

Original Research Article

Application of big data auditing for comprehensive audit coverage in universities

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Abstract: Ensuring full-scope audit coverage to safeguard the healthy and sustainable development of universities has emerged as a new mandate for internal audit. This study addresses the challenges that higher education institutions face in achieving comprehensive audit coverage. Drawing on President Xi Jinping's "strengthening audit through technology" concept, the advantages of big-data-driven auditing for realizing full internal audit coverage are analyzed. An integrated framework for a big data auditing information system is then established, detailing its architecture, core modules, and data-flow mechanisms. Grounded in actual university audit practices, key applications of the system are examined. Principal implementation difficulties are dissected, and corresponding improvement measures are proposed. This work presents a reference model and provides practical recommendations for leveraging big data auditing technologies to achieve comprehensive audit coverage in higher education.

Keywords: big data auditing; full-scope audit coverage; university internal audit

1. Introduction

The establishment of the Central Audit Commission in 2018 reinforced the Party Central Committee's leadership over audit work and set forth a new direction for the development of audit practice by calling for the creation of a centralized, unified, comprehensive, authoritative, and efficient auditsupervision system^[1-3]. At the first meeting of the 20th Central Audit Commission, General Secretary Xi Jinping emphasized that effective audit supervision must meet the "Threefold Requirements": to operate "as an extension of the arm," "to follow like a shadow," and "to resonate like thunder." The "follow like a shadow" requirement, in particular, underscores that audit supervision must trace funding activities and the exercise of authority wherever they occur, with the aim of eliminating blind spots and dead angles and thereby achieving truly full-scope coverage.

In recent years, with the continuous expansion of higher education institutions, the volume of funds involved in their economic activities has steadily increased, and funding sources have become increasingly diversified^[4-6]. Corresponding management challenges—Such as noncompliant fund utilization, resource waste, and disordered asset management—Have gradually surfaced. As a critical element of institutional governance, the systematic, phased, and prioritized implementation of full internal audit coverage—Encompassing all university economic activities—Ensures that no blind spots or corners are left unaddressed in supervisory oversight. However, mismatches between audit demand and resource supply, along with limited progress in audit informatization, have resulted in relatively slow advancement toward truly comprehensive internal audit coverage in higher education.

Overcoming the existing challenges in university internal audit and actively advancing fullscope audit coverage constitute major difficulties in the development of internal audit within higher education. The first and second meetings of the 20th Central Audit Commission both emphasized the proactive implementation of the "strengthening audit through technology" strategy, while the Regulations on Internal Audit Work in the Education

System explicitly mandate "enhancing audit informatization to comprehensively improve audit efficiency." Concurrently, the rapid evolution of bigdata auditing technologies—Such as cloud auditing and blockchain auditing—Provides powerful technical support for achieving full audit coverage in universities. Zhang et al. (2020) developed an overall framework for big-data auditing in higher education institutions and proposed practical pathways for its application in institutional inspections^[1]. Cao et al. (2020) examined the interrelations among big data, cloud computing, and blockchain, analyzed their impacts on internal audit, and offered recommendations for strengthening the use of cloud and blockchain technologies in audit practice^[2]. Zhang et al. (2023) leveraged distributed ledger technology to reconstruct a novel "blockchain + audit" model and advanced countermeasures—Such as awareness raising and enhanced management informatization—To accelerate blockchain adoption in university internal audit^[3]. Qi (2024) analyzed the advantages and application pathways of bigdata technologies for achieving comprehensive audit coverage in universities^[4]. Against this backdrop, the present study adopts a big-data perspective to explore the application of big-data-driven auditing in achieving full-scope audit coverage within higher education institutions.

