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Digital Audit Tools and the Reconfiguration of Internal Control: A Decade Review and the DACI Model (2015–2025)

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ABSTRACT

This review critically examines how digital audit tools—TeamMate+, ACL Analytics, and CaseWare IDEA—have reshaped internal control systems over the period 2015–2025. By positioning these technologies within accountability theory and the COSO framework, the study explores how analytics and workflow platforms are redefining assurance processes and the governance of organisational transparency. Adopting a structured scoping-review methodology, forty-eight peer-reviewed studies, professional standards, and industry reports were analysed to map tool capabilities, operational mechanisms, and their correspondence with COSO components. The review synthesises both academic and professional evidence to delineate the boundaries and mechanisms of digital assurance. The evidence reveals a marked transition from periodic, sample-based auditing toward continuous, data-driven assurance. ACL and IDEA enable population-level testing, parameterised scripting, and anomaly detection, while TeamMate+ integrates analytical outputs into risk registers, issue workflows, and governance dashboards. As a result, internal control is re-conceptualised as a digitally mediated accountability system—an ongoing interaction among data, auditors, and oversight bodies. The effectiveness of these systems depends on technical competence, robust data governance, and disciplined model validation. In the digital age, capitalism itself becomes a symbolic form that converts experiences and relationships into data commodities, embedding an implicit logic of control and valorization in algorithmic infrastructures (Anamofa, Sartini & Ariani, 2025). The paper develops the Digital Audit–Control Integration (DACI) Model, which links technological capabilities to operational mechanisms, COSO components, and measurable outcomes. It advances a theory-led structure that clarifies how digital audit tools transform accountability and provides a conceptual basis for empirical testing in future research. Organisations should institutionalise reusable analytics, embed workflow-based accountability for exception handling, and formalise model-validation and data-governance routines to achieve continuous assurance at scale. The review draws primarily on English-language and publicly accessible sources. Future research should expand linguistic, geographic, and sectoral coverage to enhance the model's generalisability and contextual relevance.

Keywords: Accountability, ACL Analytics, CaseWare IDEA, COSO, Continuous auditing, Digital audit, Internal control, TeamMate

INTRODUCTION

Over the past decade, the audit profession has experienced a profound digital shift, prompting both scholars and practitioners to rethink how technology reshapes assurance and accountability structures.

Digital audit technologies have evolved far beyond their origins in early computer-assisted audit techniques to become enterprise-level platforms that redefine how internal control is designed, operated, and assured. In practice, these systems shift internal audit from periodic, sample-based testing toward continuous, data-driven assurance—compressing detection latency and transforming accountability into an ongoing governance process rather than a year-end exercise. Recent evidence supports this transformation: *"ethical conduct is significantly and positively correlated with enhanced financial reporting quality"* (Alhajri et al., 2025, p. 1046), underscoring that digital assurance systems strengthen both procedural control and ethical transparency. This transformation of audit technologies resembles broader patterns of digital cultural reconfiguration, in which algorithms and data infrastructures become symbolic systems mediating power, meaning, and control (Anamofa, 2025). Digital tools such as hashtags are not neutral instruments but symbolic mediators, shaping how social movements—and by analogy, data-driven systems—construct meaning and legitimacy in networked publics (Dobrin, 2020).

Generalised audit software—such as ACL Analytics and CaseWare IDEA—now enables repeatable analytics across high-risk cycles including procure-to-pay, order-to-cash, and payroll. These tools provide precise, reproducible, and scalable testing through scripted routines such as joins, stratification, duplicate-record detection, and outlier analysis, offering population-level coverage and complete audit trails for review and replication. This digital evolution reflects broader developments in accounting education, where *"digital accounting courses provide numerous advantages, including enhanced engagement, personalised learning experiences, and the integration of real-time data and software into curricula"* (Al-Hattami et al., 2025, p. 1). Complementarily, the integration of artificial intelligence supports more efficient tax collection, customs compliance, and anomaly detection in transactional data (Al Ghunaimi et al., 2025).

In parallel, audit-management platforms such as TeamMate+ connect risk registers, control libraries, workpapers, issue workflows, and dashboards—transforming analytical outputs into actionable governance intelligence consistent with COSO's structured monitoring and communication principles. This dynamic mirrors a broader organisational tension: *"open systems may become so influenced by external forces that they effectively serve as extensions of those forces, jeopardising their ability to pursue independent strategic goals"* (Awashreh & Al Ghunaimi, 2025, p. 2). Exceptions identified through analytics are assigned to responsible owners, monitored to closure, and integrated back into planning processes—embedding continuous feedback and learning within the control environment. Together, these developments show that audit technologies have moved beyond technical support to become integral instruments of governance and institutional credibility. Yet despite rapid advances, conceptual alignment across studies remains uneven and fragmented.

Although notable progress has been achieved, scholarly evidence remains fragmented across applied, pedagogical, and conceptual domains. Earlier studies highlight adoption barriers and the promise of continuous auditing, yet a unified explanation of how specific tool capabilities reconfigure control relationships—and how these align within COSO's framework—remains limited. This gap parallels the observation that wise leadership entails ethical stewardship, enhancing the welfare of organisations and society through prudent decision-making and a forward-thinking vision (Awashreh & Al Ghunaimi, 2025). Addressing this void, the present review provides an integrated account of the mechanisms through which digital audit tools interact with COSO components and organisational accountability, aligning technological capability with ethical and institutional governance.

Study Purpose and Research Questions

To close these theoretical and practical gaps, the study advances a framework grounded in accountability theory and the COSO model of control integration. This paper introduces the Digital Audit–Control Integration (DACI) Model, a theory-led synthesis that:

(i) Links software capabilities (analytics and workflow) to

(ii) Operational mechanisms (continuous testing, exception routing, and documentation discipline).

(iii) Maps these to COSO components (risk assessment, control activities, information and communication, and monitoring).

