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Blockchain and Audit Regulation: Challenges of Standardization, Compliance, and Ethical Accountability

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1. Abstract

This review examines the evolving intersection of blockchain technology and audit regulation, focusing on the interrelated dimensions of standardization, compliance, and ethical accountability. Drawing on academic research, regulatory reports, and professional publications a comprehensive analysis is provided of how blockchain's promise of transparency and immutability reshapes the audit landscape while simultaneously raising complex regulatory and ethical dilemmas. The absence of harmonized technical and regulatory standards is highlighted, which impedes interoperability and under-mines the comparability of blockchain-based audits across jurisdictions. It identifies compliance challenges, particularly the paradox between blockchain's immutability and data protection frameworks such as the GDPR, as well as uncertainties regarding cross-border regulation and the legal enforceability of smart contracts. Lastly, the review emphasizes on the ethical dimension, including risks of auditor independence erosion, algorithmic bias, and the displacement of professional judgment by automated processes. By synthesizing these findings, the review argues that blockchain auditing cannot be addressed through isolated technical solutions but requires an integrated approach that aligns global standardization efforts with compliance mechanisms and ethical safeguards. Future research directions include the development of adaptive oversight models, and the design of ethical frameworks that preserve public trust in auditing within a digital and decentralized economy. This review further proposes an integrative conceptual framework linking standardization, compliance, and ethical accountability, thereby advancing prior conceptual work and addressing the research gap in ethical governance of block-chain auditing.

3. Introduction

Blockchain technology has emerged over the last two decades as a potentially disruptive force in auditing and assurance. By combining immutability, decentralization, and transparency, it promises to improve audit efficiency, reduce fraud, and strengthen confidence in financial reporting [1]. Despite these advantages, its adoption in audit regulation remains uneven due to fragmented standard-setting, unresolved compliance issues, and underdeveloped ethical frameworks.

This review addresses these challenges by synthesizing research published between 2000 and 2024 across accounting, auditing, information systems, law, and ethics. Unlike descriptive surveys, the study applies a systematic

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach and thematic synthesis to critically evaluate blockchain's integration with regulatory frameworks. The analysis is structured around three interconnected pillars standardization, compliance, and ethical accountability to highlight gaps, identify risks, and provide recommendations for advancing both scholarship and practice.

The significance of blockchain auditing lies in its potential to redefine the assurance profession by enabling continuous auditing, immutable evidence trails, and enhanced stakeholder transparency. However, these same features challenge conventional auditing standards (e.g., ISA 230, ISA 500, ISA 540) and ethical codes, thereby demanding regulatory adaptation. This study thus highlights why understanding blockchain's implications for audit regulation is crucial for the credibility of financial reporting and investor protection. Smart contracts, self-executing digital agreements recorded on blockchains enable automated audit evidence validation but raise compliance and liability issues.

4. Methodology

The review follows the PRISMA guidelines to facilitate methodological rigor and transparency. PRISMA is currently an established protocol for rendering systematic re-views more transparent and reproducible across disciplines, including healthcare and business [2]. A systematic database search identified studies on blockchain and audit regulation published from 2000 to 2024. After applying inclusion and exclusion criteria, 25 peer-reviewed articles were included. The PRISMA model, consisting of three phases identification, screening, and inclusion was applied in selecting the studies [3,4]. **Figure 1** presents the PRISMA flow diagram, while Table 1 provides a summary of the included studies, detailing their methods, scope, findings, and limitations. To move beyond description, the review employs a qualitative thematic synthesis that maps the selected literature along three areas: standardization, compliance, and ethical accountability. In doing so, it presents a composite image of blockchain auditing as a socio-technical transformation, rather than a technical advancement. The following visual representation is based on the PRISMA flow diagram provided. No review protocol was prospectively registered for this study, while a formal risk of bias assessment tool was not applied, as most included studies were conceptual or exploratory. However, potential biases such as limited empirical validation and reliance on self-reported data are acknowledged as influencing the evidence base. Each node represents a decision point in the study selection process.

