial intelligence (AI) and generative models. The company has invested in the creation and scaling of its own platforms, such as DIAL 3.0 and EliteA, which provided for the orchestration of large language models and the integration of AI solutions into the full cycle of software development. Also, the investments included the training of AI engineers, the creation of Machine Learning Operations practice, and automation of the development cycle to help the customers go from pilot AI projects to enterprise programmes. The partnerships with

technology companies, such as Google Cloud and Cursor, accompanied by the investments, provide the customers with access to cloud and AI tools (Pestel Analysis Example, 2025; Besarab, 2026).

Research and development investments formed a separate structural part of the investments. EPAM developed dedicated Research and Development (R&D) centres, such as the Automotive Embedded System Lab in Ukraine, for industry platforms and open-source solutions. The global R&D activities were supported by the governmental incentives, particularly in Poland, where the governmental incentives reached USD 68.8 million in 2024. It formed the financial basis for the development of digital engineering, cloud services, and technological solutions for the clients in the finance, energy and industry sectors (Pestel Analysis Example, 2025). Mergers and Acquisitions (M&A) became an essential tool for the realisation of the investment strategy. In 2024, EPAM acquired NEORIS for USD 630 million and First Derivative for 290 million USD. These deals allowed the company to expand its geography in Latin America and Europe, to strengthen its presence in the financial services, and to receive additional human resources, including 4,700 specialists from NEORIS (Feshchenko, 2024).

The geographical diversification of investments accompanied the M&A policy. The company realised a scale-up programme in India and reached 10,000 people by March 2025, which accounted for around 20% of the global delivery capability. Simultaneously, the investments were targeted at the geography expansion in Latin America and Central Asia, which served the

nearshore/offshore delivery model through more than 50 delivery locations worldwide and ensured the business resilience (Pestel Analysis Example, 2025). The investments in human capital formed a crucial part of EPAM's investments. A significant part of the operating expenses was targeted at the hiring, training, certification, and retention of 62,350 people. The company has invested in programmes of EPAM Campus, master's programmes together with universities, AI training, cloud technologies, agile methodologies and project management standards certification. The plan for 2026 was to recruit 750-800 junior specialists to form the staff base for further scaling of innovation projects. The financial model of EPAM in 2023-2025 ensured the implementation of the investment strategy by reinvesting profits and implementing share buybacks programmes, the planned volume of which in 2025 will amount to up to USD 1 billion, together with the upward revision of revenue forecasts, which allowed allocating resources to the development of service platforms, technological partnerships and global service delivery (Zhakhalov, 2025; Brovinska, 2026). Therefore, in 2022-2025, the investment policy of EPAM was mainly concentrated on intangible assets, innovation activity and human capital, which provided the flexibility of the business model and the ability to react to changes in the global digital solutions market. The evaluation of the implemented investment strategy included the analysis of the dynamics of financial indicators, revenue structure by key industry segments and regions, as well as staff parameters, which determined the directions of investment in the future (Table 3).

Table 3. Key financial and operational indicators of EPAM Systems, Inc.

| Indicator | Fiscal year 2022 | Fiscal year 2023 | Fiscal year 2024 | Q3 2025 |
|--------------------------------|------------------|------------------|------------------|---------|
| Revenue, billion USD | 4.83 | 4.69 | 4.73 | 1.39 |
| Year-on-year revenue change, % | +32.4 | -2.8 | +0.8 | +19.4 |
| GAAP EPS, USD | 7.09 | 7.06 | 7.84 | 1.91 |
| Non-GAAP EPS, USD | 10.9 | 10.59 | 10.86 | 3.08 |
| Number of employees, thousand | 59.3 | 53.2 | 61.2 | 62.35 |

Source: based on EPAM Systems, Inc. (2023; 2024; 2025a; 2025b)

In 2022, EPAM Systems, Inc. showed the highest rates of revenue growth, which characterised the phase of active scaling and high demand for engineering and digital services. In 2023, the financial performance underwent correction: there was a decrease in revenue and stagnation of profitability indicators, though against the background of a moderate reduction in staff. In 2024, the company entered a phase of stabilisation: revenue returned to moderate growth, and GAAP EPS increased, indicating a recovery in operational efficiency. The data for the third quarter of 2025 demonstrated an improvement in the dynamics of the company's performance: the revenue grew by 19.4% yeartoyear, while both GAAP and non-GAAP profitability remained in the positive zone. The growth in staff to 62.35 thousand in the third quarter of 2025

confirmed that the investment strategy of EPAM in 2022-2025 was primarily aimed at preserving and increasing human capital as the main productive resource. Overall, all of the above-mentioned indicators testified to the exit of the company from the correction phase and its entry into the growth phase, which created prerequisites for continued investments in digital technologies and international expansion. A justification for the comparison between Metinvest and EPAM was provided by the heterogeneity of their branches of activity, asset structures and risk profiles. Metinvest was a company operating in a capital-intensive sector, with a prevalence of material assets and a high dependence on macroeconomic and geopolitical factors, while EPAM operated in the field of digital engineering and information technology, with intangible assets

and human capital being the crucial elements. This predetermined a discrepancy between the investment priorities, forms and sources of their financing as well

as mechanisms of risk management. A comparative description of the investment strategies of Metinvest and EPAM was given in Table 4.

Table 4. Comparative description of investment strategies: Metinvest and EPAM

| Comparison criterion | Metinvest | EPAM |
|--|---|--|
| Industry and business model | Metallurgy and mining; vertically integrated production model | Information technology and digital engineering; full-cycle service model |
| Dominant investment targets | Fixed assets, production equipment, energy and environmental infrastructure | Intangible assets: technological platforms, software solutions, human capital |
| Key investment areas | Production modernisation, energy efficiency, environmental technologies, strategic partnerships | AI-solutions, R&D, M&A, geographic expansion, workforce personnel |
| Investment horizons | Mainly short- and medium-term; long-term projects are deferred | Combination of short-, medium- and long-term horizons without physical constraints |
| Sources of investment funding | Own funds, internal cash flows, phased financing, partner projects; limited access to credit | Profit reinvestment, foreign investment, M&A, share buyback programmes |
| Role of state and international programmes | Limited; mostly indirect (energy, environmental, and infrastructure programmes) | Significant role of R&D incentives and state-supported innovation programmes (e.g., in the EU) |
| Nature of investment risks | High geopolitical, regulatory, currency, and technological risks | Primarily market, workforce, and technological risks |
| Approach to risk management | Phased project implementation, flexible adjustment of capital investments, focus on liquidity | Portfolio diversification, scaling through M&A, investment in competencies |
| Role of corporate governance | Tool for risk control, alignment of investments with production and ESG strategy | Tool for integrating investment decisions into the global service and innovation model |
| Strategic investment objective | Preservation of production capacity and preparation for "green" transformation | Scaling innovation and ensuring long-term growth |

Source: developed by the author

The comparison showed that investment strategies of Metinvest and EPAM significantly differed by target orientation of investments, sources of their financing and risk structure, which was determined by the specific features of the sector and business model. Metinvest was implementing a capitalintensive investment strategy, with investments in material assets, energy efficiency and environmental protection and phased implementation of projects in conditions of high uncertainty being the crucial elements. EPAM was applying an innovation investment strategy, with investments in digital technologies, human capital and international expansion being the key elements and ensuring flexibility and a quick response to the changing market conjuncture. In general, all of the above-mentioned arguments confirmed that investment decisions were not invariant and depended on asset structure, access to financial resources and the nature of the external risks. The analysis of investment strategies of Metinvest and EPAM showed that, in the conditions of high economic and geopolitical uncertainty, the investment activity of large enterprises was an integral part of their general business and operational strategies and was aligned with asset structure and risk profile. Within the framework of investment strategies for 2022-2025, Metinvest's investments were directed to preserve the production potential, maintain the company's vertical

integration and achieve operational and energy independence. A decrease in the volume of capital investments, a staged implementation of projects, and a decrease in debt obligations indicated a prioritisation of short- and medium-term investment decisions in conditions of wartime risks with preservation of the technological and environmental modernisation potential in the long-term period. EPAM's investment strategy for the same period was based on the development of intangible assets, in particular technological and human capital. The bulk of investments was concentrated on solutions based on AI, R&D, M&A, expansion of the geography of presence and development of personnel, which allowed the company to go through the correction phase in 2023 and enter the restored growth phase in 2024-2025 without reducing human capital. Thus, Metinvest implemented a capital-intensive investment model of production orientation, which was aimed at investing in physical assets and infrastructure, while EPAM implements an innovative investment model, in which technological and human capital were of key importance for making investment decisions. Both models demonstrated an adaptation of investment decisions to financial, regulatory and external restrictions, which confirmed the investment strategy as an instrument for achieving resilience and ensuring long-term development.

Discussion

Enterprise investment decision-making in the conditions of financial constraints, increased uncertainty and growing external complexity was characterised as a multi-criteria managerial process. Modern management practice was increasingly characterised by the use of formalised analytical methods, quantitative methods and decision-making tools, which minimised the subjectivity of decisions, took into account risk factors and brought short-term financial goals in line with long-term strategic ones. A comparison of this study with the approach of B.S. Qian *et al.* (2025) demonstrated a common methodological basis and, at the same time, a clear differentiation of the levels of managerial analysis. Both studies interpreted managerial decisions as formalised choices that required quantitative substantiation and minimisation of uncertainty. However, if B.S. Qian *et al.* (2025) concentrated on the micro-level of production processes and applied decision tree models to optimise quality control and costs at the technological cycle level, this study focused on the strategic and financial level, at which investment decisions, sources of their financing and risks of enterprise development were actualised. Another logically close approach to formalising the managerial choice was proposed by S. Ren (2022), who also pointed to the need for systematisation of information as an uncertainty-reducing mechanism. However, the emphasis in S. Ren's (2022) research was on the use of big data and financial information systems for real-time optimisation of financial management. Meanwhile, in this research, the focus was not on accelerating or automating the decision-making process but on substantiating long-term investment directions and their consistency with the strategic goals of the enterprise's development.

The scope of analysis was even broader than in the research by B. Wu & L. Zhou (2025). Both studies employed portfolio logic, quantitative methods and risk analysis as the basic components for optimising investment decisions. However, B. Wu & L. Zhou (2025) used these instruments mainly at the financial market level, examining factor, sectoral and integrated investment strategies in the Chinese stock market. In contrast, in this research, the portfolio approach was used at the corporate governance level to select directions for allocating capital and structuring financing sources, which was a difference not so much in the instruments themselves as in the level at which decisions are made. Researchers T. Yang & C. Zhang (2025) focused on evaluating the effect of optimising the tax business environment on the innovation efficiency of enterprises, while this study considered institutional conditions in terms of financial constraints and their impact on the choice and implementation of investment decisions. The same logic can be traced in the comparison with the research by Y. Huang & Q. Wu (2026). In both studies, the managerial decision was perceived as a multicriteria process carried out under uncertainty and requiring formalised

analytical tools. However, Y. Huang & Q. Wu (2026) paid special attention to intelligent decision support systems and algorithmic optimisation of the general efficiency of managerial decisions, while in this study, such systems were used to evaluate investment options, manage limited financial resources, and solve the problem of risk from a strategic perspective. A comparison with the research of S. Wang & M. Mansoor (2025) made it possible to identify the difference between the algorithmic and the managerially strategic approach. Both works recognised the multi-criteria nature of financial decisions and the need for their optimisation. At the same time, S. Wang & M. Mansoor (2025) considered the application of intelligent algorithms of financial management (genetic algorithms, fuzzy logic), risk forecasting, and optimisation of financial performance indicators. In this study, the main attention was paid to the choice of sources of financing and allocation of capital in the context of bringing investment decisions in line with the strategic development goals of the enterprise.