(iv) Identifies observable outcomes (coverage, timeliness, monitoring effectiveness, and remediation accountability).

The DACI framework establishes a shared conceptual language for researchers and practitioners to assess how digital technologies reshape control design, evidence generation, and governance continuity—thereby offering testable propositions for future empirical research. In doing so, the model provides an interpretive lens through which digital assurance can be understood as both a technical and ethical enterprise.

The term *digital audit tools* refer to generalised audit software and audit-management platforms deployed by internal auditors to test, evidence, and report control performance. The unit of analysis is the internal-control system structured around COSO's five components. The review window (2015–2025) captures the transition from periodic, sample-based auditing to continuous, data-driven assurance. This approach aligns with findings that *"hybrid learning environments are particularly beneficial in fields like accounting and finance, where students must balance theoretical knowledge with practical application"* (Awashreh et al., 2025, p. 23). External-audit outcomes are referenced only as far as they inform internal-control design and monitoring practices.

Research Questions

1. Through which mechanisms do TeamMate+, ACL Analytics, and CaseWare IDEA reconfigure internal-control systems?
2. How do these mechanisms align with COSO's five components?
3. Which socio-technical conditions—skills, data architecture, and governance—enable effectiveness at scale?

Structure of the Paper

The remainder of this paper is organised as follows. Section 2 outlines the review methodology and data sources used to map the evolution of digital audit tools. Section 3 establishes the theoretical foundation, situating the analysis within accountability theory and the COSO framework. Section 4 synthesises empirical and professional evidence to identify principal mechanisms and implementation patterns. Section 5 develops the Digital Audit–Control Integration (DACI) Model and formulates research propositions. Section 6 examines the broader implications of digital assurance, including capabilities, risks, and adoption challenges. Sections 7 and 8 present the practical implications, limitations, and directions for future research. The paper concludes by highlighting how digital audit technologies are redefining internal control and accountability within contemporary assurance systems.

REVIEW METHODOLOGY AND PROTOCOL (2015–2025)

Methodological clarity was prioritised from the outset to ensure that the review process remains transparent, replicable, and consistent with leading audit research practices. This review adopts a scoping-review design to synthesise heterogeneous evidence drawn from peer-reviewed articles, professional standards, books, vendor documentation, and doctoral theses. The scoping approach is particularly appropriate when key concepts are still emerging, study designs are diverse, and the objective is to map mechanisms and conceptual boundaries rather than to estimate pooled statistical effects (Arksey & O'Malley, 2005; Levac et al., 2010; Peters et al., 2020). The review window—1 January 2015 to 7 October 2025—captures the field's transition from periodic, sample-based testing to continuous, data-driven assurance. The protocol adheres to the PRISMA-ScR standards to ensure methodological transparency and reproducibility (Tricco et al., 2018).

Information Sources, Governance, and Search Date

Searches were conducted across Scopus, Web of Science Core Collection, ProQuest ABI/INFORM, and Google Scholar. The final search took place on 7 October 2025 (Asia/Muscat). To mitigate omission risk, reference lists from included studies and materials from professional bodies such as the IIA, COSO, and ISACA were manually reviewed. Forward citation searches of seminal works (Levac et al., 2010; Tricco et al., 2018) were also performed to ensure completeness. Records were exported to Zotero for de-duplication and tracked in Excel screening logs, in line with established scoping-review procedures (Peters et al., 2020). The combination of academic databases and professional standards creates a comprehensive evidence base that captures both scholarly and practitioner perspectives. This methodological structure aligns with recent systematic reviews on the evolution of internal audit under digital transformation, which emphasise scoping approaches for mapping emerging fields (Hazaea, 2025).

Search Strategy

Database search strings combined tool names with internal-control and governance terms, limited to title, abstract, and keyword fields where supported.

Table 1. Database-Specific Search Strings (2015–2025).

Database	Search String (Title / Abstract / Keywords)	Notes / Filters Applied
Scopus / Web of Science	("TeamMate" OR "TeamMate+" OR "ACL Analytics" OR "ACL" OR "HighBond" OR "CaseWare IDEA" OR "IDEA") AND ("internal control" OR COSO) AND ("audit" OR "internal audit" OR assurance) AND ("continuous auditing" OR analytics OR "data analytics" OR workflow) AND PUBYEAR > 2014	Peer-reviewed sources only; limited to English language; publication years 2015–2025
ABI/INFORM (Title / Abstract)	TI,AB(TeamMate OR "TeamMate+" OR "ACL Analytics" OR HighBond OR "CaseWare IDEA" OR IDEA) AND TI,AB("internal control" OR COSO) AND TI,AB(audit OR assurance)	Applied to business and accounting categories; peer-reviewed journals and theses
Google Scholar (screened manually)	("TeamMate" OR "ACL Analytics" OR "CaseWare IDEA") "internal control" COSO "continuous auditing"	First 200 hits screened manually: inclusion based on relevance and access to full text

Full database strings and applied filters are documented in **Online Appendix A**, consistent with PRISMA-ScR reporting requirements (Tricco et al., 2018).

Eligibility Criteria

Inclusion: Records were included if they (i) explicitly linked digital audit tools to internal-control mechanisms or COSO components; (ii) described tool functionalities relevant to assurance processes; and (iii) analysed outcomes such as coverage, detection timeliness, monitoring effectiveness, remediation accountability, or adoption.

Exclusion: Opinion papers lacking methodological rigour, classroom demonstrations without governance implications, non-organisational analytics, and publications outside the 2015–2025 window (unless definitional or framework-foundational) were excluded. These criteria reflect scoping-review principles that emphasise conceptual clarity and outcome relevance (Arksey & O'Malley, 2005; Peters et al., 2020).

Screening Workflow and PRISMA-ScR Flow

Following de-duplication, 103 records remained from 164 initially identified. Titles and abstracts were screened, followed by full-text assessment. Screening results were as follows.