**Figure 1:** Decision tree based on the PRISMA flow diagram.
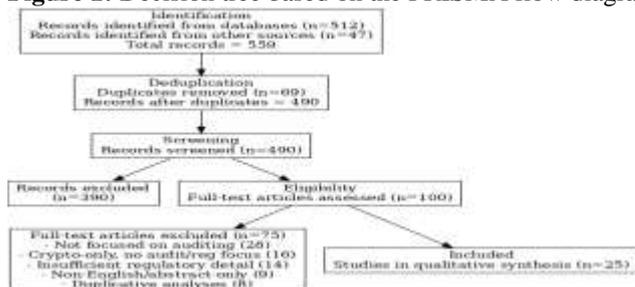
Records were identified from data-base searches (Scopus, Web of Science, Google Scholar) and other sources. After deduplication, screening, and eligibility checks, 25 studies

were included in the final qualitative synthesis. Reasons for exclusion are provided at the eligibility stage.

The inclusion of 25 studies in the final synthesis provides both breadth and depth to the analysis of blockchain and audit regulation. The selected corpus of research contains a selection of conceptual studies and empirical investigations despite the limited number of studies in emerging fields. The review benefits from diverse sources which present both technological potential of blockchain and regulatory obstacles and ethical concerns that affect its implementation. The selected studies cover blockchain research from its first exploratory phase in the early 2000s until current investigations about compliance and accountability. The number of studies provides enough data for thorough thematic synthesis yet maintains a level of focus that enables detailed evaluation of each contribution. The PRISMA flow diagram in Figure 1 presents the selection process according to PRISMA guidelines. The screening process and eligibility checks of 559 records led to the selection of 25 studies which became part of the final synthesis. The selected studies serve as evidence for the thematic analysis of blockchain and audit regulation which follows in the subsequent sections. The table serves as the foundation for the thematic synthesis developed in Sections 3.1 to 3.3.

Figure 2: Research Thematic Map of Included Studies.
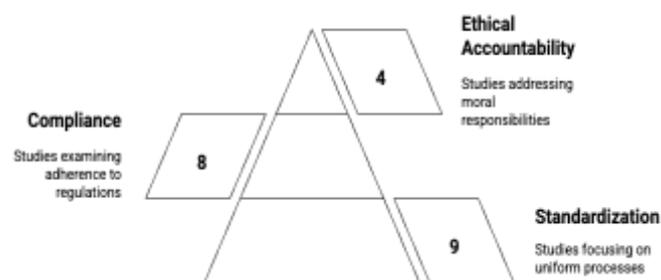
To structure the synthesis, the 25 included studies were classified into three thematic pillars: standardization, compliance, and ethical accountability. **Table 1** presents representative contributions, while **Figure 2** illustrates the thematic distribution across these categories and their overlaps. **Figure 2** shows that research on blockchain and audit regulation is fragmented across the three thematic pillars, with the majority of studies concentrated in the areas of standardization and compliance. Standardization studies dominate early contributions, focusing on interoperability, assurance models, and the adaptation of existing audit frameworks to distributed ledgers. Compliance-oriented research has expanded more recently, highlighting regulatory conflicts such as GDPR, jurisdictional fragmentation, and the enforceability of smart contracts [5]. Ethical accountability, while smaller in number, is emerging as an essential lens, particularly as automation and algorithmic decision-making challenge traditional notions of auditor responsibility and independence. The overlaps across pillars particularly between standardization and compliance indicate recognition that technical harmonization cannot be divorced from regulatory adaptation. However, fewer studies explicitly integrate ethical considerations with technical or compliance frameworks, underscoring a critical gap in the literature. This thematic distribution highlights both the progress and the fragmentation of the field, suggesting the need for more integrative approaches that embed ethical accountability alongside standardization and compliance efforts.

Table 1: Summary of included studies on blockchain and audit regulation (2000-2024).