The article of Y. Shi & C. Lu (2024) enabled the consideration of financial management decisions in a broader analytical context, while maintaining a formalised approach to their substantiation. In both studies, financial decisions were considered as the result of the processing of analytical data, taking into account risks and the need to increase the rationality of the managerial choice; information technologies were perceived as a means to support management. At the same time, the substantial accents of the articles were different: Y. Shi & C. Lu (2024) were engaged in the use of big data and data-driven approaches to optimise financial management, cash flows, and expenditures, while in this research digital technologies were subordinated to a broader task: substantiation of investment decisions, choice of sources of financing, and ensuring their consistency with the strategic objectives of the enterprise. Another aspect of the managerial choice was described in the study of Q. Zhang & J. Li (2021), in which the authors dwelled on the systematic management of large organisations. The two articles shared an understanding of managerial decisions as a structured process that required coordination at all levels of management and consistency with long-term development goals. However, Q. Zhang & J. Li (2021) paid main attention to the organisational and institutional aspects of corporate and group management, to the question of financial, strategic and operative control, as well as to the position of the headquarters in the management structure. In this connection, the object of research was not an institutional and organisational aspect of management, but a financial and investment one, that was, a choice of investments, funding sources and risk management under financial constraints.

The most similar in orientation to the quantitative substantiation of management decisions was the study of Y. Zheng & M. Luo (2023). In both studies, the authors

stressed the importance of associating the management decision with the results of the company's activity and its long-term sustainability, while also highlighting the value of formalised analytical constructions. In the research of Y. Zheng & M. Luo (2023), the main object of research was the operational efficiency of high-tech manufacturing enterprises, which was estimated using Data Envelopment Analysis and regression models, taking into account government subsidies, innovation and regional factors. The macroeconomic aspect of investment behaviour of enterprises was considered in detail in the study of D. Dejuan-Bitria & C. Ghirelli (2021). In both articles, investments were considered as being sensitive to uncertainty and financial constraints, and investments were viewed as the result of interaction of risk, financial accessibility and expectations of economic agents. D. Dejuan-Bitria & C. Ghirelli (2021) paid special attention to the impact of economic policy uncertainty on the investment of enterprises in Spain, and, using microdata and the index of Economic Policy Uncertainty, scientists revealed the effects of a "wait-and-see" behaviour and financial frictions. In the present study, uncertainty was not considered as a macroeconomic impulse, but as a factor of managerial and financial and investment decisions at the level of an economic entity, while special attention was paid to funding sources, capital investments and ensuring the consistency of investment decisions with the goals of strategic development.

As compared to the research by A. Setyawati *et al.* (2024), it was possible to note that both studies were focused on the financial sustainability of the enterprise. However, the researchers differed in the theoretical framework. In the two articles, the process of management decision-making was considered as formalised and aimed at increasing the financial sustainability of the business. However, A. Setyawati *et al.* (2024) considered the issues of financial management in the context of the agency theory and the signalling theory, with an emphasis on the specifics of small and family businesses, the relationship between the owners and the management. This study was devoted to the investment decisions of the enterprise, the structure of the sources of financing and the correspondence of the capital investments to the strategic goals of the development. As compared to K.E. Morales *et al.* (2026), it was possible to note that in the two articles, the investment and financial decisions were considered as a managerial process that was sensitive to the risk and the restrictions of resources, and the analytical tools were used to strengthen the decision-making process. K.E. Morales *et al.* (2026) focused their attention on the quantitative analysis of financial and macroeconomic determinants and their impact on the financial sustainability of the enterprise, using econometric analysis and aggregated indices. This study was devoted to the logic of the investment decision-making at the micro level of the enterprise and the inclusion of risk management into the process of strategic planning.

The transition from the financial indexes to the managerial context was most visible compared to the research by I. Baffo *et al.* (2024). In the two studies, the investment decisions were considered as an instrument for providing the financial sustainability in the conditions of the restricted resources and the increased uncertainty, and the necessity of the formalised managerial procedures was noted. However, I. Baffo *et al.* (2024) focused their attention on the short-term period, considering the optimisation of the structure of the working capital and liquidity as the basis of the financial sustainability. The presented research was devoted to the strategic investment decisions, long-term planning and the inclusion of risk management and corporate governance into the process of the investment decisionmaking. The contrast to I. Rossi (2023) provided a separation between algorithmic and managerial-strategic concepts of investing. In these two studies, the investment decision-making process was understood as a complex, formalised process carried out under uncertainty, for which the application of analytical tools was necessary to reduce the subjectivity and increase the transparency of choice. However, I. Rossi (2023) was interested in AI and its application in venture investing; this author studied the impact of digital algorithms on the behaviour of private investors and the speed of decision-making. In this research, digital and analytical tools were not considered as independent factors but as elements of managerial logic, which was subordinated to the choice of directions for capital allocation and synchronisation of investment decisions with the strategic goals of enterprise development. The comparative analysis showed that the managerial and investment decisions in various research concepts were considered a formalised process sensitive to risks, financial constraints, and external uncertainty. The difference between concepts was determined by the level of analysis and time perspective, from operational and financial optimisation to strategic investment choice. In this study, investment decisions were interpreted as an integral part of a holistic managerial system that combined the choice of directions for capital allocation, the structure of funding sources, risk management, and the synchronisation of investments with the strategic goals of enterprise development.

Conclusions

This study had ascertained that investment decision-making at the enterprise level, under the conditions of financial constraints and uncertainty, was a multi-criteria managerial process that combined financial indicators, risks, strategic priorities, and institutional factors. The practical analysis of the investment strategy of Metinvest demonstrated that the company applied an adaptive model of investing aimed at saving production capacity, providing energy independence, and implementing environmental projects. The dynamics of capital investment indicated a reduction from

USD 354 million in 2022 to USD 284 million in 2023, and USD 235 million in 2024, which testified to a shift of focus towards short- and medium-term projects implemented in stages. EBITDA had dropped from USD 1,873 million in 2022 to USD 861 million in 2023 and increased to USD 957 million in 2024. The dynamics of financial conditions were accompanied by fluctuations of the net debt-to-EBITDA ratio, which had grown from 0.9 in 2022 to 1.6 in 2023, had decreased to 1.1 in 2024, and grown to 1.9 in the first half of 2025. Against this backdrop, flexible investment programmes were adopted to control liquidity and risks and maintain a strategic reserve for long-term transformations.

Analysis of EPAM Systems, Inc.'s investment strategy revealed a different investment decision-making model, determined by the dominance of intangible assets and human capital. The financial performance was characterised by a correction in 2023, when the revenue decreased from USD 4.83 billion in 2022 to USD 4.69 billion and levelled at USD 4.73 billion in 2024. The third quarter of 2025 had already shown a 19.4% year-to-year increase in revenue. The GAAP EPS had grown from USD 7.06 in 2023 to USD 7.84 in 2024, whereas the number of employees has grown to 62,350 in 2025. The investment solutions of EPAM from 2022 to 2025 were concentrated on the development of AI solutions, R&D, M&A, and

geographical expansion, which made it possible to scale the business without reducing human capital. For Metinvest, a phased investment approach was recommended, where investment horizons were clearly separated, and scenario analysis of capital expenditures was enhanced, taking into account the dynamics of EBITDA and debt burden. For EPAM Systems, it was advisable to deepen the portfolio investment approach to intangible assets by formalising the criteria for selecting investments between R&D, M&A, AI solutions, and human capital investments, with the use of quantitative performance indicators. The limitations of the study stem from its focus on formalised management approaches and a narrow set of corporate examples. Further research should be aimed at expanding the empirical base, carrying out micro-level analysis and using more advanced scenario modelling of investment decisions.

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Прийняття та оптимізація інвестиційних рішень в управлінні підприємством

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Аспірант

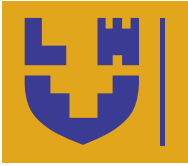
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Анотація. Метою дослідження було обґрунтування підходів до прийняття та оптимізації інвестиційних рішень у системі управління підприємством. Методологія дослідження передбачала поєднання теоретичного узагальнення, фінансово-статистичного та порівняльного аналізу із використанням офіційної фінансової звітності та відкритих корпоративних даних за 2022-2025 роки. У ході дослідження було встановлено, що у 2022-2025 роках інвестиційна діяльність групи «Метінвест» формувалася в умовах скорочення виробничих потужностей і підвищених воєнних ризиків, що зумовило зменшення обсягів капітальних інвестицій з 354 млн доларів США у 2022 році до 235 млн доларів США у 2024 році та орієнтацію на поетапну реалізацію інвестиційних проєктів. Показник співвідношення чистого боргу до прибутку до сплати відсотків, податків та амортизації зріс з 0,9 у 2022 році до 1,9 у першому півріччі 2025 року, що обмежувало інвестиційну активність. Натомість інвестиційна стратегія ЕРАМ у 2022-2025 роках була зосереджена на розвитку нематеріальних активів, технологічних платформ і людського капіталу, що супроводжувалося стабілізацією виручки на рівні 4,73 млрд доларів США у 2024 році та зростанням чисельності персоналу до 62,35 тис. осіб у 2025 році, а також підвищенням показника прибутку на акцію за стандартами загальноприйнятих принципів бухгалтерського обліку з 7,06 долара США у 2023 році до 7,84 долара США у 2024 році. Отримані результати свідчили, що ефективність інвестиційних рішень визначалася галузевою специфікою, структурою активів і характером фінансових та зовнішніх ризиків, а оптимізація інвестування вимагала узгодження фінансових обмежень зі стратегічними цілями розвитку підприємств. Практичне значення дослідження полягає в можливості використання його результатів керівниками та фінансовими менеджерами підприємств для обґрунтування інвестиційних рішень і узгодження їх зі стратегічними цілями розвитку в умовах фінансових обмежень

Ключові слова: стратегічне планування; ризик; капітал; ефективність; ресурси



Accounting and control support for expenditures on the restoration of critical infrastructure facilities in the public sector under martial law and post-war recovery

