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# *DIGITALIZING AUDIT SAMPLING AND EVIDENCE EVALUATION: A SYSTEMATIC LITERATURE REVIEW OF SOFTWARE-BASED STATISTICAL AUDITING TOOLS*

# DIGITALISASI PENGAMBILAN SAMPEL AUDIT DAN EVALUASI BUKTI: TINJAUAN LITERATUR SISTEMATIS TENTANG ALAT AUDIT STATISTIK BERBASIS PERANGKAT LUNAK

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***ABSTRACT***

*Digitalization is reshaping audit work through data analytics, automation, and software-supported sampling. Yet, evidence on whether such tools reliably improve audit time efficiency and auditability remains fragmented, and auditors still face pressures to over-sample under inspection risk. Building on recent advances in statistical auditing—including open-source tools for audit sampling and Bayesian methods that can reduce sample sizes substantially—this study conducts a systematic literature review and qualitative evidence synthesis of software-based statistical auditing tools (e.g., generalized audit software, technology-based audit techniques, robotic process automation, and Bayesian audit sampling workflows). Using a PRISMA-informed search strategy across major academic databases and targeted hand-searching, we synthesize findings from audit technology, sampling, and standards-oriented literature. The review identifies (i) consistent efficiency mechanisms (automation, standardization, optional stopping, and risk-focused sampling), (ii) conditions that enable time savings without degrading audit quality (data quality, auditor competencies, and methodology fit), and (iii) adoption barriers related to cost-benefit visibility, cybersecurity/privacy, and regulatory expectations regarding evidence evaluation. We develop a consolidated framework linking digital audit tools to audit efficiency and accountability outcomes, and we propose research directions for future empirical tests (e.g., fee and lag outcomes, stratified sampling effectiveness, and governance impacts). (Bierstaker et al., 2001; Bradford et al., 2020; Barr-Pulliam et al., 2023; Eulerich et al., 2022; Derks et al., 2023; Derks et al., 2024; Derks et al., 2025; Mensink et al., 2025; Meng et al., 2024).*

***Keywords**: Audit Digitalization, Audit Sampling, Bayesian Auditing, Audit Efficiency, Technology-Based Audit Techniques.*

**ABSTRAK**

Digitalisasi membentuk kembali pekerjaan audit melalui analitik data, otomatisasi, dan pengambilan sampel yang didukung perangkat lunak. Namun, bukti tentang apakah alat-alat tersebut secara andal meningkatkan efisiensi waktu audit dan kemampuan audit masih terfragmentasi, dan auditor masih menghadapi tekanan untuk mengambil sampel secara berlebihan di bawah risiko inspeksi. Berdasarkan kemajuan terkini dalam audit statistik—termasuk alat sumber terbuka untuk pengambilan sampel audit dan metode Bayesian yang dapat mengurangi ukuran sampel secara substansial—studi ini melakukan tinjauan literatur sistematis dan sintesis bukti kualitatif dari alat audit statistik berbasis perangkat lunak (misalnya, perangkat lunak audit umum, teknik audit berbasis teknologi, otomatisasi proses robotik, dan alur kerja pengambilan sampel audit Bayesian). Dengan menggunakan strategi pencarian yang diinformasikan PRISMA di seluruh basis data akademik utama dan pencarian manual yang ditargetkan, kami mensintesis temuan dari literatur teknologi audit, pengambilan sampel, dan berorientasi standar. Tinjauan ini mengidentifikasi (i) mekanisme efisiensi yang konsisten (otomatisasi, standardisasi, penghentian opsional, dan pengambilan sampel yang berfokus pada risiko), (ii) kondisi yang memungkinkan penghematan waktu tanpa menurunkan kualitas audit (kualitas data, kompetensi auditor, dan kesesuaian metodologi), dan (iii) hambatan adopsi yang terkait dengan visibilitas biaya-manfaat, keamanan siber/privasi, dan harapan peraturan mengenai evaluasi bukti. Kami mengembangkan kerangka kerja terpadu yang menghubungkan alat audit digital dengan efisiensi audit dan hasil akuntabilitas, dan kami mengusulkan arah penelitian untuk pengujian empiris di masa mendatang (misalnya, hasil biaya dan keterlambatan, efektivitas pengambilan sampel bertingkat, dan dampak tata kelola). (Bierstaker dkk., 2001; Bradford dkk., 2020; Barr-Pulliam dkk.,