Author(s), Year	Source	Focus Area	Main Contribution	Relevance to Blockchain Audit Regulation
Sheela, et al., 2023 [6]	*Sustainability*	Standardization / Compliance	Bibliometric + content analysis of 67 studies; identified three themes: blockchain in financial reporting, auditing transformation, and crypto valuation	Shows blockchain's transformative potential, but highlights gaps in governance, disclosure, and regulatory frameworks
Syahputra, 2022 [7]	*GRAR*	Compliance	Empirical study of blockchain-enabled auditing tools	Finds improved transparency/efficiency, but challenges in compliance, privacy, and interoperability
Ameyaw, et al., 2024 [8]	*IJSRU*	Standardization / Compliance	Literature review on blockchain's role in audit processes	Argues blockchain can enhance quality and mitigate fraud; stresses collaboration and standards
Krishna, 2023 [9]	*ShodhKosh*	Standardization / Compliance	Mixed-methods study on blockchain adoption in audits	Concludes blockchain improves trust and accuracy but faces technological and regulatory hurdles
Metwally, 2022 [10]	*SJAR*	Standardization	Mixed-methods (survey + guide) with regulatory bodies	Calls for auditors' readiness and redesign of procedures under blockchain adoption
Hoti, et al., 2024 [11]	*MultiRev*	Compliance / Standardization	Case studies + expert interviews with audit firms	Identifies hesitancy among auditors due to regulatory risks; recommends training and tailored standards
Danach, et al., 2024 [12]	*ABR (Asia)*	Compliance	Policy analysis of blockchain's effect on reporting	Emphasizes regulatory adaptation and financial reporting implications in Asia
Ugoaghalam, 2024 [13]	*CSEIT*	Standardization / Compliance	Literature review on blockchain-enabled GRC auditing	Advocates standardized blockchain-GRC interfaces and regulatory sandboxing
Georgiou, et al., 2024 [14]	*JRFM*	Standardization / Compliance / Ethics	Systematic review of 75 studies	Identifies gaps in empirical work, skills, governance, and standards
Singh, 2023 [15]	IGI Global chapter	Compliance / Ethics	Conceptual exploration of blockchain's governance role	Analyzes ethical and regulatory challenges in auditing
Hossain, et al., 2024 [16]	*EJTAP*	Standardization / Ethics	Mixed methods study of blockchain, AI, big data	Blockchain improves transparency but requires updated standards and ethics
Noviani & Muda, 2022 [17]	*EAI*	Standardization	Review of blockchain in audit software evolution	Finds blockchain enhances access, validation, and integrity but needs regulator coordination
Priom, et al., 2024 [18]	*IJEBMR*	Compliance	Bibliometric study of blockchain applications in auditing	Highlights security, governance, and regulatory framework needs
Ghazali, et al., 2023 [19]	IGI Global	Standardization	Conceptual discussion of blockchain in digital auditing	Argues blockchain can transform methodologies; auditor roles evolving
Muthirevula, et al., 2024 [20]	*JAPMI*	Standardization / Compliance	Case studies in FDA-regulated contexts	Shows blockchain reduces audit-trail time and improves compliance
Ivanova, et al., 2024 [21]	*Econ. & Finance Problems*	Standardization	Conceptual paper on blockchain-enabled assurance	Stresses reliability, efficiency, and smart contract automation
Hamzah, et al., 2024 [22]	*RAJ*	Compliance	Mixed-methods survey/interviews on reporting	Finds transparency and efficiency gains but regulatory uncertainty
Fahdil, et al., 2024 [23]	*Journal of Economics*	Standardization / Compliance	Literature review + interviews	Reports blockchain reduces fraud and audit time, but faces skill and regulatory gaps

Kamau & Yavuzaslan, 2023 [24]	*African J. Comm. Studies*	Compliance	Review of CryptoAudit challenges	Emphasizes lack of regulatory frameworks; crypto audit differs from traditional audit
Dyball & Seethamraju, 2021 [25]	*Int. J. Auditing*	Compliance	Interviews with auditors on client blockchain adoption	Finds blockchain clients viewed as riskier; impacts audit risk approach
Kamau, 2023 [26]	Preprint	Compliance / Ethics	Conceptual analysis of CryptoAudit	Stresses auditors must adapt skills; blockchain may aid auditability
Faccia, et al., 2022 [27]	*JOITMC*	Standardization / Compliance	Conceptual + modeling on permissioned chains	Proposes permissioned blockchains to enable open innovation in audit
Huang, et al., 2024 [28]	*AJPT*	Compliance	Archival study of 10-K blockchain disclosures	Shows blockchain activity disclosures linked to higher audit fees (perceived risk)
Adekunle, et al., 2024 [29]	*IJMOR*	Standardization / Compliance	Conceptual paper on blockchain-based financial reporting	Finds blockchain strengthens internal controls but governance risks persist
Rozario & Thomas, 2019 [30]	*JETA*	Standardization / Ethics	Conceptual paper proposing external audit blockchain	Suggests blockchain + smart contracts improve audit effectiveness

4.1. Search strategy

A comprehensive search was conducted across multiple databases, including Scopus, Web of Science, ProQuest, SSRN, and IEEE Xplore. The search covered the period from January 2000 to December 2024, reflecting the timeframe during which blockchain and distributed ledger technologies emerged as topics of academic and professional concern. The following search strings were employed in various combinations: "blockchain AND auditing," "distributed ledger AND audit regulation," "blockchain AND compliance," "audit ethics AND blockchain," and "smart contracts AND assurance."