2. Advantages of big data auditing in achieving comprehensive internal audit coverage in universities

2.1. Enhancing audit supervision efficiency

Establishing a truly full-scope audit supervision system—Covering all functions, processes, and domains—Requires continually expanding both the breadth and depth of oversight. Under traditional audit methods, a fixed staffing level cannot keep pace with the growing volume of audit tasks, making comprehensive coverage practically unachievable. Big data auditing addresses this challenge by integrating the audit engine into a university's smart-campus platform. The system can automatically harvest and preprocess the vast amount of data required for audit engagements, dramatically reducing the time auditors spend on data collection and preparation, thereby easing their workload. Advanced analytics then enable rapid comparison across disparate datasets and deep data mining to reveal institutional baselines, transaction patterns, and emergent risk signals. Auditors can quickly pinpoint high-risk areas and concentrate their efforts where they are most needed. Furthermore, embedding every audit phase—Planning, pre-audit investigation, fieldwork, reporting, corrective-action monitoring, and working-paper management—Within a unified big data auditing information system ensures that each procedure is executed effectively and with minimal delay. For instance, online approval workflows for audit projects can eliminate manual signature bottlenecks and shorten lead times for authorization.

Constructing a truly comprehensive audit-supervision system—One that spans all functions, processes, and domains—Requires continuously expanding both the scope and depth of oversight. Under traditional audit methods, static staffing levels cannot keep pace with the growing volume of audit tasks, rendering full coverage practically unattainable. Big-data auditing addresses this challenge by integrating the audit engine into a university's smart campus platform. The system automatically acquires and preprocesses the large volumes of data required for audit engagements, significantly reducing the time auditors devote to data collection and preparation. Advanced analytics then enable rapid cross-dataset comparisons and in-depth data mining to uncover institutional baselines, transaction patterns, and emerging risk signals, allowing auditors to quickly identify high-risk areas and concentrate resources where they are most needed. Moreover, embedding each audit phase—Including planning, pre-audit investigation, fieldwork, reporting, corrective-action monitoring, and working-paper management—Within a unified big-data auditing information system ensures that every procedure is executed effectively and with minimal delay. For example, online approval workflows for audit projects eliminate manual-signature bottlenecks and shorten authorization lead times.

2.2. Enhancing audit supervision quality

Implementing bigdata auditing enhances the quality of audit supervision through three key mechanisms. First, centralized and unified management of audit processes ensures that audit objectives are clearly defined, audit plans are precise, procedures are complete, and documentation is comprehensive—Thereby improving supervisory rigor at the operational level. Second, the real-time, automated collection of financial and operational data establishes immutable, time-stamped trails, preventing data tampering and enabling the prompt detection of anomalies in economic activities. This foundation supports a shift from traditional ex-post review toward ex-ante and real-time auditing, facilitating full-process coverage. Third, both vertical ("to the source") and horizontal ("across boundaries") data reconciliation and analysis become possible. By interfacing the auditing system with financial, academic affairs, research management, student management, and logistics platforms, structural and trend analyses of financial metrics and business data can be conducted in real time. Early-warning alerts and dynamic monitoring reveal indicator fluctuations and risk signals more quickly than fragmented manual review. Such comprehensive analytics achieve true integration of operational and financial information, accelerate issue identification, uncover root causes, and generate targeted recommendations—Thereby increasing the accuracy and impact of audit conclusions and driving the realization of audit objectives.

2.3. Enhancing audit supervision synergy

A big-data auditing information system enables the seamless sharing and integration of audit data across audit modules and with other institutional information systems, thereby laying the foundation for a comprehensive "big supervision" framework in universities. Centralized management and data sharing of audit information are achieved through the big-data auditing information system. Audit teams can utilize the system to share collected datasets and documentation, thereby eliminating redundant data gathering and enhancing operational efficiency. The platform also enables the dissemination of identified issue leads, supporting cross-validation of audit findings and the early detection of systemic, directional, and emergent risks. In addition, the system facilitates the development of specialized repositories—Such as regulatory-policy libraries, audit-scheme libraries, procedure libraries, and project libraries—By aggregating regulatory references, optimizing audit methodologies, and compiling best-practice case studies. These knowledge resources foster mutual learning, collaboration, and ongoing professional development among audit personnel.

