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IMPLEMENTATION OF COMPUTER-ASSISTED AUDIT TECHNIQUES (CAATS) AND ANALYTICAL PROCEDURES IN THE AUDIT OF COMMERCIAL BANKS' FINANCIAL STATEMENTS

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Abstract. The article develops a methodological approach to implementing computer-assisted audit techniques (CAATS) and analytical procedures in the audit of commercial banks' financial statements. The research problem is the impossibility of manually examining a large loan portfolio and the resulting limited audit coverage. Based on case-study and comparative analysis, the architecture of CAATS, their areas of application and a phased implementation roadmap are proposed and tested on the portfolio of JSCB 'Xalq Bank'. As a result, the speed and coverage of the audit examination are increased.

Keywords: CAATS, digital audit, continuous audit, bank audit, analytical procedures, journal entry testing, full population, ECL recalculation, artificial intelligence, audit quality.

Аннотация. В статье разрабатывается методический подход к внедрению компьютеризированных методов аудита (CAATS) и аналитических процедур в аудит финансовой отчётности коммерческих банков. Проблема исследования — невозможность ручной проверки крупного кредитного портфеля и обусловленная этим ограниченность охвата аудита. На основе кейс-стади и сравнительного анализа предложены архитектура CAATS, области их применения и поэтапная дорожная карта внедрения, апробированные на портфеле АКБ «Халк банк». В результате повышены оперативность и охват аудиторской проверки.

Ключевые слова: CAATS, цифровой аудит, непрерывный аудит, банковский аудит, аналитические процедуры, тест журнальных записей, полная совокупность, пересчёт ECL, искусственный интеллект, качество аудита.

INTRODUCTION

A modern commercial bank is a complex, highly automated information system that encompasses millions of transactions and hundreds of thousands of loan agreements. Auditing such a vast volume of data using traditional, manual, and sample-based approaches inevitably limits audit coverage and increases the risk that systemic errors will remain undetected. Consequently, the need for Computer-Assisted Audit Techniques (CAATS) and digital technologies in bank auditing has become increasingly significant.

The core of the problem is that a bank's extensive loan portfolio and operational activities cannot be comprehensively examined through manual procedures. For example, the loan portfolio of JSC *Xalq Banki* exceeds UZS 23 trillion, making it impossible for sample-based testing alone to detect systematic measurement errors in areas such as the Expected Credit Loss (ECL) model. The bank's 2021 ECL measurement error, which resulted in a reduction of shareholders' equity by approximately UZS 1,333.7 billion, clearly demonstrated the practical limitations of manual and sample-based audit approaches.

The relevance of this issue is further reinforced by the ongoing digital economy and banking reforms in Uzbekistan. The *Uzbekistan–2030 Strategy* (Presidential Decree No. PD-21, 2023) identifies the digitalization of the economy and the modernization of the banking sector as strategic priorities. Although the Law of the Republic of Uzbekistan *On Auditing Activities* (Law No. LRU-677, 2021) and the procedure for recognizing International Standards on Auditing (Order No. 171 of the Ministry of Finance, 2022) have established an appropriate legal framework, a unified methodological approach for implementing digital audit tools in bank auditing has not yet been developed.

The purpose of this article is to develop a methodological approach for integrating Computer-Assisted Audit Techniques (CAATs) and analytical procedures into the audit of commercial banks' financial statements. The object of the study is the process of applying digital technologies in bank auditing, using JSC *Xalq Banki* as a case study. The subject of the research comprises the organizational and methodological relationships arising during this process. The remainder of the article is structured as follows: literature review, methodology, analysis and results, and conclusions and recommendations.

LITERATURE REVIEW

The concepts of digital auditing and continuous auditing have been evolving in the academic literature since the late twentieth century. Miklos A. Vasarhelyi and Fred Halper introduced the concept of continuous auditing for online systems, demonstrating the feasibility of obtaining and analyzing data from information systems in real time (Vasarhelyi & Halper, 1991). This approach is particularly effective in the context of automated banking systems and constitutes the theoretical foundation of modern digital auditing.