To capture relevant professional and regulatory perspectives, reports from standard-setting bodies such as the International Auditing and Assurance Standards Board (IAASB), the International Federation of Accountants (IFAC), the European Commission, and professional associations (AICPA, Big Four firms) were also included. The search was supplemented by snowballing from reference lists of key articles.

4.2. Eligibility criteria

Inclusion and exclusion criteria were established to ensure relevance and focus. Eligible studies included peer-reviewed journal articles, regulatory reports, and professional publications that explicitly addressed blockchain in the context of auditing, regulation, compliance, or ethics. Both conceptual and empirical contributions were considered. Exclusion criteria included non-English publications, conference abstracts without full papers, opinion pieces without substantive analysis, and studies focusing exclusively on cryptocurrency or blockchain applications unrelated to auditing.

4.3. Study selection

The search initially identified 559 records. After removing duplicates, 490 records remained. Titles and abstracts were screened for relevance, leading to the exclusion of 390 records. The full texts of 100 articles were reviewed against the eligibility criteria, resulting in the exclusion of 65 studies that were either peripheral to auditing or did not substantively engage with regulatory or ethical issues. Ultimately, 25 studies were included in the qualitative synthesis.

The selection process is summarized in the PRISMA flow diagram (Figure 1), which illustrates the narrowing from the initial pool of records to the final set of studies.

4.4. Data extraction and synthesis

For each included study, data were extracted on author(s), year, publication outlet, research design (conceptual, empirical, regulatory analysis), and focus area (standardization, compliance, ethics). Extracted data were organized into a summary table (**Table 1**), which provides an overview of the included studies and their contributions. The synthesis followed a qualitative thematic approach. Textual findings and conclusions were coded line by line to identify recurring patterns, tensions, and gaps. Codes were grouped into descriptive themes aligned with the three pillars of interest: standardization, compliance, and ethical accountability. From these descriptive themes, higher-order analytical in-sights were developed to answer the guiding research questions.

4.5. Scope and limitations

As a systematic review, this study is limited by its reliance on existing literature and reports, which may reflect the state of knowledge up to 2024 but not the most recent regulatory developments. The review does not include unpublished empirical data, and thus its conclusions are interpretive rather than predictive. Nonetheless, the systematic application of PRISMA ensures that the analysis is comprehensive, transparent, and replicable, providing a robust foundation for identifying gaps and proposing directions for future research. Although the PRISMA protocol was rigorously applied, no formal risk-of-bias tool was used. This is acknowledged as a limitation, and future reviews should incorporate bias assessment frameworks such as AMSTAR 2 or ROBIS to evaluate the strength of evidence.

5. Blockchain and Audit Regulation: State of the Art

5.1. Standardization in blockchain auditing

The literature highlights blockchain's potential to deliver interoperability, continuous assurance, and more reliable audit evidence through immutable,

decentralized ledgers [1]. Yet the absence of universally recognized technical or regulatory standards remains a critical obstacle. Current international frameworks such as the ISA and IFRS do not explicitly address distributed ledger technologies, leaving auditors without authoritative guidance [31]. Table 2 below conceptually maps blockchain's implications to selected International Standards on Auditing (ISA 200, 230, 315, 500, 540) to illustrate where existing requirements for audit evidence, documentation, and risk assessment may need revision. For instance, blockchain's immutable ledgers align with ISA 500's evidential sufficiency yet conflict with ISA 230's documentation flexibility, revealing the need for explicit blockchain audit guidance. Industry consortia and professional associations have begun initiatives to establish protocols, but these remain fragmented and risk reinforcing silos rather than promoting harmonization [32]. The consequence of inaction is clear: without global recognition of blockchain as valid audit evidence, practices will diverge, comparability will weaken, and the credibility of financial reporting could be undermined [33]. This makes standardization not just a technical necessity but a foundational requirement for blockchain's legitimacy in auditing.