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Abstract. The aim of the study was to examine the issues of accounting and control support for the restoration of critical infrastructure facilities in the public sector under conditions of martial law and post-war recovery. The formation of an evidence bases regarding the losses incurred required proper documentation, systematisation and accounting recognition based on reliable and structured information on damaged or destroyed assets, incurred costs, and economic consequences. It was established that 60-70% of the significance in the process of verifying damages was ensured by documented accounting and registration data. The remainder was attributable to supporting analytical and expert materials that provided their interpretation and justification for further use in assessment and compensation procedures. It was substantiated that, as a result of simplified procurement procedures, the heterogeneity of procurement items within the Prozorro system, and the absence of a unified approach to the accounting recognition of costs, the risks of their misclassification as either current or capital expenditures increase. The structure of expenditures included costs for construction and engineering works, design and estimate documentation, technical and author supervision, engineering consultancy services, and the acquisition of materials and equipment. It also encompassed costs associated with ensuring physical protection, fortification, and restorative sheltering of critical infrastructure facilities, which collectively formed the overall cost of their restoration and the maintenance of uninterrupted operation. It has been demonstrated that the consequences of such uncertainty included the undercapitalisation of expenditures, distortion of accounting information, weakening of financial control, and a reduction in the evidential suitability of data for international compensation mechanisms. Based on an analysis of national and international regulatory documents, as well as procurement practices within the Prozorro system, it has been established that the key criterion for the proper classification of expenditures was their economic substance and the outcome of the transaction. The classification also considered its impact on the asset, rather than the formal designation of the transaction or the procurement item. The application of a criteria-based identification approach will contribute to improving the reliability of accounting information, strengthening financial control, reducing the risk of undercapitalisation, and forming an appropriate evidence base for subsequent compensation of losses

Keywords: current expenditures; capital expenditures; undercapitalisation; financial control; compensation mechanisms

Introduction

Under conditions of martial law and the post-war recovery of Ukraine (2022-2026), the need for effective accounting and control support for expenditures on the restoration of critical infrastructure facilities in the

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public sector had increased significantly. At the same time, existing approaches to accounting and financial control were not fully adapted to wartime conditions, which complicated the operational management of expenditures and the adoption of well-founded managerial decisions. This necessitated the improvement of methodological and organisational frameworks for accounting and control of expenditures within the system of critical infrastructure recovery. The urgency and simplification of procurement procedures have become a practical necessity; however, they simultaneously increased the risks of erroneous managerial and accounting decisions, as well as potential abuses. In particular, a portion of expenditures on the protection of critical infrastructure facilities in the public sector was recorded as current expenditures or included in the cost of goods, works, and services, although in economic substance the results of such activities involve the creation or improvement of property, plant and equipment. As a result, the asset does not acquire an appropriate accounting status despite its actual creation or modernisation, leading to undercapitalisation. Consequently, control over the use of funds and expenditure management was significantly weakened. This considerably limited the possibilities for subsequent compensation of damages through reparation mechanisms and created obstacles for the overall process of post-war recovery.

The issue of distinguishing between current and capital expenditures, asset capitalisation, and accounting for property, plant and equipment had been examined by both Ukrainian and international scholars. In particular, the fundamental principles of the criteria-based classification of expenditures and their impact on capitalisation were outlined in the work of O. Hrytsenko (2025), who studied accounting approaches to determining expenditures on the restoration of assets and infrastructure in the post-war period, systematising the main challenges of their identification and recognition. The author substantiated directions for improving the methodological framework for accounting such expenditures, taking into account the specific features of reconstruction. In addition, V. Mykytenko (2023) developed an algorithm for the recovery-oriented development of critical infrastructure under wartime and post-war conditions, identifying key stages and the logic of their implementation. Researcher demonstrated the relationship between the level of infrastructure damage and the prioritisation of managerial decisions regarding its restoration. P. Gomes *et al.* (2022) carried out a study to determine the impact of the implementation of International Public Sector Accounting Standards on the use and usefulness of accounting information within the public sector. Their findings indicated that the implementation of these standards led to increased transparency of financial reports, which allowed for improved decision-making by the managers responsible for those organisations. Scientists B. Cuadrado-Ballesteros &

M. Bisogno (2022) examined the relationship between budget transparency and the financial sustainability of public finances, demonstrating that a higher level of openness in budgetary information positively affects long-term financial stability. Similarly, G.L. Tampubolon & R. Maisyarah (2025) investigated the impact of implementing accounting and accountability principles in the public sector on institutional performance, concluding that an adequate level of accounting transparency reduced the risks of fraud and enhanced management effectiveness.

Researchers S. Svirko *et al.* (2023) assessed the level of transformation in the information support for public finance management in Ukraine. The authors identified key trends in digitalisation and the enhancement of the analytical component of accounting and information systems. N.T.T. Hien *et al.* (2025) investigated the factors influencing the development of accountable accounting in the public sector using structural equation modelling. It was found that organisational, technological and institutional factors significantly determined the level of effectiveness of accounting practices. In particular, V. Melnyk & V. Rudenko (2022) analysed the impact of the fiscal mechanism on the investment development of economic entities in Ukraine and EU countries. The study demonstrated that effective tax policy contributed to the stimulation of investment processes and economic growth. M.M. Amalia (2023) summarised contemporary approaches to ensuring accountability and transparency in the public sector based on an analysis of public accounting practices. Scientist established that a proper accounting system increased trust in state institutions and the efficiency of resource management. In the study by L. Korotnyk (2022), accounting aspects of public financial management in the field of science were examined, with a focus on the specifics of their recognition. It was determined that the improvement of accounting procedures contributed to a more rational use of budgetary funds. V. Zhuk *et al.* (2025) analysed the policies regarding the assessment and compensation of damages caused by the aggression of the Russian Federation against Ukraine. The aim of the authors was to determine the specifics of accounting and control support for the processes of restoring critical infrastructure facilities in the public sector.

Materials and Methods

The methodology of the research involved a step-by-step combination of different approaches to achieve a particular goal. Six stages of the research all built upon the results of the previous stage of the research to ensure that the research was logically complete. In particular, the study progressed from problem identification and analysis of the regulatory framework to empirical analysis, comparison of approaches, and further generalisation of results with the development of an applied methodological toolkit. The study examined the

provisions of the Draft Articles on Responsibility of States for Internationally Wrongful Acts developed by the International Law Commission (United Nations, 2008), which established the fundamental principles of international state responsibility, including the obligation of full reparation for damage caused. At the same time, the political dimension of russia's responsibility was reflected in the G7 Leaders' Communiqué adopted at the summit in Borgo Egnazia, which confirmed the intention to ensure the accountability of the russian federation and the use of frozen assets for Ukraine's recovery (European Council, 2024). An important component of the research was also the analysis of the institutional and legal mechanism for documenting damages, established in the resolution of the United Nations (2022) General Assembly on the creation of an international register of damage as an initial stage of the compensation mechanism, which was further developed in the decision of the Committee of Ministers of the Council of Europe on the establishment of the Register of Damage for Ukraine (Resolution of the..., 2025).

The documents were integrated into the unified, multi-level system through a combination of legal, political, and institutional instruments, all of which ensured a consistent approach to counting and verifying damages. Their significance lies in forming a comprehensive international framework for the substantiation, assessment, and compensation of damages caused under conditions of armed aggression. In addition, the study identified the problem of accounting and control support for expenditures on the restoration of critical infrastructure facilities under conditions of martial law, based on the analysis of statistical and analytical materials on the scale of damage and financial recovery needs, including data from the World Bank Group (2025) and sectoral assessments of losses in energy infrastructure (Ministry for Development of Communities and Territories of Ukraine, 2025). The regulatory and legal environment governing expenditures and their accounting was also analysed, including Resolution of the Cabinet of Ministers of Ukraine No. 1178 (2022), Ukraine Recovery Conference (2022), and Resolution of the European Parliament No. 2026/2599(RSP) (2026) concerning Europe's contribution to establishing a just peace and sustainable security for Ukraine. The study further included an analysis of the audit of the implementation of the experimental project on the protection of critical infrastructure in the energy sector conducted by The Accounting Chamber (2025), in order to assess the efficiency of resource utilisation and the organisation of relevant measures. Particular attention was also given to the regulatory framework governing the implementation of the pilot project on new construction, reconstruction, repairs, and engineering and technical protection of critical infrastructure facilities across various sectors, as defined by Resolution of the Cabinet of Ministers of Ukraine No. 142 (2025). The specific features of public

procurement under martial law conditions were analysed, along with the results of the audit of the development of administrative services and their digitalisation, leading to conclusions regarding the improvement of managerial decision-making in this area (The Accounting Chamber, 2024). This made it possible to substantiate the necessity of forming reliable accounting information as a basis for future reparation claims.

The second stage involved an analysis of public procurement practices via the Prozorro system, using a sample of contracts from government bodies and classifications based on CPV (DK 021:2015) codes (Prozorro, 2023; 2024; 2025a). In addition, procurements in the infrastructure and energy sectors were analysed taking into account classifications, which made it possible to identify specific risks associated with the accounting classification of expenditure (Prozorro, 2025b; 2025c; 2025d). Procurement in the social and healthcare sectors was examined in this way, enabling an assessment of the heterogeneity of procurement items and the associated risks (Prozorro, 2025e). A comparative analysis was carried out of national regulatory approaches to the classification of expenditure based on Order of the Ministry of Finance of Ukraine No. 333 (2012) to determine the criteria for classifying budget expenditure. Order of the Ministry of Finance of Ukraine No. 1202 (2010) was also analysed with regard to the recognition, measurement and identification of assets in the public sector. A comparison was made of international approaches to the accounting for property, plant and equipment in accordance with IFRS (2026) to determine uniform criteria for recognition and measurement. Additionally, the European Central Bank's (2026) approaches to the classification of expenses and assets were taken into account, which allowed for the summarisation of key criteria for their identification in international practice. The final stage involved synthesising the results of previous studies and developing a criteria-based identification approach to the classification of expenses, taking into account developments in public sector accounting as identified in academic sources.

Results

As a result of the full-scale invasion by the russian federation and the continuous shelling of critical infrastructure facilities in the public sector, including energy facilities, these assets have been subject to systematic damage, destruction, and loss. The scale of losses was increasing daily. International legal regulation of issues related to state responsibility and compensation for damages has become particularly relevant in light of the large-scale consequences of armed conflicts. The development of institutional and legal mechanisms for compensating losses provided a foundation for documenting damages and implementing the principle of justice at the global level. The International Law Commission established the basic principles of compensation for the harm caused

through the Draft Articles on Responsibility of States for Internationally Wrongful Acts (United Nations, 2008). The articles enshrined the idea that the state responsible for the wrongful act shall compensate for the damage caused. The G7 Leaders in the Borgo Egnazia Communiqué also confirmed the political position of the leaders for the need to hold Russia accountable for its actions and ensure compensation for the damage done to Ukraine by utilising the frozen assets of the Russian Government (European Council, 2024). The United Nations (2022) adopted a resolution on the establishment of an international register of damage caused by the aggression of the Russian Federation against Ukraine, recommending the creation of mechanisms for documenting and systematising losses. The Committee of Ministers of the Council of Europe established the Register of Damage for Ukraine, defining the organisational framework for its functioning (Resolution of the..., 2025), and providing for the recording of claims as a basis for future compensation mechanisms. As of 31 December 2024, the amount of damage in the energy sector was estimated at USD 14.8 billion, excluding lost revenues (World Bank Group, 2025), while in 2025 the number of damaged energy facilities increased by 70% (Ministry for Development of Communities and Territories of Ukraine, 2025). The greatest damage has been inflicted on the sectors of electricity generation, transmission, and distribution. Given the significant and growing level of damage to critical infrastructure facilities, and taking into account their functional and social importance, the restoration of critical infrastructure in general, and energy facilities in particular, was predictably a priority during martial law and will remain so in the post-war recovery period.