The integration of the big data auditing information system with other oversight platforms addresses the fragmentation of supervisory efforts, isolated responsibility, and lack of communication and collaboration. Such interconnectivity allows all supervisory bodies to share annual oversight plans, thereby preventing redundant audits and eliminating coverage gaps. It also facilitates the efficient exchange of supervisory findings across entities, promoting collective utilization of results. Case leads requiring transfer can be rapidly forwarded through the shared system, with full traceability of their origins and supporting evidence. This enables recipient units to quickly reconstruct the context, identify intervention points, and foster cooperative synergy among oversight agencies, achieving a " $1 + 1 > 2$ " effect in supervisory effectiveness.

3. Application of big data auditing for comprehensive audit coverage in universities

3.1. Developing the overall framework of the big data auditing information system

To fully leverage the capabilities of big data auditing, a comprehensive information system should be developed that integrates data acquisition and analysis with online audit workflows. The overall framework is illustrated in **Figure 1**.

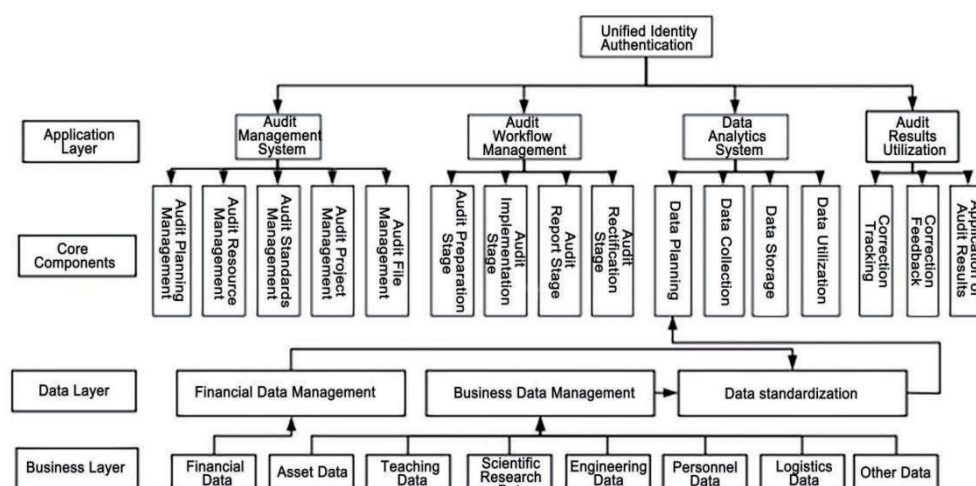


Figure 1. Overall framework of the big data auditing information system for universities.

3.2. Applications of the big data auditing information system

3.2.1. Unified user authentication

To ensure data security, all users must log in through a centralized authentication system.

3.2.2. Application layer functionality

The application layer comprises the system's core modules, including: Audit Management Module, Audit Workflow Management Module, Data Analytics Module, Audit Results Utilization Module, and Additional auxiliary subsystems. The Audit Management Module integrates all facets of internal audit administration within the big-data auditing information system, including audit plan management, audit resource management, audit standard management, audit project management, audit file management, and other related content. Mid-to-long-term and annual audit plans are entered and visually tracked to ensure that all scheduled engagements are clearly defined and monitored. Audit resources—Both internal teams and available external partners—Are cataloged alongside the audited entities, enabling a strategic, phased allocation of personnel and a systematic progression toward full-scope coverage. Standardized audit procedures, documentation templates, regulatory requirements, and formal issue definitions are embedded to promote consistency and serve as an on-demand reference for practitioners. Completed audit projects and their associated records are securely archived for efficient retrieval and review. By consolidating planning, resourcing, standards, project workflows, and archival functions into a unified platform, this module streamlines processes, optimizes resource utilization, and significantly enhances the effectiveness and efficiency of the university's internal audit function.

The Audit Workflow Management System manages the execution of audit engagements across the preparation, fieldwork, reporting, and remediation phases. It automates key processes by matching audit frameworks to engagement types, adapting existing audit schemes to generate projectspecific procedures, and invoking workpaper and evidencecollection templates alongside historical audit findings for reference. Integrated online review and approval workflows facilitate task completion, while automated data acquisition and seamless archival of audit records ensure efficient evidence gathering and timely project closure. The Audit Results Utilization System facilitates the implementation of corrective actions and operationalizes audit findings. The system generates a remediation ledger, which is distributed electronically to the responsible departments. Audit, responsible, and oversight units can monitor remediation progress in real time, enforce compliance, and perform multidimensional statistical analyses of issue resolution rates and recommendation adoption metrics. Commonly identified issues are shared across multiple departments to initiate selfinspection and corrective efforts, thereby

enhancing the overall impact of audit outcomes. Auxiliary modules can be tailored to each institution's requirements—For example, decision-support analytics, remote collaboration platforms, and automated notification mechanisms for audited entities—Leveraging intelligent capabilities to further enhance the efficiency and effectiveness of achieving full audit coverage.