5.2. Compliance Challenges

Blockchain's immutability and transparency support audit traceability, but they also generate legal and regulatory conflicts. A widely cited example is the tension between blockchain's permanent records and the GDPR's "right to be forgotten," which illustrates how existing legal frameworks are poorly aligned with distributed ledger technology [34]. National jurisdictions diverge further in their treatment of smart contracts, liability allocation, and recognition of blockchain-based audit evidence [6]. If left unresolved, these inconsistencies will hinder multinational audits, forcing auditors to operate under incompatible regimes and discouraging adoption by firms with cross-border operations. Inaction would reduce audit quality, increase compliance costs, and slow the profession's transition to digital-first assurance [14]. Regulatory convergence is therefore essential, yet progress remains

limited and piecemeal.

5.3. Ethical accountability

Compared to technical and compliance issues, ethical accountability in blockchain auditing is less developed but equally critical. Scholars warn that over-reliance on automation risks compromising auditor independence, professional judgment, and accountability for outcomes [35,36].

Algorithmic bias, ambiguous responsibility for system failure, and the risk of auditors being both validators and developers pose other accountability barriers [30]. Lack of robust ethical frameworks is a strong deficiency in practice and scholarship. Unless controlled, blockchain's promise of increased transparency can ironically erode public trust by concealing the site of fault and failure [19,37]. The integration of blockchain into auditing therefore necessitates ethical controls transparent algorithms, explainable systems, and clear rules of liability mixed with technical demands and compliance provisions. Cumulatively, the art of the possible establishes that blockchain auditing cannot be reduced to technical, legal, or ethical domains alone. Each forum is implicated in the others, informing and engaging them in mutually reinforcing patterns that highlight risks as surely as opportunities. Attempting to capture these interdependencies, the following section provides a thematic synthesis that integrates the three pillars into one analytical framework.

Ethical accountability in blockchain auditing must be understood through the lens of established frameworks such as the IFAC Code of Ethics for Professional Accountants (IESBA, 2024). Core principles integrity, objectivity, professional competence, confidentiality, and professional behavior face reinterpretation in automated audit environments. Blockchain introduces ethical tensions where algorithmic decision-making may compromise objectivity or obscure responsibility, underscoring the need for algorithmic transparency and auditor liability safeguards.

Table 2: Mapping of Blockchain Implications tom ISA Standards.

ISA Standard	Objective	Blockchain Implication for Auditing	Future Guidance
ISA 200 Overall Objectives of the Independent Auditor	Defines auditor's overall responsibilities to obtain reasonable assurance and express an opinion on financial statements.	Immutable blockchain records can strengthen assurance but may reduce auditor discretion if algorithms automatically validate evidence.	IAASB guidance should clarify auditor responsibility when automated blockchain tools perform substantive procedures.
ISA 230 Audit Documentation	Requires sufficient, appropriate documentation for evidence and judgments.	Blockchain ledgers provide permanent, time-stamped records but cannot be amended	Guidance needed on how immutable ledgers interact with documentation flexibility

		to correct documentation errors.	and confidentiality requirements.
ISA 315 Identifying and Assessing the Risks of Material Misstatement	Requires risk assessment procedures to identify and understand the entity and its environment.	Smart-contract-based transactions create new IT control environments and risks of code errors or cyber-manipulation.	Auditors should assess blockchain-specific risks (governance, access rights, consensus protocols).
ISA 500 Audit Evidence	Establishes requirements for obtaining sufficient, appropriate evidence.	Blockchain data provide high reliability (immutability, transparency) but may lack relevance if system design is flawed.	IAASB should define conditions under which blockchain data qualify as "appropriate" audit evidence.
ISA 540 Auditing Accounting Estimates and Related Disclosures	Requires evaluation of management estimates and assumptions.	Automated valuation or tokenization processes in blockchain can embed complex algorithms that auditors cannot easily verify.	Need for guidance on auditing algorithmic estimates and fair-value measurements recorded on distributed ledgers.
ISA 580 Written Representations	Requires management representations to support evidence obtained.	Smart-contract automation reduces human representations but still requires accountability confirmation.	Auditors must obtain hybrid representations acknowledging automated data flows and system-governance responsibilities.

6. Thematic Synthesis and Critical Insights

The three fundamental means of blockchain auditing ethics responsibility and standardization and ethics responsibility and compliance depend on each other through synthesis of literature revealing that awareness of any one of them separately does not provide the whole picture of blockchain auditing. The three topics both contain ad-vantages and disadvantages which together create a complex image of how blockchain technology affects audit legislation.