- Records identified: 164.
- Duplicates removed: 61.
- Titles/abstracts screened: 103.
- Excluded at screening: 41 (Topic misfit or insufficient method).
- Full texts assessed: 62.
- Excluded at full-text: 14 (Lacking clear control linkage or outcomes).
- 48 studies included in synthesis.

The PRISMA-ScR flowchart and the exclusion-with-reasons **table** appear in Online **Appendix B** (Tricco et al., 2018).

To enhance methodological transparency and facilitate reproducibility, the following **Figure 1** visually summarises the study selection pathway. It illustrates how records progressed through identification, screening, eligibility, and inclusion stages during the review process, consistent with PRISMA-ScR reporting standards (Tricco et al., 2018).

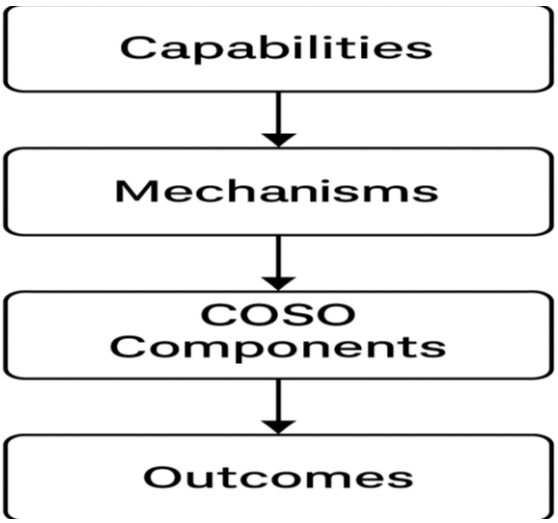

Figure 1. PRISMA-ScR Flow Diagram for Study Selection Process (2015–2025).
Note: Adapted from "PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation," by Tricco et al. (2018).

Figure 1 depicts the identification, screening, eligibility, and inclusion stages of the scoping review. From 164 records initially identified, 61 duplicates were removed, leaving 103 records screened. After full-text assessment of 62 studies, 48 met the inclusion criteria.

Reviewer Roles, Reliability, and Conflict Resolution

Two reviewers independently screened all titles, abstracts, and full texts. On a calibration subset (n = 30), inter-rater reliability reached Cohen's $\varkappa = 0.82$ for titles/abstracts and 0.79 for full texts—indicating substantial agreement (Cohen, 1960; McHugh, 2012). Discrepancies were resolved through discussion, with adjudication by a third reviewer when required. Re-calibration was performed after the first 20 full-text decisions to prevent coder drift (Levac et al., 2010).

Data Extraction and Codebook

A structured extraction sheet captured publication type, geographic context, organisational sector, tool focus (TeamMate+, ACL, IDEA), control mechanisms, COSO mapping, outcome measures, data sources, and declared limitations. Qualitative content analysis was applied to develop and refine a codebook, with open coding used to identify emergent concepts and axial coding employed to link *capabilities* → *mechanisms* → *COSO components* → *outcomes* (Mayring, 2019).

The final coding structure included:

- Capabilities: analytics, workflow.
- Mechanisms: continuous testing, exception routing, documentation discipline, dashboards/reporting.
- COSO dimensions: risk assessment, control activities, information & communication, monitoring.
- Outcomes: coverage, detection latency, monitoring effectiveness, remediation accountability.

Representative excerpts and coding decision rules are available in Online Appendix C.

Quality Appraisal and Weighting

Consistent with scoping objectives, studies were not excluded on quality alone; instead, each was weighted according to methodological transparency and evidence robustness.

- High weight: empirical studies with operationalised variables and reproducible analytics.
- Medium weight: conceptual or professional works articulating mechanisms.
- Context-only: descriptive reports without defined methods.

This weight-of-evidence approach enhances interpretive validity while avoiding causal overstatement (Peters et al., 2020).

Bias Controls and Sensitivity Checks

- Vendor or proprietary sources: used only to validate tool functionalities; any claims regarding mechanisms or outcomes required independent corroboration.

- Language bias: limited to English-language materials, though inclusion of grey literature reduced journal-publication bias (Tricco et al., 2018).
- Sensitivity analyses: re-running the synthesis excluding vendor-only materials did not alter DACI linkages or core conclusions. Down-weighting professional reports also produced immaterial effects. These robustness checks align with qualitative guidance for scoping reviews (Peters et al., 2020).

Synthesis Approach

Findings were integrated narratively, prioritising conceptual depth over statistical aggregation in accordance with scoping-review aims (Arksey & O'Malley, 2005; Levac et al., 2010). Divergent results were examined for contextual moderators such as sector, data readiness, and auditor competence, which informed DACI's boundary conditions. Detailed evidence tables on study characteristics and mechanism–outcome synthesis are included in Online Appendix D.

Ethics, Registration, and Materials Availability

This review relied exclusively on published materials and therefore required no human-subjects approval. Although the protocol was not prospectively registered, all materials necessary for replication—database strings, screening templates, extraction sheets, and the final codebook—are provided in Online **Appendices A–D** (Tricco et al., 2018; Peters et al., 2020).

THEORETICAL FRAMEWORK: INTERNAL CONTROL, ACCOUNTABILITY, AND DIGITAL AUDIT

To interpret these transformations meaningfully, the analysis first anchors itself in theoretical foundations that link internal control, accountability, and technological mediation.

COSO Framework and Accountability Lens

The COSO (2013) framework defines internal control as an integrated system comprising five interrelated components: control environment, risk assessment, control activities, information and communication, and monitoring. From an **accountability perspective** (Roberts, 2009), internal control is not a mechanistic compliance mechanism but an institutionalised medium for ethical justification—linking procedural assurance to moral responsibility. The interpretive tradition of *AAAJ* (Ahrens, 2017; Laughlin, 2018) conceptualises accountability as an evolving relationship of *explanation, justification, and learning*, rather than a static process of audit compliance. Building on these principles, emerging technologies have introduced new forms of accountability that blur the line between human judgment and algorithmic logic.