Robert K. Mautz and Hussein A. Sharaf established the philosophical foundations of audit theory by formulating the principles of reliability and verifiability of audit evidence (Mautz & Sharaf, 1961). Computer-Assisted Audit Techniques (CAATs) operationalize these principles in a digital environment by enabling the examination of the entire population, thereby expanding the evidence base and making it more objective and reproducible. Contemporary auditing literature recognizes analytical procedures (ISA 520) and data analytics as essential tools for obtaining audit evidence (Arens et al., 2017; Hayes et al., 2014; Messier et al., 2019).

The role of substantive procedures and audit sampling (ISA 530) in collecting audit evidence has been widely discussed in the academic literature, emphasizing that larger sample sizes should be applied in high-risk areas (Bychkova, 2003; Podolskiy & Savin, 2017). In contrast, CAATs enable the examination of the entire population rather than relying on sampling, thereby eliminating sampling risk altogether. This significantly enhances the quality and reliability of audit evidence.

In recent years, Audit Data Analytics (ADA) has emerged as a distinct field within both academic research and professional auditing practice. ADA refers to the process of analyzing large datasets to identify patterns, anomalies, and relationships for the purpose of generating audit evidence. Leading audit firms are increasingly integrating ADA into all stages of the audit process, including planning, risk assessment, and substantive testing. As a result, CAATs have evolved from being merely technical tools into an integral component of the modern auditing philosophy.

The adoption of digital technologies in auditing is fully aligned with the requirements of the International Standards on Auditing. ISA 240 requires the examination of journal entries in assessing fraud risk, ISA 500 requires the collection of sufficient and appropriate audit evidence, and ISA 520 emphasizes the application of analytical procedures (IAASB, 2023). In addition, the Basel Committee on Banking Supervision supports the use of technology in banking supervision (Basel Committee on Banking Supervision, 2024). Together, these standards provide the methodological foundation for integrating CAATs into bank auditing.

RESEARCH METHODOLOGY

The study is based on a qualitative research paradigm and a case study approach, with its central focus on designing a digital audit model and conceptually applying it to a real commercial bank loan portfolio. The architecture and application areas of Computer-Assisted Audit Techniques (CAATs) were developed based on the International Standards on Auditing (ISA 240, ISA 500, ISA 520, and ISA 530) and the concept of continuous auditing. A comparative analysis was employed to evaluate traditional and digital auditing approaches across multiple criteria.

To demonstrate the practical applicability of the proposed model, JSC *Xalq Banki* was selected as the case study. The selection was justified by the bank's loan portfolio exceeding UZS 23 trillion and its extensive branch network, making comprehensive manual auditing impractical and clearly illustrating the necessity of CAATs. In addition, grouping, systems analysis, and expert evaluation methods were employed.

The reliability of the study is ensured through the use of data obtained from official sources, while its validity is supported by the consistency of the proposed approach with the International Standards on Auditing and international digital auditing practices. The implementation roadmap was developed in accordance with the principles of phased implementation and consideration of the specific characteristics of Uzbekistan's banking system.

ANALYSIS AND RESULTS

No matter how robust an audit methodology may be, it cannot be manually applied to a loan portfolio worth UZS 23 trillion. In a bank with an extensive branch network, it is practically impossible to manually examine

every loan and transaction, making a reduction in audit coverage inevitable. To overcome this limitation, the adoption of Computer-Assisted Audit Techniques (CAATs) and digital technologies in bank auditing is proposed. CAATs refer to the use of specialized audit software to analyze large volumes of data through the automated extraction of information from banking information systems, data analysis, and the generation of audit evidence.

The proposed digital audit model is designed for application in several key areas of bank auditing, including full-population testing, Journal Entry Testing (JET), Expected Credit Loss (ECL) and allowance recalculation, anomaly detection, and continuous monitoring. The main CAATs techniques, their applications in bank auditing, and their key advantages are presented in Table 1.