Blockchain technology improves the auditing process by increasing efficiency through real-time confidence and reduced traditional sampling requirements per Bejjar & Siala [38] and Lombardi, et al. [32]. They are attainable with international recognition of strong standardized processes that all signatories commit to observing. The absence of standardized methods of validation of blockchain ledgers leads to different mechanisms of

interpretation that undermine the integrity of distributed ledgers as audit evidence [8,39]. Auditors provide inconstant audit outcomes and are under public distrust of their outputs on account of failing to depend on firm-specific policy or ad-hoc judgment whenever there have not been any blockchain validation processes in place [39,40].

Standardizing blockchain for auditing purposes requires more than technical solutions because it needs major institutional and political components. Multiple international organizations together with national authorities and industry partnerships work to establish standardized rules which merge regulatory frameworks with technological advancements [8,39]. The different competing interests prove that a single leadership entity must exist to link technological requirements with institutional monitoring systems. The

establishment of complete guidelines and universal blockchain standards will enhance data reliability and auditability while fostering stakeholder agreement between regulators and audit firms [38,40].

The full deployment of blockchain technology for financial audits depends on achieving universal standardization because it provides real-time transaction tracking and reduced sampling needs [32,39]. The lack of established standards creates an environment where practitioners must work through multiple conflicting practices which threatens to damage the overall trustworthiness of auditing activities. The establishment of a regulatory framework that combines technical excellence with institutional strength demands joint collaboration between technology specialists and audit professionals and regulatory bodies [8,39].

The compliance theme shows that usage of blockchain is heavily dependent on existing legal infrastructures that empower yet constrain its functional operations. The inherent nature of blockchain that includes immutability and transparency are advantageous since they have enhanced audit trails and traceability that have been favored by regulators. The accounting profession has indicated that blockchain tamperproof and verifiable ledgers help simplify audits and increase the accountability of financial transactions [35,41]. Blockchain attributes are especially desirable for industries which have the highest need for transparency and trust as they guarantee established legal requirements for accountability.

The same blockchain features which provide advantages create substantial obstacles when they violate current legal rights and duties. The European Union's "right to be forgotten" faces an important challenge because blockchain immutability prevents data modification which violates

existing privacy regulations [42,43]. The inability to modify blockchain data creates conflicts with existing data protection standards which has led to the development of off-chain data management solutions [42]. The process of adapting blockchain to legal requirements demonstrates that compliance requires both technological and organizational changes to make blockchain properties work within established legal frameworks. The absence of regulatory convergence makes the situation more complex. The different regulatory standards between jurisdictions create a problem because blockchain audit evidence compliant with one national framework may not receive legal recognition in another jurisdiction Mohammed Abdul, 2024) [44]. The different regulatory systems that multinational enterprises need to follow create challenges for them to operate because these systems often have conflicting rules. The current state of legal frameworks requires fundamental transformation to properly manage blockchain technology according to Mohammed Abdul [44]. The compliance challenges drive legal innovation because they force regulators and technologists to work together for rule development instead of trying to fit blockchain into current legal structures [6,41].

Blockchain systems encounter multiple compliance issues because their technical features interact with existing legal standards. Blockchain systems achieve better accountability and auditability through their transparent and unchangeable nature but this creates challenges for privacy protection and international legal standards [42,44]. Research must create hybrid solutions which com-bine technical solutions with legal frameworks and organizational approaches to resolve these conflicts and achieve enhanced blockchain technology governance and compliance in digital environments [6,41].

The field of blockchain auditing identifies ethical accountability as its core subject because it determines the professional trustworthiness of auditors. Auditors must demonstrate three fundamental qualities for ethical accountability which include maintaining independence and possessing sound judgment and showing dedication to public interest [14,37]. The implementation of blockchain technology with smart contracts for auditing purposes breaks traditional auditing expectations because these systems enable automated algorithms to replace human auditor decision-making authority [45,46]. The heavy use of automated auditing systems generates two major issues according to researchers because it makes fault identification more difficult and introduces undetectable biases that are hard to resolve [21,47]. The implementation of blockchain applications demands the development of operational ethical frameworks to handle emerging ethical dilemmas which determine distribution benefits and stake-holder priority levels [48].