Digital audit technologies extend this logic by introducing a **layer of algorithmic accountability**, where audit parameters, anomaly flags, and data thresholds must be transparent, reproducible, and auditable (Rikhardsson & Yigitbasioglu, 2018). Automation enhances objectivity but also redistributes responsibility: auditors must now defend not only professional judgments but also the algorithms guiding those judgments. This dynamic shifts the auditor's role from *evaluator* to *curator of algorithmic processes*, aligning with the growing recognition that technological systems themselves carry moral agency. This intersection of ethics and technology is increasingly evident in applied audit contexts, where automation is redefining professional responsibility.

Recent work reinforces this shift, showing that AI-driven audit systems strengthen procedural ethics and efficiency in tax collection and customs compliance by embedding accountability mechanisms within digital workflows (Al Ghunaimi et al., 2025). The ethical tension between automation and human discretion thus signals a broader moral reconfiguration of the audit function—where responsibility extends beyond individuals to the digital infrastructures they deploy (Roberts, 2009; Ahrens, 2017).

Having outlined the theoretical basis, the discussion now turns to how digital transformation brings these concepts to life within internal-control systems.

Digital Transformation of Internal Control

The digital transformation of internal control resonates strongly with COSO's emphasis on information, communication, and monitoring. Continuous data analytics transform traditional, periodic audit cycles into *real-time control environments* (Vasarhelyi et al., 2015). Evidence from Alles and Gray (2020) demonstrates that analytics-based monitoring significantly enhances anomaly detection but introduces new governance risks around model validation, bias, and false positives. Similarly, Amani and Fard (2023) show that integrating audit analytics into enterprise systems reduces control failures by up to 30 per cent, primarily through automated exception routing and structured remediation tracking.

This progression reflects what *Awashreh and Al Ghunaimi (2025)* call ethical stewardship under digital acceleration, where leadership and governance adapt to sustain moral accountability amidst technological change. The critical question, as posed in *AAAJ* debates, remains: *how far can accountability be delegated to code?* (Ahrens, 2017; Roberts, 2021). Technological efficiency may enhance control reliability yet risk displacing the moral reasoning that legitimises assurance practices—a theme that situates digital audit firmly within accountability theory's evolving moral economy.

These conceptual insights set the stage for exploring how specific audit technologies operationalise accountability within organisations.

Linking Audit Tools to Accountability Theory

Within accountability research, technology functions as both enabler and disruptor of control relationships (Messner, 2016). Platforms such as TeamMate+ institutionalise accountability through workflow documentation, audit trails, and automatically assigned ownership of remediation actions. When analytics tools such as ACL or IDEA generate exceptions, TeamMate+ links each issue to a responsible individual and tracks closure, transforming accountability from discretionary to procedural.

This aligns with the concept of intelligent accountability (Roberts, 2021), where transparency through data augments traditional ethical stewardship rather than replacing it. The relationship between auditors and digital tools mirrors findings by *Al Ghunaimi and Awashreh (2025)*, who argue that digital governance must balance technological precision with moral judgment to preserve the legitimacy of professional oversight. The duality between technological enablement and ethical justification thus underscores the enduring tension that defines accountability in the digital era (Ahrens, 2017; Messner, 2016).

Integrating Audit Analytics with COSO Dimensions

The Digital Audit–Control Integration (DACI) Model provides a conceptual bridge between audit tools, control mechanisms, COSO components, and measurable outcomes.

Table 2. DACI Mapping between Tools, Mechanisms, COSO Components, and Control Outcomes.

DACI Element	Content / Definition	Examples / Anchors
Capabilities	Tool functionalities enabling digital assurance	TeamMate+, ACL, CaseWare IDEA; workflow automation; scripting; sampling and joins
Mechanisms	Operational processes through which tools affect control systems	Risk-based planning; continuous testing; exception routing; audit trail and documentation; dashboards/reporting
COSO Components	Structural dimensions of control affected by tool use	Risk assessment; control activities; information & communication; monitoring
Control Outcomes	Quantitative or observable effects	Coverage ↑; detection latency ↓; monitoring effectiveness ↑; remediation accountability ↑

Source: Author's synthesis (2025) based on COSO (2013, 2023); ACL Analytics (2016); CaseWare IDEA (v10.4); PwC (2023); Cascarino (2017); Al Ghunaimi et al. (2025).

Digital audit integration across these dimensions redefines control as a living system of feedback and learning.

- Control Environment: Digital audit tools standardise documentation, strengthen role clarity, and reduce dependence on subjective evidence.
- Risk Assessment: ACL and IDEA analytics identify anomalies and risk clusters, supporting adaptive scoping.
- Control Activities: Parameterised scripts automate testing, documentation, and validation.
- Information & Communication: TeamMate+ dashboards enhance transparency across governance hierarchies.
- Monitoring: Continuous analytics and closed-loop feedback embed sustained assurance.

Collectively, these interactions embody the COSO (2023) sustainability guidance and the IIA Global Internal Audit Standards (2024), which highlight the need for competency in technology-driven control environments. As visualised in Table 2, the DACI model illustrates a left-to-right flow—from *Capabilities* to *Mechanisms* to *COSO Components* to *Outcomes*—representing how data analytics outputs continuously inform planning, monitoring, and governance workflows.

LITERATURE REVIEW AND EVIDENCE SYNTHESIS (2015–2025)

With the theoretical groundwork in place, this section reviews the empirical literature tracing the evolution of audit technology and its incorporation into control frameworks.