2023; Eulerich dkk., 2022; Derks dkk., 2023; Derks dkk., 2024; Derks dkk., 2025; Mensink dkk., 2025; Meng dkk., 2024).
**Kata kunci**: Digitalisasi Audit, Pengambilan Sampel Audit, Audit Bayesian, Efisiensi Audit, Teknik Audit Berbasis Teknologi.

## INTRODUCTION

Audit practice is undergoing a rapid digital shift as audit clients migrate to paperless systems and auditors increasingly rely on software to plan, execute, and document procedures (Bierstaker et al., 2001). Recent reviews highlight that data analytics, artificial intelligence, blockchain, and robotic process automation are among the dominant technologies shaping modern audit work, with promised gains in efficiency, effectiveness, and transparency (Dasinapa & Ermawati, 2024; Herdiana & Nugrahanti, 2025; Leocádio et al., 2024; Nadzari & Yussof, 2024; Ruslaini et al., 2024). However, adoption remains uneven and the realized benefits are often difficult to quantify, especially when compliance expectations and inspection risk encourage auditors to gather additional evidence (Eulerich et al., 2022; Wellmeyer, 2020).

Complementing these reviews, bibliometric evidence also documents a sharp growth in digital auditing research since 2015, with prominent clusters around automation, fraud detection, and ethical considerations—signaling a maturing research agenda for digital audit tools (Nadzari et al., 2024). Early case-based work on computer-assisted audit further illustrates how data-oriented approaches can expand audit scope and deepen analysis, supporting efficiency and quality improvements in information system audits (Wang et al., 2012).

Within this broader digitalization agenda, statistical auditing tools are especially relevant because sampling remains a practical necessity when full-population testing is infeasible or cost-prohibitive (Christensen et al., 2014; Santoso et al., 2023). Stratification is widely used to improve efficiency by increasing representativeness and precision, but dominant evaluation methods can be suboptimal because they focus on between-strata differences and ignore similarities, leading auditors to review more items than necessary (Derks et al., 2025; Liu et al., 2021). In parallel, open-source and user-friendly software (e.g., JASP for Audit) has been developed to bridge the gap between audit practitioners and statistical methods, supporting planning, selection, evaluation, and documentation (Derks et al., 2023; Derks et al., 2021).

This article contributes to the digitalization of accounting by synthesizing recent evidence on software-based statistical auditing tools and their implications for audit time efficiency and accountability. We focus on three interrelated questions: (1) What tool categories and statistical approaches are most associated with time savings? (2) Under what conditions do these tools improve auditability (e.g., defensible evidence evaluation and documentation)? and (3) What barriers and risks limit their effective adoption in practice? Our review also responds to the standards modernization agenda for audit evidence evaluation, where technology's role and professional judgment are central concerns (Barr-Pulliam et al., 2023; IAASB, 2022).

## LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Digital audit technologies are typically framed as tools that enhance auditors' ability to collect, analyze, and evaluate evidence at scale, thereby

improving efficiency and potentially effectiveness (Afadzinu et al., 2024; Ruslaini et al., 2024). Empirical evidence from internal audit settings suggests that greater use of technology-based audit techniques (TBATs) is associated with completing more audits, finding more risk factors, providing more recommendations, and decreasing audit days, but also with higher audit function costs (Eulerich et al., 2022). Similarly, survey-based studies indicate that auditors' beliefs about usefulness and satisfaction are key determinants of perceived efficiency gains from audit automation software and generalized audit software (Bradford et al., 2020; Chafik & Mghizou, 2019). In external auditing, fintech development has been linked to enterprise digitization and reduced audit fees, alongside improved governance outcomes such as reduced violations and stronger internal controls (Meng et al., 2024).