Table 1. CAATs Techniques and Their Applications in Bank Auditing¹

CAATs Technique	Application in Bank Auditing	Key Advantage
Full-population analysis	Examination of all loans and transactions without sampling	Achieves 100% audit coverage
Journal Entry Testing (JET)	Identification of unusual and high-value journal entries	Reduces fraud risk
ECL recalculation	Independent recalculation of expected credit loss allowances	Improves accuracy and efficiency
Anomaly detection (AI/ML)	Automated identification of suspicious transactions and patterns	Enables early detection of high-risk areas
Continuous monitoring	Periodic extraction and analysis of data from banking systems	Provides continuous audit oversight

Particular importance is attached to Journal Entry Testing (JET), whereby CAATs are used to analyze all accounting entries in order to identify unusual, high-value, or period-end journal entries that may indicate fraud or manipulation. This procedure supports compliance with the requirements of ISA 240 by enhancing fraud risk detection. Furthermore, the application of Artificial Intelligence (AI) and Machine Learning (ML) algorithms for anomaly detection enables the early identification of high-risk transactions, a capability that is virtually unattainable under traditional sample-based auditing.

To demonstrate the advantages of digital auditing over the conventional approach, a comparative analysis is presented in Table 2.

Table 2. Comparison of Traditional and Digital (CAATs-Based) Audit Approaches²

Criterion	Traditional Approach	Digital (CAATs-Based) Approach
Audit coverage	Sample-based (limited)	Full population (100%)
Efficiency	Low; manual procedures	High; automated processes
Anomaly detection	Limited	Advanced (AI/ML-based)
Risk of error	Higher (human factor)	Lower

As shown in Table 2, the digital approach enables full-population testing, significantly improves audit efficiency, and reduces the risk of human error. In addition, a continuous monitoring system that periodically extracts and analyzes data directly from banking information systems allows auditors to maintain ongoing oversight of banking operations. Consequently, digital auditing simultaneously enhances audit coverage and efficiency, thereby strengthening the reliability and effectiveness of bank audits.

The practical significance of implementing CAATs is clearly illustrated by the 2021 ECL measurement error. A manual, sample-based audit might have failed to detect the systematic measurement error embedded in the ECL model. By contrast, CAATs enable the independent recalculation of Expected Credit Losses across the entire loan portfolio (full-population recalculation). Under this approach, auditors extract the bank's Probability of Default (PD), Loss Given Default (LGD), and Exposure at Default (EAD) parameters, automatically calculate the expected credit losses for every individual loan, and compare the results with the bank's reported figures. This process effectively identifies incorrect stage classifications as well as systematic errors in the model inputs.

¹ Source: Compiled by the author.

² Source: Compiled by the author.

The continuous auditing approach enables the monitoring of Expected Credit Loss (ECL) calculations and loan stage classifications in near real time. Such a system identifies errors as soon as they occur rather than at the end of the reporting period, thereby preventing delayed restatements such as the one experienced in 2021. This represents the practical application of the continuous auditing concept proposed by Vasarhelyi and Halper (1991) within the banking environment.

The practical value of CAATs is clearly demonstrated by the case of JSC *Xalq Banki*. The bank's total loan portfolio exceeds UZS 23 trillion and comprises hundreds of thousands of loan agreements, making comprehensive manual examination impossible. By using CAATs, auditors can independently recalculate the ECL for the entire portfolio, automatically identify differences between their calculations and the bank's estimates, verify the consistent application of loan stage classification criteria across all loans, and detect unusual transactions, such as overdue loans that remain incorrectly classified in Stage 1. Such full-population testing would have identified the systematic ECL measurement error that occurred in 2021 more effectively than a conventional sample-based audit.

The CAATs used in bank auditing can be classified into several categories. Data analytics software (such as ACL, IDEA, or SQL-based tools) is employed to analyze large transaction datasets, identify duplicate records, and independently recalculate Expected Credit Losses. Robotic Process Automation (RPA) accelerates repetitive audit procedures, while data visualization tools facilitate the identification of unusual trends and patterns. More advanced practices also incorporate Artificial Intelligence (AI) and Machine Learning (ML) techniques. In banks with extensive loan portfolios, such as JSC *Xalq Banki*, these technologies make full-population auditing practically feasible.