The evaluation of these issues becomes more complex because standardization and compliance issues exist as interconnected problems. The absence of standardized protocols makes it challenging to verify that blockchain-based audit evidence fulfills current legal standards [49]. The absence of proper technical standards weakens compliance systems while it creates confusion about which party bears responsibility for oversight between automated systems and human supervisors [37]. Smart contracts that perform audit procedures autonomously reduce human involvement in areas which used to serve as ethical and legal checks [45,50]. The three elements of ethical accountability and compliance and standardization maintain a structural relationship because technical protocol inconsistencies lead to increased ethical risks which weaken the auditing framework [49].

The literature shows a time-based pattern where blockchain technology receives more attention for its technical aspects while regulatory and ethical aspects receive less focus. The initial research focused on blockchain's operational efficiency and fraud prevention features while emphasizing its technological aspects [30,51]. Research on audit practice automation compliance and ethics has started to emerge as a new focus in recent academic studies [12]. The rates of adoption of blockchain and related safety measures create a huge risk because regulators and auditors are open to unforeseen risks [14,50]. Upcoming blockchain auditing activities will achieve their pioneering goal and maintain public trust when research and policy actions focus on the creation of holistic solutions that address technical elements alongside legal and ethical areas [48]. Relevant examination of these problems indicates blockchain auditing is an ongoing journey that presents numerous regulation and ethical challenges. Overlapping standardization and compliance with ethical obligation defines blockchain auditing as needing a system-based end-to-end solution more than piecemeal parts [30,49]. An integrated perspective would maintain auditing integrity along with reacting to social consequences of blockchain technology like trust sustenance and safeguarding the stakeholders [14,37].

7. Discussion

The synthesis of the literature shows that blockchain auditing sits at the intersection of technological innovation and regulatory adaptation. Much of the enthusiasm in both practice and research has emphasized blockchain's ability to deliver transparency, efficiency, and tamper-evident assurance. Yet the evidence demonstrates that its integration into audit regulation is far more complex. Adoption depends not only on technical feasibility but also on the harmonization of standards, the resolution of compliance conflicts, and the embedding of ethical safeguards. Without timely regulatory intervention, blockchain auditing risks being adopted in fragmented and inconsistent ways, which would erode the comparability of audits and weaken investor confidence in international financial reporting [31,32].

A major theme in the literature is the regulatory lag compared to the rapid pace of technological development. Pilot studies, industry experiments, and professional reports highlight blockchain's potential to enhance audit trails, automate workflows, and deliver continuous assurance [41,52]. However, global standard setters remain cautious, and existing frameworks such as the ISA and IFRS do not explicitly account for distributed ledger technologies [31]. This regulatory lag has antecedents in history, but unlike prior transitions, the distributed and immutable nature of blockchain increased the cost of inaction. Poor evolution of smart standards can lead to systemic vulnerabilities, foster avenues for complex fraud schemes, and ultimately undermine the credibility of the auditing profession [31,33].

Compliance challenges further cloud adoption of blockchain. The tension between blockchain's immutability and data rights such as the GDPR's "right to be forgotten" illustrates how existing law is not applicable to emerging technologies. While technical fixes have been proposed they undermine blockchain's value as an audit tool and add complexity to

assurance processes. In addition, the absence of convergence between jurisdictions leads to inconsistent verification of audit evidence derived from blockchain, which erodes the reliability of financial reporting by multinational firms [34]. These disagreements, unless resolved, will discourage adoption by multinational firms, forcing auditors to perform under incompatible national frameworks. The resulting uncertainty can lower audit quality and slow the transition of the profession to digital-first assurance systems [6,14].

Beyond conceptual debates, there is a pressing need for empirical inquiry. Future research could survey auditors' perceptions of blockchain reliability, analyze adoption barriers in audit firms, and evaluate pilot blockchain assurance engagements. Such studies would provide empirical grounding and validate theoretical propositions emerging from this review.

Ethical accountability is the least developed but most critical pillar. The viability of auditing depends on independence, professional judgment, and decision-making responsibility, but blockchain and smart contracts shift most of these functions to automated systems. This creates difficult questions: who bears responsibility when an algorithm fails, how can biases embedded in code be detected, and how can auditor independence be safeguarded when professionals also serve as system designers or validators? Without ethical safeguards, over-reliance on automated auditing tools risks undermining auditor independence and weakening public trust. If algorithmic errors or biases go unmonitored, responsibility for audit failures will remain unclear, exposing both firms and regulators to reputational and legal crises [35,36].