The conditions of martial law have created a need for the rapid provision of security for critical infrastructure facilities in the energy, transport, and social sectors. In order to accelerate procurement procedures for goods, works, and services, Resolution of the Cabinet of Ministers of Ukraine No. 1178 (2022) introduced simplified procurement mechanisms. At the same time, international approaches to reconstruction emphasised that the recovery process should be based on the principles of transparency and accountability, the consistent strengthening of the rule of law, and appropriate anti-corruption safeguards (Ukraine Recovery Conference, 2022). Post-war recovery in general, and the restoration of critical infrastructure facilities in the public sector, including energy facilities, in particular, will require the mobilisation of extremely large financial resources. In the context of identifying sources of financing for Ukraine's post-war recovery, it was appropriate to take into account the position of the international community regarding the attribution of responsibility to Russia for the damage caused. According to Resolution of the European Parliament No. 2026/2599(RSP) (2026), the offending state was obliged to provide full compensation

for the damage resulting from its unlawful actions. The position on the necessity of compensation was also supported by European Union institutions. In particular, the European Parliament, in its resolution of 24 February 2026 on four years of Russia's war of aggression against Ukraine and Europe's contribution to ensuring a just peace and sustainable security for Ukraine, emphasises that "Russia must compensate for the extensive damage caused to Ukraine, and the European Union should utilise frozen Russian assets to support reconstruction" (The Accounting Chamber, 2024). Thus, the principle that one of the sources of financing of the reconstruction of Ukraine was the provision of reparations from the aggressor was also embodied in various legal documents of an international nature and in the statements of the leading international organisations and states.

The implementation of the mechanism of reparation was possible only on the condition of documenting the losses that were incurred as a result of the aggression of Russia against Ukraine. The formation of evidence as to the losses that were caused by the aggression required information regarding the destruction of the assets of Ukraine and the losses of its resources as a result of the war. The accounting of these losses will make it possible to determine the losses of Ukraine in accordance with established accounting standards. It was this accounting of the losses of Ukraine that will make it possible to determine the amount of compensation that was to be provided to Ukraine as a result of the aggression of Russia, to prove such losses in legal proceedings, and to present such proof as a foundation for the claims of the Ukrainians for compensation. In addition to the losses that resulted from the destruction of the assets of Ukraine, the structure of the losses that were to be compensated also included the expenditures that were made by the Ukraine for the protection of those assets. For example, it was necessary to include in the calculation of the losses, for which Ukraine was to be compensated the expenditures for providing physical protection, fortification and sheltering for the infrastructure facilities of the public sector. Such expenditures could include, for example, engineering protection for public infrastructure facilities, the installation of protective structures and systems, the installation of backup systems for the supply of energy to those critical facilities, the installation of security systems to those critical facilities, and any other measures taken to protect those public facilities from further destruction. The recording, proper documentation, and accounting recognition of such expenditures constitute a necessary prerequisite for forming an evidence base for the subsequent inclusion of the relevant amounts in claims for compensation within international reparation mechanisms. According to the audit of the The Accounting Chamber (2025) concerning the implementation of the experimental project on engineering protection of critical infrastructure

facilities in the fuel and energy sector, in 2023-2024, UAH 5.9 billion was allocated for ensuring physical protection, fortification, and restorative sheltering of critical infrastructure facilities, of which UAH 29.97 billion was actually financed, and UAH 18.71 billion was

utilised. An analysis of procurement within the Prozorro system indicated that measures for the protection of critical infrastructure facilities were implemented as fragmented procurement items, which can be generalised into the following groups (Table 1).

Table 1. Structure of procurement items for measures aimed at the protection of critical infrastructure facilities in the Prozorro system

| Procurement item group | Typical wording of the procurement item in Prozorro | CPV code (DK 021:2015) | Name according to DK 021:2015 |
|----------------------------------|---|------------------------|---|
| Construction works | Installation of engineering protection; new construction of protective structures; reconstruction/major repair of protective elements | 45000000-7 | Construction works and current repairs |
| Specialised construction works | Engineering protection; counter-drone protection; installation of anti-drone structures | 45220000-5 | Engineering and construction works |
| Design works | Preparation of design and cost estimate documentation; design works for protective structures | 71242000-6 | Preparation of designs and sketches; cost estimation |
| Technical supervision | Technical supervision of construction works | 71520000-9/71247000-1 | Supervision services for construction works/ Construction supervision |
| Client supervision | Author's supervision of works execution | 71247000-1/71520000-9 | Construction supervision/ Supervision services for construction works |
| Engineering consultancy services | Engineering consultancy services in the design and reconstruction of the facility | 71530000-2 | Consultancy services in the field of construction |
| Materials | Procurement of materials for the engineering and technical protection of critical infrastructure facilities | 44110000-4 | Construction materials |

Source: Prozorro (2023; 2025a; 2025b; 2025c; 2025d; 2025e)

The analysis of the data presented in the Table 1 indicated the heterogeneity of procurement measures for the protection of critical infrastructure facilities within the Prozorro system. Such procurements encompassed works, services, and goods, while certain operations that were similar in their economic substance were classified under different procurement codes. This pointed to the absence of a unified approach to their representation within the public procurement system. Under such conditions, there were risks of inconsistent interpretation of the nature of the relevant expenditures, their differing classification, and, accordingly, discrepancies in accounting treatment. In turn, errors in distinguishing between current and capital expenditures may occur. The heterogeneity of procurement item groups for the measures for protecting critical infrastructure facilities created the risk of misrecognition of expenditures. The risk of misrecognition included the potential for expenditures that

have economic substance of current expenditures to be classified as capital expenditures. A clear distinction of expenditures according to their economic substance was required to avoid the errors in recognising such expenditures, which will lead to distortions in accounting information for such entities and complicate the exercise of financial control. In order to distinguish between expenditures, it was necessary to ensure their proper identification and formalisation in accordance with their economic substance, intended purpose, and the outcome of the measures undertaken, which made it possible to reasonably determine whether such expenditures were of a current nature or were associated with the creation or improvement of non-current assets. Such an approach was a necessary condition for the proper recognition of expenditures in accounting. For this purpose, it was advisable to refer to regulatory documentation and to identify the key normative characteristics (Table 2).

Table 2. Regulatory approaches to the definition of current and capital expenditures in national and international practice

| Source | Term | Definition |
|---|---------------------|--|
| Instruction on the Application of the Economic Classification of Budget Expenditures, approved by Order of the Ministry of Finance of Ukraine No. 333 dated 12 March 2012 | Current expenditure | Expenditures directed towards the implementation of budget programmes and ensuring the current functioning of budgetary institutions, the conduct of research, development, measures, and the provision of current transfers |
| | Capital expenditure | Expenditures directed towards the acquisition of fixed capital, non-current assets, capital investments, capital repairs, the creation of state stocks and reserves, the acquisition of capital assets, as well as compensation for losses associated with damage to fixed capital |

Table 2, Continued

| Source | Term | Definition |
|--|---------------------|--|
| National Public Sector Accounting Standard 121 "Property, Plant and Equipment", approved by Order of the Ministry of Finance of Ukraine No. 1202 dated 12 October 2010 | Current expenditure | Costs incurred for the maintenance of an item of property, plant and equipment, carried out to restore or maintain its service potential at the initially assessed level; recognised as expenses of the reporting period, in which they are incurred |
| | Capital expenditure | Costs related to the improvement of an item of property, plant and equipment (reconstruction, modernisation, extension, additional equipment, restoration), which increase its initial value |
| IAS 16 Property, Plant and Equipment | Current expenditure | Costs of routine servicing of an asset are not included in its carrying amount but are recognised as expenses at the time they are incurred |
| | Capital expenditure | The carrying amount of an asset includes costs for the replacement of parts, major periodic inspections, and other costs directly attributable to bringing the asset to a condition suitable for use, provided that the recognition criteria are met |
| Government Finance Statistics Manual 2014 | Current expenditure | Expenses represent a decrease in the net value of assets as a result of a transaction; the acquisition of non-financial assets is not considered an expense |
| | Capital expenditure | Investment in non-financial assets is presented separately from expenses as net investment in non-financial assets |

Source: Order of the Ministry of Finance of Ukraine No. 1202 (2010), Order of the Ministry of Finance of Ukraine No. 333 (2012), IFRS (2026), European Central Bank (2026)

The analysis of the regulatory definitions presented in the Table 2 indicated that Ukrainian and international regulatory documents generally followed a unified methodological approach to distinguishing between current and capital expenditures, although they employed different terminology. Within the regulatory framework, both at the level of budget legislation itself and within the classification of expenditures according to their economic characteristics, primary attention was paid to the purpose, for which expenditures were to be made. Expenditures for current purposes were associated with the functioning of institutions and the implementation of programmes, while capital expenditures related to the purchase of fixed capital and non-current assets. Accounting standards recognised those expenditures related to the maintenance of an asset to the level initially assessed for that asset as expenses for the reporting period, in which they were made, while expenditures related to the improvement of the value of that asset were subject to capitalisation. In international accounting standards, expenditures related to the maintenance of an asset were not reflected within the carrying amount of that asset, while expenditures related to the replacement of component parts of that asset were reflected within the value of that asset for accounting purposes. Government finance statistics recognised expenses as a means of reducing the value of an entity's assets through the investment in non-financial assets, which was not to be equated with current expenditures. Thus, within the regulatory framework for Ukraine, it was possible to conclude that the distinction between current and capital expenditures relates to each of these economic concepts. Such an approach was especially crucial to the accounting for

expenditures related to the protection of critical infrastructure facilities, as the various items that may need to be procured to provide such protection may make it difficult to categorise expenditures as either current or capital expenditures.

At the same time, the regulatory framework for Ukraine does not provide for full clarity in relation to the accounting for these expenditures. More specifically, distinctions between current and capital expenditures within Ukraine were made within the context of budgetary legislation, while accounting standards related to the economic outcomes of those expenditures. Thus, the regulatory framework provided general approaches to the classification of expenditures, but does not provide specific guidance regarding the classification of expenditures that relate to a single measure, but that were made through various procurement items. For this reason, in the field of protection and restoration of critical infrastructure facilities, the issue lies not so much in the formal existence of relevant definitions as in the insufficient alignment between budget classification, accounting recognition, and documentary substantiation of expenditures. It created preconditions for their incorrect classification as either current or capital. A significant contribution to the study of this issue was made by L. Korytnyk (2021), who examined the improvement of reporting by public sector entities, the enhancement of the informational value of cost accounting, and the alignment between national accounting standards and forms of financial and budgetary reporting. To further specify approaches to the practical identification and classification of expenditures, Table 3 presented the key characteristics that may be used for the correct classification of expenditures as current or capital.