Sampling-specific literature underscores that auditors often face complex populations and must decide how to allocate sample sizes across strata or combine evidence across phases (Christensen et al., 2014; Wellmeyer, 2020). Statistical designs such as stratified random sampling and probability-proportional-to-size sampling can enhance precision in complex environments (Liu et al., 2021; Santoso et al., 2023). Recent work proposes Bayesian approaches as particularly suitable for digital audit contexts: Bayesian optional stopping allows auditors to monitor evidence sequentially and stop when sufficient evidence has been obtained, enhancing flexibility (Mensink et al., 2025). Bayesian hierarchical modeling can further improve the evaluation of stratified samples by borrowing strength across strata, reducing required sample sizes substantially (Derks et al., 2025). Complementary practitioner-oriented work shows how integrating data analytics outputs into the sampling phase using Bayesian statistics can rationalize follow-up work, improving transparency (Derks et al., 2024).

These developments align with the broader push to modernize audit evidence standards in response to digital evidence and technology-mediated judgment (Barr-Pulliam et al., 2023; IAASB, 2022). At the same time, digital transformation introduces risks (data privacy, cybersecurity, algorithmic opacity) and human-capital constraints (digital competency gaps, resistance to change), which can attenuate benefits (Dasinapa & Ermawati, 2024; Herdiana & Nugrahanti, 2025; Rahman et al., 2021).

Therefore, based on this relationship, the propositions proposed in this study are as follows:

P1: Software-supported statistical auditing tools are associated with improved audit time efficiency through automation and risk-focused sampling (Eulerich et al., 2022; Mensink et al., 2025; Ishtiak & Tonmoy, 2024).

P2: Bayesian approaches (e.g., optional stopping and hierarchical modeling) enable measurable efficiency gains in audit sampling while maintaining defensible evidence evaluation (Derks et al., 2024; Derks et al., 2025; Mensink et al., 2025).

P3: The impact of audit digitalization on efficiency and accountability is moderated by data quality, auditor competencies, and regulatory expectations for evidence evaluation (Barr-Pulliam et al., 2023; Wellmeyer, 2020; Leocádio et al., 2024).

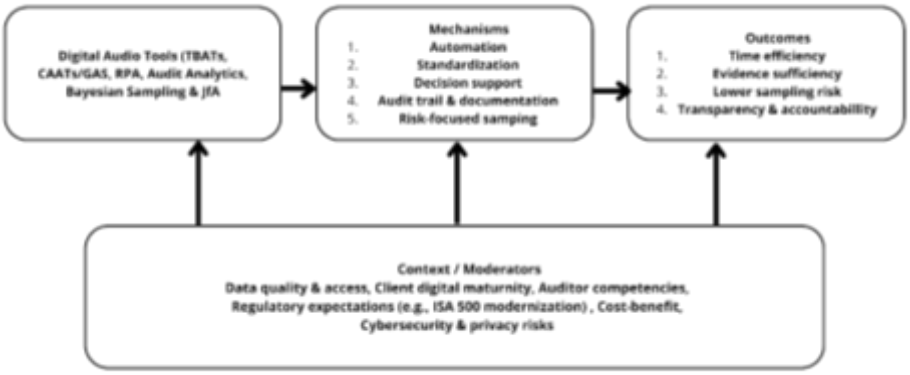


**Figure 1. Conceptual Framework**

## METHOD

This study uses a qualitative systematic literature review (SLR) design with thematic synthesis to consolidate evidence on software-based statistical auditing tools and their implications for audit efficiency and accountability (Herdiana & Nugrahanti, 2025; Leocádio et al., 2024). The SLR protocol follows PRISMA-informed steps: (1) database search, (2) screening for relevance, (3) full-text eligibility assessment, and (4) qualitative coding and synthesis (Nadzari & Yussof, 2024; Santoso et al., 2023).