Collectively, they note the risk of reliance on blockchain technology. As much as early research had depicted it as a panacea for inefficiency and fraud, it is chimeric to expect technology to address deeply ingrained institutional and moral challenges. Auditing is not technically centered but a social practice underpinned by trust, accountability, and independence. Dependence on blockchain protocols runs the risk of blunting auditors' professional judgment and, ultimately, compromising the integrity of the audit function itself.

At the same time, the literature suggests that there are opportunities for successful reform. Blockchain allows regulators and professional organisations to redefine auditing so as to marry efficiency with responsibility. Rather than viewing it as an afterthought, standards could be rewritten to explicitly take into account distributed ledger technology, such as prescriptions for how blockchain-based evidence is to be authenticated and how ethical safeguards are to be incorporated. Blockchain traceability can also be used to facilitate monitoring for compliance, enabling real-time detection of anomalies and improved enforcement.

Lastly, blockchain auditing is about achieving the middle path between innovation and legitimacy. Any failure to do so will doom blockchain auditing to become a passing technological trend, rather than a true institutional innovation. Alternatively, visionary synchronization of standards, compliance, and ethics may position blockchain as a cornerstone of digital-age auditing [11,14].

The certainty of evidence is moderate to low, as the majority of studies are conceptual, with few empirical validations across jurisdictions. This limitation highlights the need for future research to expand empirical testing in real audit environments.

8. Conclusions and Future Directions

This paper illustrates that blockchain auditing has vast transformative power but is restrained by unresolved issues in three interconnected fields: standardization, com-liance, and ethical responsibility. Although the technology possesses unique strengths transparency, immutability, and decentralization their embrace as substantive audit evidence entails more than technological breakthroughs. Without coordinated regulatory action, fragmented standards, patchwork compliance regimes, and weak ethical protections will undermine the legitimacy of blockchain and prevent it from taking a strong position in global auditing practice.

The first major finding concerns standardization. Blockchain can bring traceability and credibility, but without official recognition by standard-setting bodies such as the IAASB or the IFRS Foundation, its application to audit evidence is questionable. Without this deficiency, worldwide practice can branch off into divergent systems that compromise comparability and investors' faith in financial reporting.

The second finding recognizes compliance issues. Battles between blockchain's immutability and the right to safeguard data exampled by the GDPR's "right to be forgotten" witness the inapplicability of existing law for distributed ledger technologies. Not reconciling these tensions will see auditors exposed to incompatible national regimes, particularly for cross-border audits. These inconsistencies can lower audit quality, increase costs, and discourage businesses from adopting blockchain-based solutions, de facto bringing the profession's digital development to a standstill.

The third and most underdeveloped finding is ethical responsibility. Auditing has long relied on professional independence, integrity, and responsibility, yet blockchain and smart contracts shift many of these responsibilities to automated processes. With algorithmic errors, biases, or failures without a clear responsibility, public trust in the audit profession will decrease, and auditors and regulators will be exposed to reputational and legal risks. To neglect this dimension risks turning blockchain into a source of un-certainty and liability, instead of a vehicle for trust creation.

Going forward, the research has several policy and academic implications. Policymakers and regulators must accelerate the development of standardized blockchain auditing standards, ideally coordinated at the supranational level by institutions such as the European Union, IOSCO, or the OECD. Professional bodies must complement these efforts by embedding ethical safeguards into blockchain applications, including trans-parent algorithms, explainable decision-making, and mechanisms for auditor independence. Without such initiatives, blockchain will remain a fragmented innovation rather than an institutional reform.

For research, substantial knowledge gaps persist. While technical and legal aspects have received attention, ethical concerns remain comparatively neglected. Moreover, much of the current scholarship is conceptual, with limited empirical testing in real audit environments. Future studies should examine how stakeholders including auditors,

regulators, and clients perceive blockchain-based audits relative to traditional ones, and how legitimacy is established in digital auditing ecosystems. Longitudinal studies could track how regulatory frameworks evolve in response to blockchain adoption, while interdisciplinary projects combining computer science, law, and ethics could design systems where compliance and ethical safeguards are embedded into blockchain infrastructure.

Ultimately, the success of blockchain auditing will depend on whether innovation can be balanced with legitimacy. If global actors fail to harmonize standards, resolve compliance conflicts, and embed ethical accountability, blockchain will be dismissed as a transient technological experiment. Conversely, if regulators, auditors, and technologists collaborate strategically, blockchain could reshape auditing into a more efficient, trust-worthy, and resilient institution for the digital age.

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