Table 3. Key characteristics for the identification and classification of expenditures by public sector entities

| Feature | Characteristic | Significance for the correct classification of expenditures |
|--|--|---|
| Cost object | Costs should be attributed to a specific type of work, service, activity, or measure | Makes it possible to determine, which outcome a cost relates to, rather than identifying it solely by the name of the procurement item |
| Costing object | Costs should be grouped around the final outcome, for which the cost is determined | Allows different procurement items to be grouped within a single measure and their economic substance to be established |
| Method of allocating expenditure to cost | Costs are classified into direct and indirect (overhead) costs | Enables the distinction between costs directly related to a specific measure and those of a supporting nature |
| Direct link between expenditure and results | Direct costs can be directly attributed to the cost of a specific service or measure | The existence of such a link provides a basis for more accurate identification of a cost according to its economic substance |
| Need to allocate expenditure | Indirect costs cannot be directly attributed to a single cost object and are subject to allocation | Helps to avoid the mechanical inclusion of supporting costs in the cost of a specific measure |
| Cost structure | The cost structure should distinguish between direct material costs, direct labour costs, other direct costs, and overhead costs | Forms an analytical basis for verifying the composition of costs and prevents their arbitrary classification |
| Link between expenditure, budgetary funds and operational results | Costs should be recorded in a way that allows the relationship between the use of budgetary funds and performance outcomes to be established | Makes it possible to distinguish between costs related to the payment for results and those associated with maintaining the institution |
| Consistency in approaches to planning, cost accounting and costing | Alignment is required between planning, cost accounting, and cost determination | Reduces the risk of inconsistent interpretation of the same costs at the stages of planning, procurement, accounting, and reporting |

Source: based on T. Yefimenko & L. Lovinska (2016), L. Korytnyk (2022)

Based on the analysis conducted, a criteria-based identification approach to the classification of expenditures on the protection and restoration of critical infrastructure facilities as either current or capital was proposed. Unlike existing regulatory approaches, which were primarily oriented either towards budget classification or towards the general economic outcome of expenditures, the proposed approach involved their assessment based on a set of interrelated criteria: object specificity, functional and result-oriented change in the asset, duration of the effect, project and documentary

integration, structural inseparability of the expenditure, and compensatory verifiability. This made it possible to reduce the risk of misclassification of expenditures as current or capital in situations, where a single measure was implemented through a combination of different procurement items, as well as to strengthen control and enhance the evidential value of accounting documentation for future compensation mechanisms. Table 4 presented the criteria-based identification approach to the classification and distinction of expenditures on the protection and restoration of critical infrastructure facilities.

Table 4. Criteria-based identification approach to distinguishing expenditures on the protection and restoration of critical infrastructure facilities

| Criterion | Content of the criterion | Indicator of capital expenditure | Indicator of current expenditure |
|--|--|---|--|
| Targeting of expenditure to a specific asset | The ability to clearly attribute an expenditure to a specific item of property, plant and equipment, its component, or a distinct protection element | The expenditure is directly related to a specific asset or protection element | The expenditure is of a general, supporting, or operational nature and is not attributable to a specific asset |
| Functional and performance-related change | The impact of the expenditure on the technical condition, functionality, protective capacity, or resilience of the asset | The expenditure results in the creation of a new asset, a new protection element, or the improvement of an existing asset | The expenditure is aimed solely at maintaining, servicing, or restoring the asset to its previously existing level |
| Duration of effect | The duration of the useful effect resulting from the expenditure incurred | The result is of a long-term nature and is used for more than one year or across several reporting periods | The effect is short-term in nature and is consumed within the current period |
| Project and documentary integration | The existence of design and cost estimate, technical, as-built, and acceptance documentation linking the expenditure to a specific measure | The expenditure is included in the project, cost estimate, certificate of completed works, technical decision, or other documentation confirming its role in the creation or improvement of the asset | The expenditure is documented as a separate service, material, or measure without a confirmed link to capitalisation |

Table 4, Continued

| Criterion | Content of the criterion | Indicator of capital expenditure | Indicator of current expenditure |
|--------------------------------|---|---|--|
| Structural inseparability | The degree of necessity of the expenditure for completing the creation or improvement of the asset | Without such expenditure, the asset or protection element cannot be created, commissioned, or perform a new function | The expenditure is not decisive for the creation or improvement of the asset, but merely supports or ensures its operation |
| Nature of resource consumption | The manner in which the acquired works, services, materials, or solutions are utilised | The resource is embodied in the asset, retains its usefulness in future periods, and contributes to the asset's value | The resource is consumed in the course of current operations without forming a separate asset or increasing its value |
| Compensatory verifiability | The possibility of using information about the expenditure as part of the evidence base for compensation of damages | The expenditure can be directly linked to a specific asset, protection measure, investment amount, and the consequences of damage or preservation | The expenditure is of a general nature and cannot be properly identified as a distinct element of a compensation claim |

Source: developed by the author

Based on the data presented in Table 4, it was proposed that the classification of expenditures as current or capital should be carried out not solely on the basis of the formal designation of the transaction, the procurement item, or the code of the economic classification of expenditures, but rather through a system of interrelated evaluation criteria. Such criteria should include: the object-specific nature of the expenditure, its impact on the creation or improvement of an asset, the duration of the resulting effect, project and documentary integration, structural inseparability within the overall set of expenditures, and compensatory verifiability. These criteria should be applied in conjunction with one another. The basis for classifying expenditures as capital lain in confirming their connection with a specific non-current asset, their impact on the creation of a new asset or the improvement of an existing one, the long-term nature of the result, and appropriate documentary substantiation. Conversely, those expenditures, which did not result in the creation of a new asset, which did not result in the alteration of the functional characteristics of an existing asset, which were of a short-term nature, or which were related to the maintenance or operation of an asset should be treated as current. Where expenditures were made that include both current and capital expenditures, each of those components should be classified according to the economic substance of each component rather than the classification of the item that was procured. Such an approach will enable the expenditures to be more accurately classified in situations, in which the protection or restoration of critical infrastructure included both works, services, and materials.

Discussion

The study established that the reconstruction of Ukraine was accompanied by the need to implement comprehensive financial management and control systems. The reconstruction included the restoration of infrastructure facilities, modernisation of public assets, and ensuring

the provision of public services. The optimisation of financial resources played a significant role in reconstruction. The findings of this study were in line with the findings of T. Bogdan (2024) regarding the essential role of public finance in the recovery and reconstruction of Ukraine. The author also determined the need for the efficient allocation of financial resources in the country as a means of contributing to its sustainable development. The establishment of financial control systems provided the preconditions for the stability of public finances and public trust and as a means of providing the environment necessary for the development of the economy of Ukraine. Another question of the study was to determine the role of the accounting for non-financial assets in the management of public finances of Ukraine. The study established that proper accounting for non-financial assets played a vital role in enhancing the reliability of the financial reports of the country. It played a role in the management and decision-making in the management of public finances. These findings were in line with the findings of O. Tsiatkovska *et al.* (2024), who studied the accounting for non-financial assets within the system of public finances of Ukraine. The researchers found the need to enhance the approaches to the accounting for such assets. The findings of the study demonstrated that the timeliness of the accounting processes and the management information systems were vital in the management of public financial resources of Ukraine.

The results of this study demonstrated that the administration of budgetary funds and the management of financial tools within infrastructure projects contributed to the reduction of costs and the increasing of the effectiveness of the reconstruction of these infrastructure facilities. This finding was in line with the conclusions of S. Yudina *et al.* (2025), whose study investigated the approaches to the optimisation of financial management in infrastructure projects. The researchers found that the proper organisation of financial processes within these projects enhanced the effectiveness of the

recovery of the economy of Ukraine. Furthermore, the investigation of financial control within infrastructure projects indicated the decisive role of financial control within the management of public financial resources. The audit, monitoring and evaluation of these projects enabled the identification of violations in the management of public finances, the minimisation of the risks of the misuse of financial resources of the country, and the increase in the accountability of the management of these financial resources. Such findings were in line with the conclusions of H. Filatova *et al.* (2025), who explored the forensic audit of public debt of Ukraine as part of the financial control system of the country. The forensic audit of public debt was a set of procedures that aimed to detect the financial irregularities that existed within the management of the public finances of Ukraine. The procedures included the investigation of the financial documentation of the country and the audit of financial operations to determine whether they were legal, the reliability of the reports that were made by public authorities regarding the management of the country's finances, and the reconstruction of the financial flows of the country with the aim of determining the causes and consequences of the identified financial irregularities. Considerable attention was paid to the assessment of financial risk, the detection of financial manipulation of public finances, and the provision of an evidence base for the decision-making processes of managers or the legal authorities that managed public finances. Thus, the forensic audit of public debt was a tool for both the prevention and investigation of financial irregularities within the management of the finances of the public sector of Ukraine.

Another of the challenges for the accounting field in Ukraine was adapting to the accounting challenges created by the crisis, digitalisation, and the need for transparency in financial reports. The improvement of accounting procedures, the implementation of digital technologies into accounting procedures, and the adoption of internationally recognised accounting standards all have the potential to enhance the efficiency of financial management within the nation's economy. Authors like L. Shevchenko *et al.* (2024) have performed analyses of the accounting challenges within Ukraine, for instance, which revealed the need for the transformation of Ukrainian accounting procedures to those recognised internationally. Specifically, the authors recommend the adoption of International Financial Reporting Standards and International Public Sector Accounting Standards as a means of creating a system that can produce unified methods of reporting financial information. Adapting to these international standards can lead to the increasing transparency of financial reports, the comparability of financial indicators across different countries, and the strengthening of the accountability of those, who managed the nation's budgetary funds. Furthermore, the adoption of internationally recognised standards can

also contribute to the increasing trust in the country's financial system, which will lead to an increase in the ability of the nation to attract investors, and to increase the efficiency of its management of public resources.

To combat the consequences of the military actions within the nation, the Ukrainian government had introduced a series of policies to address these challenges. One of the policies that had been implemented was the introduction of management systems for the government that can enhance the effectiveness of the government in fulfilling its governmental roles. Scientist O. Pivnenko (2023) had published a study on the creation of such organisational mechanisms for the Ukrainian government to effectively implement its policies regarding the overcoming of the consequences of those military actions. The effectiveness of financial control within the government was closely related to the level of development of the government finances and management system. As such, improving the financial control of the government was important to increasing the transparency of those financial systems and improving the accountability of the government in the management of its budgetary funds. Researchers H. Kaletnik & N. Zdyrko (2021) investigated the public financial control system within Ukraine in their publication of an analysis of the state of the system and its challenges, as well as the prospects for developing that system within the government. The principles of financial control were legality of financial procedures, transparency of financial records, efficiency in the use of financial resources, and the detection of violations in financial processes in a timely manner. Each of these components can enhance the trust in financial management systems and their abilities to manage public funds. Additionally, the implementation of modern technologies into the governmental financial management system will enhance its effectiveness.