The effectiveness of CAATs depends directly on the quality of the data extracted from banking information systems. Auditors must first verify the completeness, accuracy, and integrity of the data, as automated analysis based on inaccurate or incomplete information may lead to incorrect conclusions, consistent with the “garbage in, garbage out” principle. Therefore, before implementing CAATs, the bank's general IT controls—including data access management and change management procedures—should be evaluated. In banks with extensive branch networks, particular attention should be paid to integrating data from multiple information systems and ensuring its consistency.

The implementation of CAATs in Uzbekistan's banking sector should be carried out in a phased manner. The proposed implementation roadmap consists of four stages, as presented in Table 3: initial automation, automated verification of estimated values, continuous auditing, and advanced AI-based analytics (Table 3).

Table 3. Proposed Roadmap for the Implementation of CAATs in Bank Auditing³

Stage	Description	Expected Outcome
Stage 1	Analysis of core data (identification of duplicate records and unusual transactions)	Initial automation
Stage 2	Full-population recalculation of ECL and automated verification of loan stage classification	Improved accuracy of estimated values
Stage 3	Continuous auditing and real-time monitoring	Continuous audit oversight
Stage 4	Advanced analytics based on Artificial Intelligence	Early identification of risks

Each implementation stage should be supported by professional training for auditors and the deployment of appropriate audit software. Such a phased approach will contribute to the continuous improvement of audit quality while enabling organizations to adopt digital technologies in accordance with their operational capabilities.

The implementation of CAATs also establishes new competency requirements for auditors. Modern bank auditors must possess not only accounting and auditing expertise but also skills in data analytics, database management, and statistical methods. Accordingly, audit firms and higher education institutions should incorporate digital auditing and data analytics into their educational and professional training programs. Furthermore, the implementation of CAATs requires audit firms to invest in appropriate software solutions and information security infrastructure. Although these investments involve initial costs, they are expected to generate long-term benefits through improvements in audit quality, efficiency, and effectiveness.

The expected benefits of implementing Computer-Assisted Audit Techniques (CAATs) and digital technologies can be observed in three key dimensions. From a quality perspective, full-population testing provides a significantly greater likelihood of detecting systematic errors than sample-based auditing. In terms of efficiency, automated data analysis is performed many times faster than manual procedures. From an economic

³ Source: Compiled by the author.

perspective, although the implementation of CAATs requires an initial investment, it reduces labor costs and expands audit coverage in the long run. In the case of JSC *Xalq Banki*, with a loan portfolio exceeding UZS 23 trillion, comprehensive manual auditing is practically impossible; therefore, digital technologies have become a necessity for auditing banks of this scale.

The foundation of CAATs lies in the extraction of data from banking information systems and its preparation for analysis. Auditors first obtain the required information from the bank's core banking system, general ledger, and loan management modules in a standardized format. The extracted data are then cleansed and normalized to ensure consistency before analysis. At this stage, the standardization of audit data requests substantially improves the effectiveness of CAATs. The quality of data preparation ultimately determines the reliability of all subsequent analytical results.

The ability to examine the entire population represents the most significant advantage of CAATs. Traditional auditing is inherently subject to sampling risk—the possibility that material errors remain undetected because they fall outside the selected sample. CAATs eliminate this risk by enabling the examination of every loan and transaction without exception. For example, auditors can identify overdue loans that have been incorrectly classified into an inappropriate stage or transactions exceeding established limits within minutes, whereas such procedures would require months if performed manually.

CAATs also significantly enhance the effectiveness of analytical procedures in accordance with ISA 520. Using large datasets, auditors can automatically calculate ratios, identify trends, and detect deviations from expected values, thereby rapidly identifying unusual conditions. For instance, abnormal differences in loan loss allowance ratios, interest income, or the proportion of non-performing loans across bank branches can be visualized using CAATs, directing auditors' attention to areas requiring further investigation. This data-driven analytical approach strengthens auditors' professional judgment with objective and verifiable evidence.