3.2.3. Data and business layers

These layers serve to integrate the bigdata auditing information system with financial and operational systems by collecting or retrieving relevant data. The data are then aggregated, organized, cleansed, and transformed to establish a standardized database, thereby laying the foundation for efficient querying and utilization.

3.2.4. Inter-module relationships

The modules of the bigdata auditing information system are interlinked to form a virtuous cycle that drives the auditing process. The Audit Management Module supplies foundational project information, audit standards, and relevant regulatory references to the Audit Workflow Management Module, thereby facilitating onsite audit operations. Conversely, onsite audits generate best practices and findings that are fed back into the Audit Management Module, further enriching its content. The Data Analytics Module provides audit evidence and risk indicators to fieldwork teams, supporting highquality and efficient audit execution; the predictive models derived from field audits serve as a critical input for enhancing the Data Analytics Module's capabilities. The Audit Results Utilization Module's remediation ledger is populated with issues and leads identified during field audits; remediation actions and utilization feedback are then reported back to the Audit Management Module, further augmenting its project repository and auditee database. The Data and Business Layers underpin the effective operation of the entire system and are essential to implementing bigdata auditing, as the functionality of all other modules depends on data integrity, accuracy, and validity. The intermodule relationships are illustrated in Figure 2.

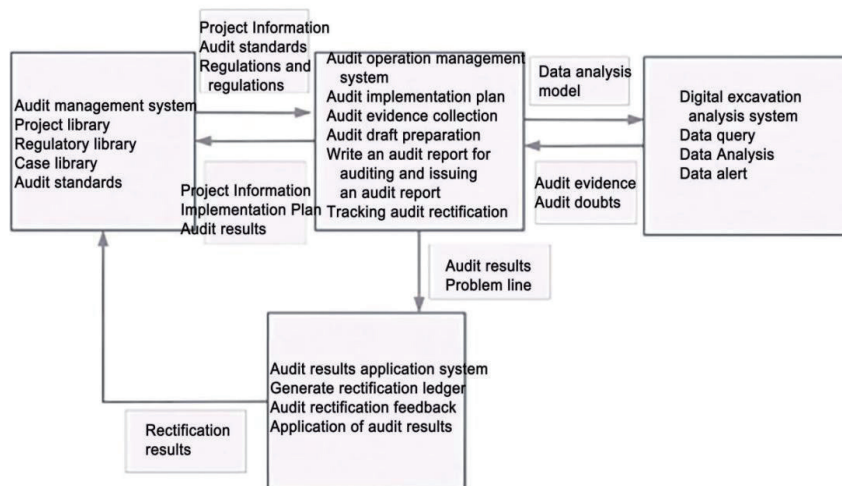


Figure 2. Inter-module relationship diagram of the university big data auditing information system.

4. Challenges and recommendations for deploying big data auditing to achieve full audit coverage

4.1. Limited funding for big data auditing implementation

Implementing a comprehensive big data auditing program constitutes a large-scale, systemic undertaking that demands substantial financial investment to develop a fully featured auditing information system. However,

university audit departments often operate under constrained budgets, making in-house development of such a system prohibitively difficult. Therefore, it is recommended that higher education institutions, under the unified coordination of educational authorities, partner with software development firms to jointly create a big data auditing platform tailored to the specific needs of universities. This collaborative model both alleviates individual budgetary pressures and ensures that the resulting system is closely aligned with university financial and operational processes.