Another of the challenges of the accounting field within Ukraine was the importance of establishing an internal financial control system within the government's budgetary institutions. The establishment of an effective internal financial control system will ensure that the government can effectively manage its budgetary funds, which will lead to the reduction of the risks of financial issues within the budget, as well as an increase in the accountability of those who manage the funds. The authors L. Ivanchenkova *et al.* (2021) published a research study into methods of improving the internal financial control system of the government regarding its management of budgetary expenditure within crisis conditions. Scientists indicated the need for an improvement to the procedures that were established as part of the government's financial control system. Thus, the recovery of Ukraine's critical infrastructure, as well as the management of the government's public funds, required the establishment of an effective system for accounting for the expenditures of those funds, improving financial control, and the application of modern management

systems. Furthermore, the adoption of the international accounting standards will enhance the transparency and accountability of the financial reports of the Ukrainian government. The success of the recovery of Ukraine's critical infrastructure will rely upon the coordination of governmental finances and management decisions. The methods and strategies that were employed will indicate the necessity of the development of methodological approaches to the accounting for public expenditure, as well as the strengthening of the government's control system over its finances.

Conclusions

Under the conditions of martial law and the process of reconstruction following the war, the issue of the distinction between current and capital expenditures for critical infrastructure facilities had become significant. The variety of objects provided for procurement in the Prozorro system, their division into different categories, and the lack of unified accounting for these expenditures may lead to the misclassification of such expenditures. The result of such misclassification may be the undercapitalisation of critical infrastructure facilities, the distortion of accounting information, and the weakening of financial control. While there were some general approaches established in the regulatory framework for the distinction between current and capital expenditures, the framework lacked the methodological clarity to effectively identify such expenditures. The criteria for their classification related not to the expenditures themselves, but to their substance, their outcome, and their impact on the critical infrastructure facility.

Based on the need to establish such a criterion for the recognition of such expenditures, a criteria-based

approach to the identification of expenditures for the protection of critical infrastructure facilities as either current or capital expenditures was proposed. Such criteria do not relate to the name of the expenditures, the procurement items, or their economic classification codes. Instead, the criteria related to the substance of the expenditures, the critical infrastructure facility related to those expenditures, the impact that such expenditures will have upon that critical infrastructure facility, and the verifiability of those expenditures and impacts. The application of such as criteria will enable the accurate identification of such expenditures, reduce the risk of misclassification, increased the control over public funds, and enhanced the suitability of accounting information for the international compensation mechanisms. The limitations of this analysis were the insufficient level of access to information regarding actual expenditures and damages to critical infrastructure facilities in martial law conditions, and due to the changes to the regulatory framework. Prospects for future research into this topic relate to the digitalisation of tools that may aid in the accounting and control of the expenditures for critical infrastructure restoration, including the integration of such digital tools into the international compensation mechanisms.

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Conflict of Interest

None.

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Обліково-контрольне забезпечення витрат на відновлення об'єктів критичної інфраструктури державного сектору в умовах військового стану та повоєнного відновлення

Михайло Лиценко

Аспірант

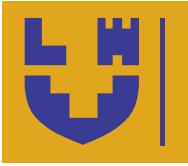
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Анотація. Метою дослідження було вивчення проблем обліково-контрольного забезпечення відновлення об'єктів критичної інфраструктури державного сектору в умовах воєнного стану та повоєнного відновлення. Формування доказової бази щодо завданих втрат вимагало належного документування, систематизації та облікового відображення на основі достовірної й структурованої інформації про пошкоджені або знищені активи, понесені витрати та економічні наслідки. Було встановлено, що 60-70 % значущості у процесі підтвердження збитків забезпечували документально підтверджені дані обліку і реєстрації, тоді як решта припадала на супровідні аналітичні та експертні матеріали, що забезпечували їх інтерпретацію та обґрунтування для подальшого використання у процедурах оцінки та відшкодування. Обґрунтовано, що внаслідок спрощення процедур закупівель, неоднорідності предметів закупівлі в системі Prozorro та відсутності єдиного підходу до облікового визнання витрат зростають ризики їх помилкової класифікації як поточних або капітальних. Структура витрат включає витрати на будівельні та інженерні роботи, проектно-кошторисну документацію, технічний і авторський нагляд, інженерно-консультаційні послуги, придбання матеріалів і обладнання, а також витрати на забезпечення фізичного захисту, укріплення та відновлювальне укриття об'єктів критичної інфраструктури, що у сукупності сформували комплекс витрат на їх відновлення та забезпечення безперервного функціонування. Доведено, що наслідками такої невизначеності стала недокапіталізація витрат, викривлення облікової інформації, послаблення фінансового контролю та зниження доказової придатності даних для міжнародних компенсаційних механізмів. На основі аналізу національних і міжнародних нормативних документів, а також практики закупівель у системі Prozorro встановлено, що ключовим критерієм правильного віднесення витрат була їх економічна сутність, результат здійснення та вплив на актив, а не формальна назва операції чи предмета закупівлі. Застосування критеріально-ідентифікаційного підходу сприятиме підвищенню достовірності облікової інформації, посиленню фінансового контролю, зменшенню ризику недокапіталізації та формуванню належної доказової бази для подальшого відшкодування збитків

Ключові слова: поточні витрати; капітальні витрати; недокапіталізація; фінансовий контроль; компенсаційні механізми



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Social innovation as a driver of household standard of living: Insights from selected states in Nigeria

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Abstract. In developing economies, grassroots-level interventions that reconfigure existing systems showed increasing potential for poverty reduction and welfare enhancement. This study investigated how social innovation dimensions influenced household economic welfare among smallholder farmers in Nigeria. Specifically, it examined the effects of new services/products (farm advisory, crop insurance, weather forecasts), new practices (climate-smart agriculture, organic farming, integrated pest management), and new processes (e-marketing, digital payments, supply chain optimisation) on household standard of living across Adamawa, Kano, and Oyo States. Using a cross-sectional survey design, data was collected from farmers belonging to three agricultural non-governmental organisations KickStart, TechnoServe, and AGRA. Partial Least Squares Structural Equation Modelling revealed that new practices exerted the strongest positive influence on household standard of living ($\beta = 0.669$, $t = 10.183$, $p < 0.000$), followed by new processes ($\beta = 0.322$, $t = 5.299$, $p < 0.000$). New services/products showed a negative but significant effect ($\beta = -0.150$, $t = 2.555$, $p = 0.011$), suggesting implementation challenges or adoption barriers. The combined model explained 69.4% of variance in household standard of living ($R^2 = 0.694$). Economic indicators showed that 56.1% of farmers reported revenue increases from new products, while 48.3% experienced enhanced productivity through innovative practices. The findings confirmed that social innovation significantly drove household economic welfare among Nigerian smallholder farmers. Practically, these results provided evidence-based guidance for NGOs and policymakers to prioritise capacity-building in sustainable farming practices and digital agricultural processes, while addressing barriers in service/product uptake to maximise poverty reduction outcomes

Keywords: agricultural innovation; farmer livelihoods; new services/products; new practices; new processes; poverty alleviation

Introduction

Persistent poverty and poor living conditions remained major challenges in many developing countries. Approaches that work from the ground up, using local knowledge and community action, had shown more lasting results than top-down programmes. Nigeria presented a clear case for studying such approaches, especially in states, where smallholder farmers faced compounding economic and environmental pressures. A.A. Nova *et al.* (2024) explored subjective quality-of-life indicators in long-term care settings and found direct links between implementing innovative service models

and measurable improvements across multiple well-being dimensions. The authors used a mixed-methods design across several care facilities, demonstrating that structured, evidence-based interventions consistently raised life satisfaction, social participation, and economic security. These findings highlighted how organised, community-level interventions can help build populations that depend less on external aid over time. D. Dushkova & O. Ivlieva (2024) conducted a semi-systematic review of 21 community empowerment programmes targeting sustainability and resilience. Researchers

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found that programmes, which strategically reorganised local resources and community capital generated significant human development gains beyond what state institutions alone could achieve. The authors confirmed that empowered local action supplements formal government capacity, particularly in underserved regions. Financial stability and food security were among the most direct benefits of community-level innovation. A. Alfiana *et al.* (2025) studied cooperative finance and mobile technology programmes in Nigerian states including Lagos and Anambra. Scientists found these initiatives substantially expanded capital access for previously unbanked households, enabling them to manage economic shocks, invest in small businesses, and maintain more stable consumption. O. Corrigan *et al.* (2024) confirmed that locally adapted, collaborative models also contributed meaningfully to both economic stability and broader household wellbeing.

M. Espinoza *et al.* (2024) conducted a three-wave experimental study in rural Peru to test whether social innovation programming produced measurable household welfare gains. Researcher's findings showed statistically significant improvements in economic wellbeing, food information access, and community cohesion among participating households. The programme helped farmers shift from traditional subsistence farming to more specialised, entrepreneurial activities, raising family incomes and building resilience during COVID-19. G.M. Eichler & E.J. Schwarz (2019) reviewed published social innovation case studies and found that most projects target health and wellbeing outcomes, with significant consequences for developing nations. Their review emphasised that social entrepreneurs, NGOs, and civil society organisations play a central role in nurturing these innovations. Digital tools and services carry both promise and risk for low-income households. H. Shan & M. Gu (2024) cautioned that digital financial technologies can produce unintended consequences, including debt accumulation among households with limited financial literacy. F. Joudar & O. El Ghmari (2025) stressed that strong consumer protection frameworks were essential to prevent financial inclusion tools from destabilising household economies. Given this mixed evidence, this study investigated how different dimensions of social innovation affect household standard of living among smallholder farmers in Adamawa, Kano, and Oyo States. Three hypotheses guided the study: H1: New services/products have a positive influence on household standard of living. H2: New practices have a positive influence on household standard of living. H3: New processes have a positive influence on household standard of living. The research objectives were: 1) to determine the effect of new services/products on household standard of living; 2) to investigate the influence of new practices on household standard of living; 3) to examine the influence of new processes on household standard of living.

Literature Review

Researchers S. Carrasco *et al.* (2024) noted that social innovation referred to new ideas, practices, and organisational forms that met social needs, while strengthening community relationships and resilience. This indicates that social innovation helps in generating new ideas and organisational forms, which helps to develop the organisation. Y. Chandra (2017) described this process as one that transformed power dynamics and mobilised resources in ways that challenge and eventually reshaped institutional structures. This implied that social innovation brought about transformation within firms. W. Fan *et al.*, (2024) stated that household standard of living goes beyond income to include access to education, healthcare, nutrition, housing quality, and the capacity to absorb economic shocks. This was to say that standard of living can improve with strong focus on social needs rather than its common index. S. Sarwar *et al.* (2019) linked welfare measurement to A. Sen's (2001) capability approach, which centres on people's freedom to live a life they value. As living the life they value helped their social life and enhanced their standard of living. A. Deaton (2018) argued that single monetary indicators failed to capture the full picture and that multidimensional analysis was necessary for accurate welfare assessment. Hence, focus should be more on the multidimensional analysis for adequate welfare assessment. H. Teklewold *et al.* (2019) demonstrated that sustainable farming methods, including conservation tillage and integrated pest management, boosted farm yields and revenues in Ethiopia, while maintaining environmental sustainability. This supported the dominant effect of new practices in this study, where climate-smart agriculture, organic farming, and integrated pest management showed the highest combined impact on standard of living. D. Karlan *et al.* (2014) found that formal savings programmes and budgeting support helped rural households smooth consumption during lean periods and invest in income-generating activities. Social Capital Theory, developed by J.S. Coleman (1988) and extended by R.D. Putnam (2001), held that social networks, trust, and reciprocity generate resources that promoted collective action and individual improvement.