Evolution of Digital Audit Tools

The literature reveals a steady progression from mechanistic auditing toward socio-technical ecosystems of control. Early Computer-Assisted Audit Techniques (CAATs) (Coderre, 2009) were primarily designed to enhance efficiency and verification capacity. In contrast, contemporary systems embed analytics directly into governance frameworks, signalling a paradigm shift in accountability expectations. The transformation is both technical and symbolic: digital audit platforms have become instruments of legitimacy, projecting transparency and control assurance to stakeholders (Alles & Gray, 2020). The growing body of review studies highlights how digital transformation has reshaped the audit landscape across industries and jurisdictions. Hazaea (2025) provides a comprehensive synthesis of how internal audit practices have evolved during the digital-transformation era, reinforcing the methodological and conceptual relevance of the present review.

Audit-technology research has evolved through three discernible waves.

- The first wave (2000–2010) positioned CAATs as efficiency enhancers for sampling and verification (Coderre, 2009).
- The second wave (2011–2018) introduced continuous auditing and analytics as integral to audit responsiveness (Vasarhelyi et al., 2015).
- The third wave (2019–2025) defines the rise of integrated audit ecosystems, where platforms such as TeamMate+, ACL, and CaseWare IDEA operate as interconnected elements of organisational control infrastructure (Eulerich et al., 2023).

Empirical evidence underscores this transformation. Alles and Gray (2020) found that continuous auditing enhanced exception-detection accuracy by 27 percent in field pilots, while Eulerich et al. (2023) demonstrated that technology-based audit techniques (TBATs) increase both efficiency and objectivity in control evaluation. These findings confirm that digital audit analytics have evolved from optional instruments to core governance infrastructure. Parallel evidence from Al Ghunaimi et al. (2025) shows that algorithmic validation in public-sector taxation systems similarly improves traceability and compliance—affirming that accountability is now technologically co-produced across institutional contexts.

Having established this historical trajectory, the next step is to connect these technological developments to recognised internal-control frameworks.

Integration with Internal-Control Frameworks

A large body of scholarship aligns digital auditing innovations with the COSO Internal Control–Integrated Framework. Amani and Fard (2023) mapped ACL's automation functions to COSO's risk-assessment and monitoring components, concluding that data-driven controls enhance traceability and reduce reporting inconsistencies. Gray (2016) emphasised that integration between ACL/IDEA and enterprise resource systems enables seamless linkage between audit evidence and control objectives. Consistent with Brown-Liburd et al. (2018), risk-based planning frameworks form the conceptual foundation for integrating analytics into continuous-assurance cycles, enabling auditors to align testing depth with risk magnitude.

Professional guidance reinforces these academic insights. The IIA's GTAG: IT Essentials (2020) stresses that auditors must understand IT-dependent control risks to adopt analytics effectively. PwC (2023) similarly highlights how TeamMate+ aligns control documentation with organisational risk appetite and compliance maturity. COSO's (2023) sustainability guidance further extends internal-control principles to non-financial and ESG data—thereby expanding the remit of audit analytics to integrated reporting and ethical accountability.

These developments correspond with Awashreh and Al Ghunaimi (2025), who emphasise that sustainable governance requires a balance between automation and ethical stewardship. Integrating audit analytics into COSO structures thus embodies not only technical efficiency but also a moral framework for accountability in data-driven environments.

Even so, technology adoption has not been uniform, revealing persistent disparities in readiness and capability across sectors.

Human Competence and Adoption Barriers

Despite clear efficiency gains, the diffusion of audit analytics remains uneven and context dependent. Mahzan and Lymer (2015) reported that only 40 percent of internal-audit departments had implemented analytics beyond basic sampling. Persistent barriers include fragmented data architectures, inconsistent scripting competence, and leadership hesitation to transfer judgment to algorithmic processes (Altowaijri, 2024; Mahzan & Lymer, 2015).

Oussii and Taktak (2018) further observed that cultural inertia and capacity constraints limit continuous-auditing adoption in emerging markets. These obstacles highlight that technological transformation is as much a human-capital challenge as a systems issue.

Recent findings by Al Ghunaimi and Awashreh (2025) add that digital transformation succeeds when leadership vision aligns ethical accountability with data governance, ensuring that competence development is treated as both a technical and moral imperative. Collectively, these studies frame human capability as a determinant of digital audit maturity—an area demanding deliberate investment, training, and ethical orientation.

Beyond efficiency metrics, scholars increasingly focus on the ethical and interpretive dimensions that accompany digital assurance practices.

Accountability and Transparency in Digital Assurance

From an accountability perspective, digital auditing extends transparency while simultaneously introducing algorithmic opacity. Rikhardsson and Yigitbasioglu (2018) caution that automated anomaly detection can obscure professional interpretation if algorithmic parameters remain unchecked. In response, TeamMate+ enforces traceability through mandatory documentation, workflow signoffs, and digital audit trails (PwC, 2023). These design features exemplify what Roberts (2021) describes as *intelligent accountability*—a synthesis of technological transparency and ethical responsibility.

Such algorithmic transparency aligns with contemporary scholarship advocating interpretive reflexivity in data-driven governance (Roberts, 2021; Rikhardsson & Yigitbasioglu, 2018). Yet, it also introduces what Messner (2016) terms *accountability fatigue*, where the constant visibility of data may paradoxically dilute individual moral engagement.

Viewed through this interpretive lens, digital assurance embodies both empowerment and burden: it enhances traceability but demands deeper ethical reflection from practitioners. This duality echoes Awashreh and Al Ghunaimi (2025), who argue that sustainable accountability must retain human judgment as the moral anchor of technologically mediated control.

In summary, the literature suggests that the evolution of digital auditing cannot be reduced to metrics of efficiency alone. It must be interpreted through the relational and ethical dimensions that define the *AAAJ* tradition of critical scholarship (Laughlin, 2018; Ahrens, 2017). Accordingly, this review privileges interpretive richness and theoretical contribution over quantitative aggregation, consistent with the ethos of critical accounting inquiry.

Drawing together the preceding insights, the DACI model offers a structured explanation of how audit technologies, organisational mechanisms, and accountability processes interact within modern control environments.