Another valuable digital analytical technique involves examining the distribution of numerical data, such as through the application of Benford's Law, to identify unusual patterns and potential financial manipulations. CAATs are also effective in detecting fraud indicators, including duplicate payments, transactions deliberately split among the same counterparties, and journal entries posted outside normal business hours. These techniques constitute a digital extension of the fraud response procedures required by ISA 240.

Integrating CAATs with the evaluation of internal controls is equally important. Since the majority of banking operations are automated, auditors can test application controls—such as credit approval limits and dual authorization mechanisms—using system-generated audit logs. Conducting these control tests on a full-population basis rather than through sampling enables a more objective assessment of control risk (CR) and provides more reliable conclusions regarding the effectiveness of internal controls.

Continuous monitoring represents the most advanced application of CAATs. Connected directly to the bank's information systems, it continuously monitors predefined risk indicators. For example, the system can automatically generate alerts when loans are incorrectly classified into stages, when loan loss allowance ratios change significantly, or when unusually large transactions occur. This capability allows auditors to respond to emerging risks in real time rather than waiting until the end of the reporting period. Consequently, auditing evolves from a periodic activity into a continuous process that facilitates the early detection and correction of material financial reporting errors.

CAATs also provide significant advantages in documenting and controlling audit quality in accordance with ISA 230. Every stage of the automated analytical process—including the data source, the algorithms applied, and the analytical results—is systematically recorded, creating a complete and verifiable audit trail. This facilitates both internal quality reviews and external regulatory inspections while strengthening the credibility and supportability of the audit opinion. In this respect, digital auditing enhances not only efficiency but also audit quality and transparency.

In international practice, Computer-Assisted Audit Techniques (CAATs) and Audit Data Analytics (ADA) have become standard components of audit methodologies employed by leading audit firms. Major international audit networks extensively utilize full-population analytics platforms and Artificial Intelligence technologies. For the banking sector in Uzbekistan, adapting these international practices to national conditions—including the characteristics of banking information systems, data quality, and regulatory requirements—through a phased implementation strategy is both appropriate and necessary. Such an approach represents an important step toward aligning the quality of bank auditing with international best practices.

The practical value of the proposed approach becomes even more evident through specific audit applications. One important application is the full-population recalculation of interest income on loans. Auditors independently calculate interest income for every loan agreement based on the contractual interest rate, outstanding principal balance, and relevant reporting period, and then compare the results with the amounts recognized by the bank. Any discrepancies are identified automatically, revealing systematic errors or unusual

conditions in interest income recognition—an area where conventional sample-based auditing often has limited effectiveness.

A second application is the verification of interest expenses on deposits and other borrowed funds. Using CAATs, auditors independently recalculate accrued interest based on the terms of deposit agreements and verify the assertions of completeness and accuracy. This type of audit is particularly valuable in banks offering numerous deposit products with different interest rates, where manual verification is practically infeasible.

A third application involves the independent recalculation of prudential ratios. By using CAATs, auditors recalculate capital adequacy, liquidity, and credit concentration ratios based on the bank's underlying data and compare the results with the figures reported by the bank. This enables an objective assessment of compliance with prudential regulations and facilitates the early detection of regulatory breaches, which represents one of the distinctive responsibilities of bank auditing.

A fourth application concerns cut-off testing. Through CAATs, auditors analyze significant transactions recorded near the reporting date to verify that they have been recognized in the appropriate accounting period. Transactions recorded in the wrong reporting period may materially distort financial results; therefore, automated cut-off testing helps ensure the proper period recognition of revenues and expenses.

A fifth application is the identification of related parties and interconnected lending relationships. By combining CAATs with network analysis techniques, auditors can identify hidden relationships among borrowers, shareholders, and members of management, as well as detect concentrations of credit risk. Such analysis is virtually impossible to perform manually and is particularly important when assessing preferential loans granted to related parties and evaluating their Expected Credit Loss (ECL) estimates.

A sixth application involves the analysis of cash flows and unusual transactions. Through the examination of large transaction datasets using CAATs, auditors can identify indicators of concealed fund transfers, unusually large transactions, and potential fraud patterns. This provides additional assurance in areas where auditing intersects with anti-money laundering (AML) requirements and the prevention of financial crime.