Regarding sustainability, M. Espinoza *et al.* (2024) conducted 3-waves of household-inferenced data collected before, after, and during-programme participation, determined that social innovation programming had statistically significant drastic impacts on economic well-being of households, access to information on food and community perspective. This intervention helped design the further shift of traditional farming to more upholder, entrepreneurial, and specialised activity, increasing the level of family income and investment in being able to overcome the COVID-19 pandemic with a mountainous expenditure. It was concluded in the paper that social innovation was effective in reorganising livelihood of households and improve welfare,

particularly during the external shock. G.M. Eichler & E.J. Schwarz (2019) noted that the investigation of which Sustainable Development Goals (SDGs) sustainable innovations reduced, in relation to which sustainability areas was conducted systematically and was content-analysed in a systematic review and content analysis of the literature on social innovations. Such published article case studies were analysed and sorted. Its findings also indicated that the majority of the social innovation projects aimed at enhancing health and well-being with dire consequences of well-being in developing nations. It was also essential that among the latter actors, social entrepreneurship, and Arab world NGOs, social institutions, and civil societies, among others, as agents of nurturing such innovations were part of the alternatives as well as emphasised in the review. The authors discovered how social innovation had been such an influential process of household and community well-being yet the domain was in its development. So, farmers-led social innovation implementation had potential to be used as an augmentation of externalised promoted technologies to enhance food security and relieve rural poverty.

Materials and Methods

A cross-sectional survey design was employed to collect primary data. The study, conducted between August 2024 and January 2025, targeted smallholder farmers enrolled in poverty reduction agricultural programmes operated by three NGOs: KickStart (n.d.), TechnoServe (n.d.), and AGRA (n.d.). These organisations maintained operational offices in Adamawa, Kano, and Oyo States, with headquarters in Lagos and Abuja. A purposive sampling approach was adopted to ensure manageable data collection and in-depth analysis. Ten farmers were selected from each organisation (N = 30 total), chosen based on active programme participation for at least two years and willingness to participate. This reduced sample size allowed for more detailed qualitative insights, while maintaining representation across all three NGOs. Additionally, focus group discussions were conducted with nine NGO representatives (three per organisation) to triangulate farmer responses. A structured questionnaire comprised five sections: Section A: demographic information – age, gender, education level, household size, farming experience. Section B: New services/products (3 items): 1) new farm products, which I produce through NGO training have increased my revenue; 2) I have been constantly working towards producing new farm products based on training experience, which increases my profits; 3) the NGO programme has helped increase product variety, assisting in increasing my revenue streams. Section C: New practices (3 items): 1) new farming ideas practiced during NGO training have increased my farming productivity level; 2) new farming methods practiced during NGO training have increased farm outputs using minimal time; 3) mixed farming practice has helped me generate more yield, in-

creasing my productivity level. Section D: New processes (3 items): 1) the change from traditional to modern farming processes has increased my production rate as a trained farmer; 2) using technological farming processes learned during training has led to increased farm produce; 3) soil preparation has helped increase my farmland's productivity level. Section E: Household standard of living (4 items): 1) my farm produce has been a major source of my improved standard of living; 2) my well-being as a trained farmer has improved due to large farm outputs; 3) as a trained farmer, I now live a quality life due to increased profits from farm produce sales; 4) I have more economic opportunities through farming due to increased farming transactions. All items used a 5-point Likert scale: Strongly Disagree (1), Disagree (2), Undecided (3), Agree (4), Strongly Agree (5).

Construct validity was assessed using convergent and discriminant validity techniques. Convergent validity was established through Average Variance Extracted (AVE > 0.50). Discriminant validity was evaluated using the Fornell-Larcker criterion, which required that the square root of each construct's AVE exceeded its correlations with other constructs, confirming that constructs were empirically distinct. Internal consistency was demonstrated using Cronbach's Alpha Coefficient ($\alpha > 0.70$). Partial Least Squares Structural Equation Modelling (PLS-SEM) using SmartPLS 4.0 software served as the inferential statistical technique. PLS-SEM was chosen for its effectiveness with small sample sizes and non-normal data distributions. The analysis evaluated both measurement model (outer model) and structural model (inner model). The latent variable covariance was used to access the correlation between the latent variables of the R-squared (R^2) coefficient was calculated to determine the proportion of variance in household standard of living explained by social innovation dimensions, with values above 0.25 considered moderate effects. Household standard of living was the dependent variable, while social innovation dimensions constituted independent variables. The structural equation model was specified as:

$$HSL = f(NSP[FA + CI + WF] + NPT[CSA + OF + IPM] + NPC[EM + DP + SCO]), \quad (1)$$

where HSL – Household standard of living, NSP – New services/products, FA – Farm advisory, CI – Crop insurance, WF – Weather forecast, NPT – New practices, CSA – Climate-smart agriculture, OF – Organic farming, IPM – Integrated pest management, NPC – New processes, EM – E-marketing, DP – Digital payment, SCO – Supply chain optimisation. The model hypothesised that social innovation dimensions (NSP, NPT, NPC) collectively and individually influenced household standard of living. PLS-SEM algorithm was run with 5,000 bootstrapping iterations to generate path coefficients, t-statistics, and p-values for hypothesis testing at 95% confidence level ($\alpha = 0.05$). Model fit was assessed through R^2 , f^2 , and path

coefficient significance levels. Analysis statistics were obtained using the SmartPLS programme. The Declaration of Helsinki (2013) was used in the conduct of the study.

Results and Discussion

It was presented findings from the PLS-SEM analysis examining how three social innovation dimensions, namely new services/products, new practices, and new processes, influenced household standard of living among smallholder farmers. Three hypotheses were tested: H1 (new services/products positively influence household standard of living), H2 (new practices positively influence

household standard of living), and H3 (new processes positively influence household standard of living). The path model in Figure 1 showed the structural relationships between these constructs and the dependent variable. Results supported H2 and H3 but refuted H1, with new services/products showing a significant negative effect. In order to evaluate the effect of social innovation on household standard of living, variables such as new services/products (NSP), new practices (NPtc), and new process (NPro) were considered in the analysis as constructs for social innovation against household standard of living (ISL).

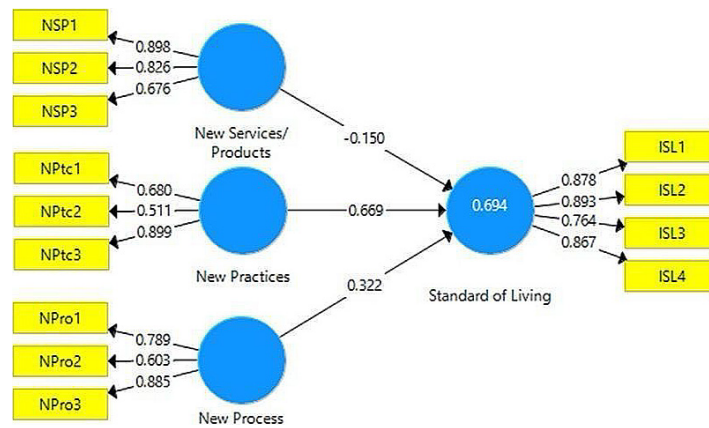


Figure 1. A path model of social innovation and improved standard of living

Source: developed by the author

Figure 1 showed the path model linking three social innovation constructs to improved standard of living ($R^2 = 0.694$). New practices (NPtc) showed the strongest path coefficient ($\beta = 0.669$) toward the dependent variable, with indicator loadings of 0.680 (NPtc1), 0.511 (NPtc2), and 0.899 (NPtc3), confirming that this construct was well-represented by its indicators. New process (NPro) showed a moderate positive path ($\beta = 0.322$) with loadings of 0.789 (NPro1), 0.603

(NPro2), and 0.885 (NPro3). New services/products (NSP) showed a negative path ($\beta = -0.150$) with loadings of 0.898 (NSP1), 0.826 (NSP2), and 0.676 (NSP3). The outcome variable had loadings of 0.878 (ISL1), 0.893 (ISL2), 0.764 (ISL3), and 0.867 (ISL4), all above the 0.50 threshold. Since all outer loadings exceed or approach 0.50, the measurement model was acceptable and no indicators needed to be dropped. Table 1 showed the path coefficient matrix.

Table 1. Path coefficient of the study variables

| | Standard of living | New practices | New practices | New services/products |
|-----------------------|--------------------|---------------|---------------|-----------------------|
| Standard of living | | | | |
| New practices | 0.669 | | | |
| New process | 0.322 | | | |
| New services/products | -0.150 | | | |

Note: other columns are left empty, as they represent independent paths directed toward the dependent variable

Source: developed by the author

New practices and new processes both contributed positively to an enhanced standard of living, but new services and products had a negative impact. New practices recorded the highest path coefficient ($\beta = 0.669$), meaning that adoption of improved farming methods contributed most to household welfare improvement. New processes followed with a coefficient of 0.322, indicating that digital and modern farming processes also

made a meaningful contribution. New services/products recorded a negative coefficient ($\beta = -0.150$), suggesting that in the short term, exposure to new products and services may create costs or adoption burdens that outweigh benefits for this population. The factors identified play a major role in predicting the standard of living in the research population. Table 2 showed the discriminant validity of the study variables.

Table 2. Discriminant validity of the study variables

| | Standard of living | New practices | New process | New services/products |
|-----------------------|--------------------|---------------|-------------|-----------------------|
| Standard of living | 0.852 | | | |
| New practices | 0.801 | 0.714 | | |
| New process | 0.725 | 0.712 | 0.768 | |
| New services/products | 0.498 | 0.692 | 0.576 | 0.805 |

Source: developed by the author

Discriminant validity was established for all constructs using the Fornell-Larcker criterion. This criterion required that the square root of each construct's AVE value exceeded its highest correlation with any other construct, confirming that each construct captured more unique variance than shared variance with others. For every outcome, the values displayed under

the related variables are higher than the values of every other variable for each column; for example, standard of living was 0.852, which was higher than 0.801, 0.725, and 0.498. The results validated discriminant validity, confirming that the components of the structural model were empirically distinct from one another. Table 3 presented the R-square values for the dependent variable.

Table 3. R-square of the study variables

| | R-square | R-square adjusted |
|-----------------------------|----------|-------------------|
| Improved standard of living | 0.694 | 0.692 |

Source: developed by the author

The combined model of social innovation represented by new services/products, new practices, and new processes accounts for 69.4% of the variance in standard of living ($R^2 = 0.694$). Since the detected factors had an impact on standard of living, this was a moderate to strong effect (i.e., the variation was more than 25%), meaning that the remaining 30.6% was

caused by additional variables not included in the model. There was no multicollinearity issue since tolerance in this dataset was larger than 0.25 at the extreme. The adjusted R^2 of 0.692 was comparable to the uncorrected R-square, as there were few variables in this model. Table 4 showed the latent variable covariance among all constructs.