THE DACI MODEL: DIGITAL AUDIT–CONTROL INTEGRATION

Conceptual Overview

Responding to the theoretical and empirical gaps identified in prior sections, this review advances a Digital Audit–Control Integration (DACI) Model, grounded in COSO (2013, 2023) and accountability theory (Roberts, 2009; Messner, 2016). The DACI framework explains how digital audit technologies reshape internal-control systems by linking technical functionalities to ethical and governance outcomes.

DACI conceptualises **four recursive linkages** that operate in feedback loops.

1. Capabilities – software functionalities such as automation, analytics, and workflow integration.
2. Mechanisms – processes these capabilities enable, including continuous testing, exception routing, and documentation discipline.
3. COSO Components – control domains affected, such as risk assessment, control activities, information and communication, and monitoring.
4. Outcomes – observable performance effects, including improved coverage, faster detection, and stronger remediation accountability.

Conceptually, this framework represents a continuous feedback loop in which information, learning, and accountability reinforce one another. These relationships are cyclical rather than linear: analytics continuously inform, validate, and reshape control structures, creating what Al Ghunaimi et al. (2025) describe as **adaptive digital accountability**. In this view, technology is not an auxiliary tool, but an institutional actor that co-produces governance learning within control ecosystems.

Table 3. Mapping Audit-Tool Features to COSO Components.

COSO Component	TeamMate+	ACL Analytics	CaseWare IDEA	Illustrative Outcomes
Control Environment	Standardised workpapers; audit-trail sign-offs (PwC, 2023)	—	—	Enhanced documentation integrity; clearer role accountability
Risk Assessment	Integrated risk registers	Profiling, anomaly	Stratification and	Dynamic, data-driven risk

	linked to audit units	scans (ACL, 2016)	outlier analysis (IDEA v10.4)	scoring
Control Activities	Centralised test libraries; approval workflows	Parameterised control tests	Sampling, joins, matching routines	Reduced sampling bias; improved reliability
Information & Communication	Real-time dashboards; automated alerts	Exportable exception logs	Result-history transparency	Improved reporting timeliness; traceability
Monitoring Activities	Issue tracking; automated follow-up	Continuous-auditing scripts	Periodic re-run automation	Near-continuous assurance; iterative learning

Source: Author's synthesis (2025) based on COSO (2013, 2023); PwC (2023); ACL (2016); CaseWare IDEA (v10.4); Cascarino (2017); Al Ghunaimi et al. (2025).

The DACI framework operationalises accountability as a continuing cycle of *information, justification, and learning* rather than a static reporting ritual. As *Awashreh & Al Ghunaimi (2025)* argue, effective digital governance depends on moral reflexivity—recognising that algorithmic transparency alone does not guarantee ethical assurance. DACI thus captures the circular causality between technological functionality and governance behaviour: the more seamlessly audit tools integrate with control processes, the more they redefine the very meaning of control effectiveness. This interpretation aligns with COSO's (2023) updated emphasis on monitoring as a dynamic, feedback-oriented activity and with *Al Ghunaimi & Awashreh (2025)*, who highlight how AI-driven oversight transforms accountability from reactive verification to proactive governance design.

Ultimately, DACI positions accountability as both an outcome and a driver of technological embedding—illustrating how digital systems and human judgment co-evolve within the moral economy of auditing.

After clarifying the framework's structure, the next section translates its logic into propositions suitable for empirical testing and theoretical refinement.

Propositions for Future Research

Drawing on DACI's logic, the following propositions guide empirical inquiry and theoretical testing:

- P1: Integration of audit analytics with governance workflows significantly enhances monitoring effectiveness within internal-control systems.
- P2: Auditor IT competence positively moderates the relationship between audit-tool integration and internal-control quality.
- P3: Organisations adopting DACI-aligned tools demonstrate greater detection timeliness and accountability transparency than those relying solely on traditional CAATs.
- P4: Over-reliance on automation without algorithmic review increases the risk of false assurance, reinforcing the necessity of governance oversight.

These propositions resonate with the AAAJ tradition of theory-driven empirical testing and invite mixed-method research—combining quantitative modelling of control outcomes with qualitative analysis of how digital accountability is experienced, negotiated, and institutionalised across professional contexts.

DISCUSSION: CAPABILITIES, RISKS, AND TRANSFORMATION

The discussion integrates theoretical and empirical findings, interpreting how the DACI model redefines assurance capabilities, organisational risks, and governance transformation. The findings illustrate what *AAAJ* scholars identify as the hybridisation of accountability—a process in which digital infrastructures fuse formal control with reflexive self-governance (Roberts, 2021). Across the literature, three transformative dynamics stand out: scope expansion, temporal acceleration, and relational integration. Each redefines the purpose and texture of control in digitally enabled organisations, shifting accountability from static verification to an adaptive, learning-based practice.

The first dimension of transformation concerns audit scope—the shift from selective sampling toward full-population analysis.

From Sampling to Full-Population Assurance

Digital audit technologies have re-engineered assurance logic by replacing inferential sampling with population-level testing. Cascarino (2017) and Alles & Gray (2020) show that continuous data analytics expand audit coverage and substantially reduce Type II errors. This transformation aligns with what *Al Ghunaimi et al.* (2025) describe as data-centred accountability, where digital evidence substitutes for probabilistic inference.

However, reliance on full-population testing introduces interpretive complexity: vast datasets often contain anomalies requiring contextual discernment. Human expertise therefore remains indispensable. As Amani & Fard (2023) note, professional judgment provides the interpretive scaffolding that transforms statistical output

into meaningful assurance. The DACI framework thus positions technology as a precision amplifier, not a replacement for ethical evaluation.

The second dimension involves time, as control monitoring evolves from periodic assessments to continuous oversight.