A seventh application is the automation of reconciliation procedures and three-way matching. CAATs automatically reconcile balances across different systems and accounts while identifying unmatched items. This capability is especially beneficial in banks with extensive branch networks, where it facilitates the verification of consistency between inter-branch transactions and the central general ledger.

An eighth application concerns the verification of foreign currency transactions and revaluation. Using CAATs, auditors can examine the entire population of foreign currency assets and liabilities to verify that they have been revalued correctly using the exchange rates applicable at the reporting date. In banks with significant foreign currency positions, this approach helps ensure the accurate recognition of exchange rate differences and the fair presentation of market risk.

The applications presented above demonstrate that CAATs are closely integrated with other methodological tools used in bank auditing, such as the Bank Risk Factors Index (BRFI) and the Expected Credit Loss (ECL) audit program. Areas identified as high-risk through these methodologies can subsequently be subjected to comprehensive full-population testing using CAATs. Furthermore, the comprehensive audit evidence generated through CAATs provides a strong foundation for supporting Key Audit Matters (ISA 701) in the auditor's report. In this way, digital technologies become the central element connecting all components of the bank auditing methodology.

At the same time, several challenges associated with the implementation of CAATs should be taken into consideration. First, auditors must have appropriate technical and legal access to complete and reliable data from banking information systems. Second, data security and confidentiality requirements must be strictly observed to ensure the protection of customer information. Third, the implementation of CAATs requires initial investment in software solutions as well as qualified professionals capable of using these technologies effectively. Fourth, the regulatory framework governing digital auditing should be further clarified to establish the legal status and acceptance of digital audit methodologies. Addressing these challenges through a phased implementation strategy will enable banks and audit firms to fully realize the potential of Computer-Assisted Audit Techniques.

CONCLUSIONS AND RECOMMENDATIONS

As a result of the study, a methodological approach was developed for integrating Computer-Assisted Audit Techniques (CAATs) and analytical procedures into the audit of commercial banks' financial statements. The proposed approach encompasses the architecture of CAATs (data extraction, data analysis, and audit evidence generation), its principal application areas (full-population testing, Journal Entry Testing (JET), Expected Credit Loss (ECL) recalculation, anomaly detection, and continuous monitoring), as well as a phased implementation roadmap.

A comparative analysis of traditional and digital audit approaches confirmed the superiority of digital auditing. The proposed approach enables full-population audit coverage, improves audit efficiency, enhances the detection of anomalies, and reduces the risk of human error. The case of JSC *Xalq Banki*, with its loan portfolio exceeding UZS 23 trillion, demonstrated that comprehensive auditing is impractical without CAATs, confirming that digital technologies have become an essential requirement for auditing large commercial banks.

Based on the findings, the following recommendations are proposed: (1) audit firms should implement CAATs in bank audits, particularly for full-population ECL recalculation and Journal Entry Testing (JET); (2) CAATs should be introduced progressively according to the proposed four-stage implementation roadmap; (3) continuous auditing systems should be implemented to enable real-time monitoring of ECL calculations and loan stage classifications; (4) auditors' competencies in data analytics should be strengthened, and digital auditing courses should be incorporated into higher education curricula; and (5) regulatory authorities should establish a clear legal framework governing the application of digital audit methodologies.

It should be emphasized that CAATs are closely integrated with other components of the proposed bank auditing methodology. Areas identified as high risk by the Bank Risk Factors Index (BRFI) are subjected to comprehensive digital examination using CAATs, while the independent recalculation procedures included in the ECL audit program are performed on a full-population basis through CAATs. Consequently, digital technologies should not be viewed merely as separate audit tools but rather as an integrating mechanism that connects all stages of the bank auditing methodology and enhances their overall effectiveness.

The theoretical contribution of this study lies in enriching the methodological foundations for integrating digital technologies into bank auditing. Its practical significance is reflected in the applicability of the proposed methodological approach and implementation roadmap for audit firms, commercial banks, and regulatory authorities. Future research may focus on developing an Artificial Intelligence-based continuous auditing system built upon CAATs and evaluating its effectiveness through implementation in different types of commercial banks.

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