Table 4. Latent variable covariance of the study variables

| | Standard of living | New practices | New process | New services/products |
|-----------------------|--------------------|---------------|-------------|-----------------------|
| Standard of living | 1.000 | 0.801 | 0.725 | 0.498 |
| New practices | 0.801 | 1.000 | 0.732 | 0.692 |
| New process | 0.725 | 0.732 | 1.000 | 0.576 |
| New services/products | 0.498 | 0.692 | 0.576 | 1.000 |

Source: developed by the author

The standard of living construct shared the highest covariance with new practices (0.801), followed by new processes (0.725) and new services/products (0.498). New practices also showed strong covariance with new processes (0.732) and new services/products (0.692), suggesting these innovation dimensions were interrelated. New processes and new services/products shared a covariance of 0.576. These patterns

confirmed that, while each construct was empirically distinct, it operated within a connected innovation system. The relatively lower covariance between new services/products and standard of living (0.498) was consistent with the negative path coefficient found in Table 1, pointing to limited welfare transfer from this dimension under current conditions. Table 5 depicted F-square of the study variables.

Table 5. F-square of the study variables

| | Standard of living | New practices | New process | New services/products |
|-----------------------|--------------------|---------------|-------------|-----------------------|
| Standard of living | | | | |
| New practices | 0.519 | | | |
| New process | 0.154 | | | |
| New services/products | 0.038 | | | |

Source: developed by the author

The bootstrapping procedure used 5,000 resamples to generate stable estimates of path coefficients, standard errors, t-statistics, and p-values. Any

T-value above 1.96 was significant at a 95% confidence interval and 5% significance level. As shown in Table 5, the F-square values revealed that new

practices have the largest effect size ($f^2 = 0.519$), which classified as a large effect according to J. Cohen's (1988) benchmarks (small = 0.02, medium = 0.15, large = 0.35). New processes ($f^2 = 0.154$) represented a medium effect, meaning it made a meaningful but secondary contribution to explaining variance in household standard of living. New services/products ($f^2 = 0.038$) fell within

the small effect range, which, combined with its negative path coefficient, suggested this dimension had limited practical impact on welfare outcomes in the current study context. Table 6 presented the bootstrapping path coefficients confirming that all three social innovation dimensions significantly predicted household standard of living.

Table 6. Bootstrapping path coefficients of the study variables

| | Original sample (O) | Sample mean (M) | Standard deviation (STDEV) | T-statistics (O/STDEV) | P-values |
|---|---------------------|-----------------|----------------------------|--------------------------|--------------|
| New practices -> Standard of living | 0.669 | 0.690 | 0.068 | 10.183 | 0.000 |
| New process -> Standard of living | 0.322 | 0.301 | 0.057 | 5.299 | 0.000 |
| New services/products -> Standard of living | -0.150 | -0.148 | 0.059 | 2.555 | 0.011 |

Source: developed by the author

New practices, new processes, and new services/products were all shown to be significant predictors. These findings suggested that the sampled farmers' standard of living was influenced by social innovation indicators, and that more attention must be paid to bolstering new services and products, upholding new practices, and developing innovative farming methods to significantly reduce poverty among the sampled respondents. The study's findings showed complex relationships between social innovation dimensions and household standard of living improvements among Nigerian smallholder farmers. All three constructs were statistically significant, though with different directionalities and effect magnitudes. African studies validate this framework, with C. Grootaert & T. van Bastelaer (2002) demonstrating linkages between social innovation initiatives and household welfare outcomes. N.S. Akpan (2014) found that social capital mobilisation improved rural infrastructure in Nigeria. E.E. Osaghae (2015) showing that stronger social networks achieved equitable resource distribution. O.J. Okwu (2011) demonstrating that farmer cooperatives leveraging social capital achieved better market access and income improvements than individual farmers. J.A. Tambo & T. Wünscher (2017) found that farmer-led innovations in Ghana significantly increased household earnings, consumption, and food security, particularly, where farmers made incremental improvements to existing techniques. This aligned with the strong positive effect of new practices found here ($\beta = 0.669$, $f^2 = 0.519$), confirming that hands-on farming method improvements translated directly into welfare gains. J. Bussell (2019) showed that digitising government service delivery reduced transaction costs and simplified welfare programme access for households. This was consistent with the positive effect of new processes ($\beta = 0.322$, $f^2 = 0.154$), where modern farming processes and digital tools contributed meaningfully to household welfare. R. Martin (2022) found that labour-saving process innovations redistributed household time, especially for women, toward more productive activities, and this mechanism may partly explain the positive and

significant effect of new processes, as farmers using modern methods report increased output with reduced time input. B. Edwards & M.W. Foley (1998) critically reconsidered the concept of social capital, demonstrating that it cannot be reduced solely to trust and civic participation, as suggested by Robert Putnam, but should instead be analysed within the broader framework of civil society. The authors emphasised that social capital possessed political and institutional dimensions, which may both strengthen democratic processes and reproduce social inequalities. N. Lin (2004) developed a comprehensive theory of social capital as a resource embedded in social structures and utilised by individuals to achieve their goals. Scientist demonstrated that access to networks and one's position within the social hierarchy directly determined the capacity to mobilise resources and facilitate social mobility. A. Portes (2014) drew attention to the negative aspects of social capital, particularly its potential to constrain individual freedom and reinforce closed social groups. Researcher showed that social networks may contribute not only to support and cohesion but also to exclusion, social pressure, and the persistence of inequality.

T. Suri & W. Jack (2016) found that mobile money services substantially improved household consumption in Kenya. The negative effect of new services/products in this study ($\beta = -0.150$) appeared to contradict this finding. However, researchers studied a mature mobile money ecosystem, while this study examined early-stage agricultural advisory and insurance services among farmers, who faced significant infrastructure and literacy constraints. B.S. Thapa *et al.* (2025) cautioned that financial services and new products can generate debt and financial stress among low-literacy populations, which may partly explain this negative result, as adoption costs and learning requirements can outweigh short-term benefits for smallholder farmers. Several additional mechanisms may explain this finding. First, cross-sectional data capture immediate conditions, potentially missing delayed benefit realisation from farm advisory services, crop insurance, and weather forecasting, which required time

for competency development. Second, services may suffer from poor delivery or misalignment with farmer needs, as B.D. Christens & P.T. Inzeo (2015) emphasised that programmes fail, when externally imposed rather than co-created. Third, farmers lacking smartphones, internet connectivity, or digital literacy cannot fully utilise app-based services, incurring costs without proportional benefits. D. Acemoglu & P. Restrepo (2020) noted that resources allocated to service subscriptions may divert funds from more immediately productive investments in seeds or fertilizers, creating short-term negative effects despite potential long-term gains. The finding that new practices demonstrated effect sizes more than triple those of new processes and more than thirteen times those of new services/products provided clear intervention prioritisation guidance. B. Leubold *et al.* (2017) explained that participatory, practice-oriented innovations enabled households to become change agents rather than passive recipients, building capabilities that compounded over time. The model's 69.4% variance explanation represented robust predictive power, though the remaining 30.6% suggested that factors beyond the model scope, including land size, market access, household composition, external shocks, and policy environments, also meaningfully influenced welfare outcomes.

Conclusions

This study examined how social innovation dimensions influenced household standard of living among smallholder farmers in Adamawa, Kano, and Oyo States. The PLS-SEM analysis explained 69.4% of variance in household standard of living ($R^2 = 0.694$). New practices exerted the strongest positive influence ($\beta = 0.669$, $t = 10.183$, $p < 0.001$, $f^2 = 0.519$), confirming H2. This finding demonstrated that capacity-building in climate-smart

agriculture, organic farming, integrated pest management, and mixed farming systems constituted the most impactful intervention for farmer welfare enhancement. New processes showed a significant positive effect ($\beta = 0.322$, $t = 5.299$, $p < 0.001$, $f^2 = 0.154$), confirming H3, indicating that e-marketing platforms, digital payment systems, and supply chain optimisation meaningfully contributed to welfare improvements. New services/products showed a negative significant effect ($\beta = -0.150$, $t = 2.555$, $p = 0.011$, $f^2 = 0.038$), refuting H1, suggesting that farm advisory services, crop insurance, and weather forecasting impose short-term adoption costs that exceeded immediate benefits, or required longer time horizons for benefit realisation. These findings confirmed that social innovation significantly drives household standard of living in selected Nigerian states, though effectiveness varies across innovation types. NGOs and development stakeholders should prioritise intensive farmer training in sustainable agricultural practices, while strategically addressing barriers limiting the effectiveness of digital services and products to maximise poverty reduction outcomes. Future studies should use longitudinal designs, qualitative methods, and comparative cross-regional approaches to clarify the temporal dynamics, implementation barriers, and interaction effects among social innovation dimensions.

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Conflict of Interest

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Соціальні інновації як чинник підвищення рівня життя домогосподарств: результати дослідження окремих штатів Нігерії

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Анотація. У країнах, що розвиваються, ініціативи на рівні місцевих громад, спрямовані на трансформацію наявних систем, демонстрували зростаючий потенціал щодо зменшення бідності та підвищення добробуту. У цьому дослідженні проаналізовано, як різні виміри соціальних інновацій впливали на економічний добробут малих фермерських господарств у Нігерії. Зокрема, було оцінено вплив нових послуг/продуктів (консультаційна підтримка фермерів, страхування врожаю, погодні прогнози), нових практик (кліматично розумне землеробство, органічне виробництво, інтегроване управління шкідниками) та нових процесів (електронний маркетинг, цифрові платежі, оптимізація ланцюгів постачання) на рівень життя домогосподарств у штатах Адамава, Кано та Ойо. Застосовано перехресний (крос-секційний) дизайн опитування; дані дослідження було зібрано серед фермерів, які були членами трьох аграрних неурядових організацій: KickStart, TechnoServe та AGRA. Моделювання структурними рівняннями за методом часткових найменших квадратів показало, що нові практики мали найсильніший позитивний вплив на рівень життя домогосподарств ($\beta = 0,669$; $t = 10,183$; $p < 0,000$), далі – нові процеси ($\beta = 0,322$; $t = 5,299$; $p < 0,000$). Нові послуги/продукти продемонстрували негативний, але статистично значущий ефект ($\beta = -0,150$; $t = 2,555$; $p = 0,011$), що свідчило про проблеми впровадження або бар'єри прийняття. Сукупна модель пояснила 69,4 % варіації рівня життя домогосподарств ($R^2 = 0,694$). Економічні показники засвідчили, що 56,1 % фермерів повідомили про зростання доходів від використання нових продуктів, тоді як 48,3 % відзначили підвищення продуктивності завдяки інноваційним практикам. Отримані результати підтвердили, що соціальні інновації суттєво впливають на економічний добробут домогосподарств малих фермерів у Нігерії. Практичне значення дослідження полягає у наданні доказової бази для неурядових організацій та політиків щодо пріоритетності розвитку потенціалу у сфері сталих аграрних практик і цифрових процесів, а також необхідності подолання бар'єрів у впровадженні послуг/продуктів для максимізації ефектів зниження бідності

Ключові слова: аграрні інновації; засоби існування фермерів; нові послуги/продукти; нові практики; нові процеси; подолання бідності

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