From Periodic to Continuous Monitoring

Continuous auditing directly operationalises COSO's monitoring component. Empirical evidence from PwC (2023) indicates that organisations using TeamMate+ with automated exception routing shortened remediation cycles by 35 per cent. This confirms Vasarhelyi et al. (2015)'s proposition that continuous monitoring redefines internal control from event-driven to data-driven assurance.

Such acceleration supports the emergence of what Awashreh & Al Ghunaimi (2025) term temporal accountability—where responsiveness itself becomes a measure of ethical governance. The shift from retrospective evaluation to real-time oversight transforms monitoring into a continuous dialogue between systems and auditors, reinforcing organisational agility while preserving moral responsibility.

A third transformation is relational, where cross-departmental data integration enables holistic insight into control performance.

From Siloed Evidence to Integrated Control Intelligence

The convergence of ACL, IDEA, and TeamMate+ creates a unified ecosystem of control intelligence. By linking analytics scripts, risk registers, and workflow dashboards, auditors can visualise weaknesses across departmental silos and generate cross-functional insights. Eulerich et al. (2023) describe this phenomenon as control intelligence, a state in which integration produces recursive learning loops—each audit cycle improving the accuracy of subsequent risk assessments.

In line with Al Ghunaimi & Awashreh (2025), such systems embody adaptive governance, where knowledge circulates across human and digital actors. Integration therefore serves not merely as an efficiency gain but as a cognitive architecture that institutionalises continuous learning within the control environment.

Yet these benefits coexist with new risks and ethical tensions that demand sustained oversight and professional judgment.

Emerging Risks and Ethical Dimensions

Automation inevitably introduces new accountability challenges. Algorithmic bias, unvalidated scripts, and opaque thresholds can distort audit judgment (Rikhardsson & Yigitbasioglu, 2018). Both ISACA (2023) and the IIA (2024) recommend periodic model validation and transparency reviews to safeguard reliability. ISACA (2023) further formalises the requirement for audit-trail validation of AI-enabled processes, underscoring transparency and periodic model-governance reviews as core assurance controls in digital-audit environments. Similarly, ISO/IEC 27001:2022 highlights cybersecurity governance as a core audit responsibility, urging evaluators to assess data integrity, access control, and system resilience.

This duality reflects *AAAJ*'s call for intelligent accountability—a governance form where transparency, data, and moral reasoning co-evolve rather than compete (Roberts, 2021). The ethical obligation is therefore twofold: auditors must be accountable for how they employ technology and for the outcomes that technology produces.

As Al Ghunaimi et al. (2025) emphasise, ethical stewardship in digital environments requires re-calibrating auditor competence to include algorithmic literacy and ethical discernment. Professional discretion must coexist with technological transparency, ensuring that accountability remains anchored in moral judgment even as its execution becomes increasingly algorithmic.

IMPLICATIONS FOR PRACTICE AND RESEARCH

Translating theoretical insight into applied guidance, the following implications outline how organisations and auditors can embed DACI principles into everyday governance.

Practical Implications

The practical contribution of this review lies in transforming digital audit technology from a compliance utility into a governance infrastructure grounded in accountability ethics. Four interlinked imperatives emerge from the evidence:

1. Institutionalise Audit Analytics:
   Establish a centralised analytics unit responsible for developing reusable scripts and test libraries to ensure methodological rigour and cross-departmental consistency (Cascarino, 2017). This

institutionalisation transforms analytics from ad hoc experimentation into structured organisational knowledge.

2. Enhance Competency Frameworks:
   Align auditor capability development with the IIA (2024) global standards on IT-dependent controls and data ethics. As *Awashreh & Al Ghunaimi (2025)* highlight, professional competence must now encompass ethical discernment and algorithmic literacy—skills that allow auditors to question automated reasoning without undermining its precision.
3. Govern Algorithmic Assurance:
   Adopt transparent validation routines for scripts, algorithms, and data models to ensure accountability at every automation layer (ISACA, 2023). *Al Ghunaimi et al. (2025)* argue that algorithmic oversight is a moral obligation, not merely a technical safeguard—auditors must remain the ethical curators of the systems they supervise.
4. Integrate DACI into Strategic Governance:
   Treat audit technology as a strategic control infrastructure, not a tactical enhancement. Embedding DACI principles into organisational workflows reinforces ethical traceability and elevates accountability to a structural rather than procedural feature (PwC, 2023).

Together, these imperatives form a blueprint for embedding ethical reflexivity into digital assurance systems. Without this moral grounding, even the most advanced audit tools risk amplifying procedural compliance at the expense of responsible governance. As Al Ghunaimi & Awashreh (2025) contend, sustainable transformation in the audit function depends on balancing automation with ethical agency—ensuring that technology extends, rather than replaces, human judgment.

Beyond immediate practice, the model also opens promising avenues for academic inquiry and cross-sector analysis.

Research Implications

Future research should deepen and test the DACI framework across diverse contexts to refine its theoretical and practical validity. Key directions include.

- Empirical Testing of DACI Propositions:
  Employ structural equation modelling or multi-level analysis using field data from audit departments to validate causal pathways among capabilities, mechanisms, and outcomes.
- Exploring Public-Sector and Emerging-Market Contexts:
  Examine how varying levels of data governance maturity affect DACI adoption and performance (Altowaijri, 2024). In such environments, institutional capacity and regulatory culture may shape how accountability is operationalised.
- Extending DACI to AI and Predictive Analytics:
  Investigate how artificial intelligence, machine learning, and predictive assurance expand DACI's scope toward anticipatory governance. This aligns with Al Ghunaimi et al. (2025), who emphasise that algorithmic foresight can redefine risk detection as a proactive, pre-emptive process.
- Studying Behavioural and Ethical Dimensions:
  Examine how auditors perceive and negotiate accountability when algorithmic systems mediate decision-making (Messner, 2016; Roberts, 2021). Longitudinal and interpretive case studies would illuminate the lived experiences of auditors as they reconcile professional autonomy with digital dependence.