4.2. Data collection challenges

Robust bigdata auditing depends on the availability of comprehensive datasets. Although rapid digitization efforts in universities have brought financial and most operational data under information systems, two key issues remain. First, some auditcritical records are still maintained in paper form, resulting in incomplete data capture and reduced audit effectiveness. Second, persistent "data silos" and a lack of interoperability among disparate systems prevent automated data extraction, undermining the full functionality of the bigdata auditing information system.

It is recommended that, in the course of smart-campus development, the design of information-system architecture and data-sharing mechanisms be fully addressed by implementing interfaces (APIs) to enable seamless interoperability among operational, financial, and auditing platforms. For business datasets still managed via traditional paper-or silo-based processes, standardized master data tables should be defined so that each department can aggregate and consolidate its records for direct ingestion into the big-data auditing information system and subsequent analysis. Additionally, advanced dataacquisition technologies—Such as optical character recognition (OCR), 3S geospatial systems (GIS, RS, GPS), and automatic speech recognition (ASR)—Can be deployed to capture and integrate image, text, and audio data into the audit framework.

4.3. Data transformation challenges

Once the requisite audit data have been collected, they must be cleansed and transformed into standardized datasets for subsequent analysis. Universities involve numerous organizational units and personnel, and their economic activities span diverse domains—Academic instruction, research projects, and administrative operations—Each with distinct internal-control requirements and data structures. The mechanistic processing of all data en masse generates vast volumes of information while obscuring the prioritization of key elements. It is advisable to selectively filter and standardize data according to the operational characteristics and risk profiles of each type of business activity. Leveraging social network analysis can bridge the gaps between individual data entities, constructing a comprehensive, macro-level network that encompasses all institutional funds, state-owned assets, and public resources, thereby advancing the realization of full-scope audit coverage.

4.4. Limited data analysis models

Effective big-data auditing requires robust analytical capabilities built on thorough data collection and transformation. However, existing analytic modules embedded within university big-data platforms remain relatively limited and are largely repurposed from enterprise-oriented models, without design alignment to the unique characteristics of higher-education financial and operational processes. Consequently, identified anomalies tend to be superficial, and current alert mechanisms fail to detect deeper or more concealed risks. A staged approach is recommended for the development and deployment of data analysis models.

Phase I: During the design and implementation of the university's bigdata auditing information system, a crossdisciplinary team should be formed, comprising software developers and senior internalaudit professionals with extensive highereducation audit experience. Drawing on auditors' domain knowledge and relevant laws and regulations, the team should construct bespoke analytic models that capture the logical interdependencies inherent in university operations. For example, by integrating data from the Student Affairs Office—such as

national scholarship and grant award lists, collegepublished recipient rosters, and disbursement records—models can be developed to verify whether scholarship disbursement ratios and amounts align with statutory or policy thresholds.

Phase II: Advanced artificialintelligence techniques (e.g., ChatGPTdriven deeplearning algorithms) should be leveraged to accelerate model evolution. By ingesting regulatory texts, audit plans, procedural templates, previous audit reports, and relevant case studies, the system can engage in iterative questionandanswer cycles to autonomously retrieve necessary datasets and refine predictive models. This enables rapid anomaly detection, rootcause analysis, and the generation of audit findings that are underpinned by transparent logic and comprehensive evidence, thereby markedly improving the overall quality and impact of the audit process.

5. Conclusion

Achieving fullscope audit coverage represents a new mandate for internal audit within higher education institutions. However, existing human and material resources are insufficient to substantially expand supervisory reach without compromising audit quality. Big data auditing technologies—which enable the automated acquisition of financial and operational data, the construction of tailored analytic models, the rapid identification of risk signals, the consolidation of audit resources, and the end-to-end digital management of audit workflows—offer a practical and scalable solution. By markedly enhancing the effectiveness and efficiency of internal audit supervision, these technologies provide a viable pathway to comprehensive coverage and are poised to drive the future evolution of university audit functions.

Data availability: All data generated or analysed during this study are included in this published article.

Conflicts of interest: There are no conflicts to declare.

Fundings

This work was supported by the General Project "Research on University Internal Audit Based on 'Full-coverage Audit' in the New Era" funded by the Hunan Provincial Philosophy and Social Science Foundation (No. 19YBA129).

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