Search strategy. We targeted peer-reviewed journal articles and high-quality conference proceedings published between 2019 and 2026 to capture contemporary digital audit developments, supplemented by seminal works on audit technology and sampling policies where necessary to contextualize findings (Bierstaker et al., 2001; Christensen et al., 2014; Maciejewska, 2015). Keyword combinations covered: audit digitalization, audit analytics, generalized audit software, CAATs, TBATs, robotic process automation, statistical audit sampling, stratification, Bayesian audit sampling, and audit evidence standards (Atta et al., 2024; Bradford et al., 2020; Barr-Pulliam et al., 2023).

Selection criteria. Studies were included if they (a) examined audit tools or technologies that affect evidence collection/evaluation or sampling decisions, and (b) reported implications for at least one of: time efficiency, audit quality/effectiveness, transparency/documentation, or adoption barriers. Both empirical and conceptual studies were retained to map mechanisms and contextual factors (Dasinapa & Ermawati, 2024; Rahman et al., 2021).

Data extraction and coding. We extracted study metadata (context, tool category, design), outcome statements (efficiency, quality, costs), and mechanisms (automation, standardization, Bayesian updating) into a structured matrix. Thematic synthesis proceeded through open coding, axial coding, and aggregation into higher-order themes: (i) efficiency mechanisms, (ii) auditability/accountability outcomes, and (iii) adoption barriers and risks (Leocádio et al., 2024; Nadzari & Yussof, 2024).

**Table 1. Evidence map of digital audit tools and reported outcomes (author synthesis)**

| Tool category | Representative studies | Reported efficiency/accountability outcomes | Common constraints |
|---|---|---|---|
| Technology-based audit techniques (TBATs) / audit analytics | Eulerich et al. (2022); Afadzinu et al. (2024); Dasinapa & Ermawati (2024) | Reduced audit days; more risk factors found; improved transparency via better documentation and analytics. | Costs, skills shortages, data access/quality, cybersecurity risks. |
| Generalized audit software (GAS) / CAATs | Bradford et al. (2020); Atta et al. (2024); Maciejewska (2015) | Perceived audit benefits increase with use and satisfaction; improved misstatement/control deficiency detection. | Service/system quality, training needs, methodology fit. |
| Robotic process automation (RPA) | Ishtiak & Tonmoy (2024); Herdiana & Nugrahanti (2025) | Faster routine tasks; fewer manual errors; potential ROI and workflow standardization. | Legacy system compatibility; resistance to change; governance and ethics. |
| Bayesian audit sampling & software support (JASP for Audit; jfa) | Derks et al. (2023); Derks et al. (2024); Mensink et al. (2025); Derks et al. (2025) | Smaller sample sizes; optional stopping flexibility; improved stratified evaluation efficiency; clearer documentation. | Need for statistical literacy; regulator acceptance; model assumptions and communication. |

## RESULT AND DISCUSSION

### Analysis Result

Theme 1: Efficiency mechanisms. Across tool categories, the most consistent pathway to time efficiency is the automation of routine steps (data extraction, selection, and documentation) coupled with standardization of procedures. Field evidence in internal auditing shows that higher TBAT usage is associated with fewer audit days and greater task output, although costs may rise due to investment and staffing requirements (Eulerich et al., 2022). RPA studies similarly report substantial reductions in routine task completion time and improved accuracy, but highlight change-management and skill barriers (Ishtiak & Tonmoy, 2024).