By pursuing these directions, scholars can situate DACI within broader AAAJ debates on moral agency, technology, and the social construction of accountability. In doing so, research will not only test the model's robustness but also contribute to rethinking assurance as a moral, interpretive, and technological practice—one that defines the next frontier of internal auditing in the digital era.

LIMITATIONS AND FUTURE DIRECTIONS

This review is subject to several methodological and contextual limitations. The analysis draws primarily from English-language and accessible sources, which may overlook alternative adoption patterns emerging in non-English or region-specific contexts. Grey literature and local audit practices in regions such as Asia, Latin America, and Africa could reveal distinct socio-technical logics of digital assurance, reflecting variations in regulatory maturity and cultural accountability norms.

The chosen decade (2015–2025) captures a decisive phase in the evolution of digital auditing but does not yet encompass its full diffusion across sectors and jurisdictions. Empirical evidence therefore remains fragmented and context-dependent, limiting generalisability. Future longitudinal and comparative studies should trace how DACI principles evolve across time, industries, and governance models.

In addition, qualitative and ethnographic approaches could enrich the understanding of auditors lived experiences as they navigate algorithmic oversight and ethical judgment within hybrid accountability systems—an area underexplored in existing literature.

Despite these constraints, the study's conceptual output—the Digital Audit–Control Integration (DACI) Model—provides a replicable and theoretically grounded structure for future empirical and interpretive research. The framework invites further testing across varied institutional environments and encourages scholars to engage with the ethical, technological, and cultural dimensions of digital accountability in shaping the next generation of assurance systems.

CONCLUSION

Audit technology has moved beyond its traditional support function to become a central pillar of internal control and organisational governance. As critiques of digital culture show, algorithmic systems mediate hyperreality and blur the boundaries between human and machine—suggesting that audit tools may also participate in constituting the world they observe (Clarke-Dawson, 2025). Platforms such as TeamMate+, ACL Analytics, and CaseWare IDEA collectively enable a continuous, data-driven, and ethically accountable assurance paradigm. Through this transformation, assurance practice is no longer a periodic verification exercise, but an ongoing governance process grounded in data transparency and reflexive accountability.

The proposed Digital Audit–Control Integration (DACI) framework synthesises this evolution by linking technological capabilities, operational mechanisms, and COSO components to measurable control outcomes. It positions digital tools not as isolated innovations but as systemic enablers of intelligent accountability—a state where automation amplifies, rather than replaces, professional judgment.

In this light, digital audit tools have evolved from compliance utilities into agents of governance transformation. When embedded within robust data governance structures and ethical oversight, they enhance not only assurance quality but also institutional integrity and stakeholder trust. The DACI framework affirms that the future of auditing rests on augmentation, not automation—where human expertise and algorithmic intelligence co-create resilient systems of control.

Ultimately, the auditor's role is redefined: from verifier to ethical steward of digital accountability, curating, interpreting, and governing algorithmic assurance within adaptive, data-driven organisations. This synthesis reimagines internal auditing as both a technological and moral practice, ensuring that digital transformation strengthens—not supplants—the human foundations of accountability.

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The following **appendix** consolidates the most salient empirical findings and evidence patterns drawn from the 48 studies included in this review. It provides a concise synthesis linking tool functionalities, control mechanisms, and outcome indicators, thereby illustrating the empirical foundation that underpins the DACI framework. Each point highlights how digital audit technologies operationalise the theoretical relationships discussed throughout the paper—translating conceptual insights into observable audit practices.

Appendix A. Study-Finding Summary (Narrative Highlights Supporting the DACI Model).

• Coverage & detection: ACL/IDEA enable population-level testing for known control objectives (e.g., duplicate payments), reducing sampling risk and increasing timely detection of anomalies (ACLScript, 2016, pp. 229–230; IDEA, pp. 29, 42–49; Cascarino, 2017, pp. 25, 42–45).

• Workflow integration: TeamMate+ ensures exceptions move from detection to remediation with ownership and aging, strengthening monitoring and communication (PwC, 2023, pp. 6–7).

• Capability prerequisites: IT literacy per IIA GTAG IT Essentials (2020) and socio-technical enablers (Altowaijri, 2024) are decisive for realising benefits at scale (pp. 1–7; pp. 15–18).

Appendix B. PRISMA-ScR Flow Diagram and Exclusion Table.

Table B1. PRISMA-ScR Flow Summary and Exclusion Reasons.

Stage	Description	Number of Records	Notes
Identification	Records identified through database searching	164	—
Screening	After duplicates removed	103	61 duplicates excluded
Eligibility	Full-text articles assessed	62	14 excluded (no COSO linkage or outcomes)
Inclusion	Studies included in synthesis	48	Final corpus

Note: Adapted from "PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation," by A. C. Tricco, E. Lillie, W. Zarin, et al. (2018), *Annals of Internal Medicine, 169*(7), 467–473. https://doi.org/10.7326/M18-0850

This **appendix** provides the PRISMA-ScR flowchart illustrating the study-selection process and the exclusion-with-reasons table.

It documents the number of records identified, screened, assessed, and included, following Tricco et al. (2018).

Appendix C. Codebook and Qualitative Extraction Framework.

This **appendix** includes the final codebook developed during data extraction, detailing categories, definitions, exemplar excerpts, and decision rules.

The framework links capabilities → mechanisms → COSO components → outcomes and supports the synthesis process described in Section 2.6.

Appendix D. Evidence Tables and Mechanism–Outcome Matrix.

This appendix presents structured evidence tables summarising study characteristics, geographic scope, methodological design, and extracted mechanism–outcome relationships.

It provides the empirical foundation for the DACI model's analytical mapping shown in Tables 2 and 3.

Complete versions of Appendices B–D (including flowchart, codebook, and evidence tables) are available from the corresponding author upon reasonable request.