Theme 2: Sampling modernization through Bayesian approaches. Bayesian methods appear particularly aligned with digital workflows because they support sequential evidence evaluation and efficient information integration. Optional stopping allows auditors to stop sampling once sufficient evidence is obtained, improving flexibility (Mensink et al., 2025). For stratified sampling, Bayesian hierarchical modeling leverages similarities across strata to reduce sample sizes substantially relative to traditional methods, potentially lowering over-auditing driven by conservative risk assessments (Derks et al., 2025; Wellmeyer, 2020). Practitioner-oriented discussions propose using Bayesian statistics to integrate results from analytics (e.g., regression/classification/clustering) into sampling decisions, thereby rationalizing follow-up procedures and improving transparency (Derks et al., 2024).

Theme 3: Auditability and accountability. Digital tools can enhance auditability by improving evidence traceability, reproducibility, and documentation quality—features

emphasized in open-source audit sampling software designed to support end-to-end workflows and documentation (Derks et al., 2023; Derks et al., 2021). Studies on generalized audit software suggest that information quality and satisfaction shape perceived benefits and usage, which in turn relates to perceived audit benefits (Bradford et al., 2020). Regulatory modernization discussions reinforce that technology changes the nature of audit evidence and requires careful guidance on professional judgment and skepticism (Barr-Pulliam et al., 2023; IAASB, 2022).

Theme 4: Adoption barriers and risk trade-offs. Despite benefits, adoption remains constrained by (i) difficulties in quantifying benefits, (ii) shortages in digital competencies, and (iii) heightened data privacy and cybersecurity concerns (Dasinapa & Ermawati, 2024; Leocádio et al., 2024; Rahman et al., 2021). In sampling practice, auditors may still over-sample due to inspection pressures and uncertainty about how to translate reliance on controls and analytics into reduced substantive testing (Wellmeyer, 2020). These findings underscore that digitalization does not automatically yield efficiency; it must be supported by training, governance, and alignment with standards and firm methodologies (Chafik & Mghizou, 2019; Maciejewska, 2015).

**Discussion**

Overall, the synthesized evidence supports a contingent view of audit digitalization: software-based statistical auditing tools can reduce audit time and strengthen accountability, but their effectiveness depends on context. Where data quality is high and auditors have sufficient statistical and digital literacy, tools such as JASP for Audit and Bayesian sampling methods can substantially reduce unnecessary sample work while maintaining defensible evidence evaluation (Derks et al., 2023; Mensink et al., 2025). Conversely, in environments with limited skills, weak data access, or high regulatory uncertainty, technology may increase costs without proportional gains, or even encourage conservative over-testing (Eulerich et al., 2022; Wellmeyer, 2020).

## CONCLUSION

This systematic review synthesizes contemporary literature on software-based statistical auditing tools as a key stream of accounting digitalization. The evidence suggests that audit technologies—including audit analytics, CAATs/GAS, RPA, and Bayesian sampling software—can improve time efficiency and auditability through automation, standardization, and more informative statistical inference (Eulerich et al., 2022; Bradford et al., 2020; Ishtiak & Tonmoy, 2024; Derks et al., 2025). At the same time, realized benefits are contingent on data quality, auditor competencies, and regulatory expectations about audit evidence evaluation (Barr-Pulliam et al., 2023; IAASB, 2022; Leocádio et al., 2024)

**Theoretical Implications:** The review advances a consolidated framework that connects digital tools to audit efficiency and accountability outcomes via identifiable mechanisms (automation, optional stopping, hierarchical pooling) and moderators (skills, data access, regulation). Conceptually, it bridges audit technology research with sampling methodology research by showing how Bayesian approaches can operationalize efficiency gains in the sampling phase while strengthening auditability (Derks et al., 2024; Mensink et al., 2025).

**Managerial Implications:** For practitioners, the findings imply that time efficiency gains are most likely when software adoption is paired with (i) targeted training in statistical reasoning, (ii) clear guidance on how analytics informs sampling reductions, and (iii) governance processes that address cybersecurity and model-risk concerns (Chafik & Mghizou, 2019; Rahman et al., 2021). Open-source tools can help smaller practices access rigorous methods, but auditors should ensure alignment with standards and documentation expectations (Derks et al., 2023; Maciejewska, 2015).

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