

Audit 4.0: Determinants and Implications of Audit Opinions in the AI Era

Sri Mulyani Latjompo ¹ ✉, **Ayu Dhina Anggraeni** ², **Namra** ³, **Amiruddin** ⁴

^{1, 2, 3, 4, 5} *Hasanuddin University, Makassar, Indonesia*

Abstract

This study aims to analyze the factors influencing the implementation of Audit 4.0 and its implications for the formation of audit opinions in the era of artificial intelligence (AI). Audit 4.0 marks a significant transformation in the audit profession through the application of digital technologies such as artificial intelligence (AI), big data analytics, robotic process automation (RPA), and cloud computing, which can improve the efficiency, accuracy, and precision of auditor analysis. This study uses a systematic literature review method by examining scientific articles published between 2018 and 2025 from the Scopus, ScienceDirect, and Google Scholar databases. The results show that the success of Audit 4.0 implementation is determined by three main factors: auditor digital competence, technological readiness, and organizational support. The integration of digital technology has been shown to strengthen the quality of audit evidence and the objectivity of the resulting opinion, while accelerating the audit process. However, the findings also indicate that excessive reliance on automated systems can reduce the application of professional judgment and create the risk of automation bias. Thus, the success of Audit 4.0 depends not only on technological sophistication but also on the auditor's ability to maintain a balance between the use of technology and their professional responsibilities. This research is expected to provide theoretical contributions to the development of literature on audit digitalization and serve as a basis for audit institutions in formulating strategic policies to improve audit quality in the era of digital transformation.

Keywords: Audit Opinion, Audit 4.0, Artificial Intelligence

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✉Corresponding author: ms.latjompo@gmail.com ¹

Email Address : ayud26765@gmail.com ², namranamra907@gmail.com ³, amiruddinj64@gmail.com ⁴

INTRODUCTION

AI is a computing technology that demonstrates some form of human intelligence and encompasses several interrelated technologies, including data mining, machine learning, natural language processing, speech recognition, image recognition, and sentiment analysis (Seethamraju & Hecimovic, 2020). Technological developments implemented by public accounting firms have transformed the auditing profession. AI technology has transformed the way audits are conducted, with examples such as stocktaking being conducted using drones and audit evidence collection using populations

instead of samples. Therefore, AI provides more relevant and timely information and accelerates the auditor's decision-making process (Al-Sayyed, Al-Aroud, & Zayed, 2021).

The phenomenon of Audit 4.0 in the AI era involves a complex interaction between technology, humans, and regulations. Digital transformation in auditing not only increases efficiency but also raises ethical and data security issues (Seethamraju & Hecimovic, 2020). The use of AI in big data analytics carries the risk of algorithmic bias and misinterpretation, which can weaken the quality of audit opinions. Therefore, auditors need to have adequate AI literacy and data interpretation skills (Al-Sayyed, Al-Aroud, & Zayed, 2021). Current audit regulations and standards are not yet fully prepared to comprehensively regulate the use of AI, which results in legal uncertainty and challenges to accountability and transparency, particularly regarding privacy and system reliability (Warta BPK, 2021). Furthermore, the implementation of Audit 4.0 triggers organizational and work culture changes, where human-machine collaboration must be enhanced, although resistance to change and limited skilled human resources remain major obstacles (IIA Indonesia National Internal Audit Survey, 2025).

The digital era, characterized by accelerated technological innovation, has brought fundamental changes to nearly all sectors, including the audit profession. The emergence of the term Audit 4.0 describes a major transformation in traditional audit practices, driven by the adoption of key technologies such as Artificial Intelligence (AI), machine learning, robotic process automation (RPA), and blockchain technology. (Alao & Oladejo, 2019). The most visible revolution brought by Audit 4.0 is occurring in the domain of anomaly detection and financial fraud, where Artificial Intelligence (AI) and especially machine learning have proven their significant advantages over traditional methods. (Adelakun et al., 2024).

The application of machine learning in auditing involves a variety of techniques, each with its own strengths and weaknesses. Supervised learning techniques, such as logistic regression, decision trees, random forests, XGBoost, and support vector machines (SVM), are used to classify fraudulent items based on historical data. (Bakumenko & Elragal, 2022). The adoption of Audit 4.0, characterized by the integration of AI and blockchain, does not happen automatically and is influenced by a variety of complex technical, organizational, and external factors. Research courtesy of (Alshrouf et al., 2024) showed that these factors vary depending on the country context and type of organization. In the Saudi Arabian context, a UTAUT (Unified Theory of Acceptance and Use of Technology) model-based study found that performance expectancy, ease of use (effort expectancy), and social influence significantly influenced auditors' intention to adopt AI. However, facilitating conditions such as IT infrastructure and training did not have a significant impact, although IT infrastructure was found to have a positive moderating effect on the relationship between ease of use and adoption intention.

Studies have shown that (Bouebdallah & Bouhali, 2025) perceived usefulness and ease of use are also key factors in blockchain technology adoption. A study in Turkey (Qader & Cek, 2024) found that the implementation of AI and blockchain significantly impacted audit quality, with AI having a greater impact (coefficient 0.465) than blockchain (coefficient 0.325). Crucial organizational factors include leadership support, strategic AI implementation, and overall organizational readiness (Abdullah & Almaqtari, 2024).

External factors, particularly the role of high-level authorities and the regulatory framework, are also crucial. In Saudi Arabia, support from high-level authorities plays a crucial role in driving AI adoption (Alsudairi, 2024). The European Union is leading the

way in AI regulation through its AI Act, which emphasizes protection from algorithmic discrimination, transparency, accountability, and the protection of fundamental rights (Leocádio et al., 2024). This regulation provides an important framework for the ethical use of AI in auditing. Social support for AI integration in accounting curricula is also essential for preparing future auditors (Alhazmi et al., 2025).

Due to this phenomenon, this research is important because it provides an in-depth understanding of how technological advances, particularly artificial intelligence, affect the process, outcomes, and quality of audit opinions in the digital era. In the context of the transformation towards Audit 4.0, this research not only identifies the factors that determine the adoption of AI technology in audit practice but also examines the accompanying ethical, regulatory, and professional implications. Thus, this research contributes significantly to bridging the gap between technological developments and the readiness of auditors and regulatory agencies, while providing a scientific basis for policy development, improving auditor competency, and implementing more adaptive, transparent, and reliable audit practices in the era of artificial intelligence.

Artificial Intelligence (AI)

Artificial Intelligence (AI) is a set of technologies capable of performing cognitive tasks previously only human, such as thinking, analyzing, recognizing patterns, and making data-driven decisions (Kokina et al., 2025). In the context of accounting and auditing, AI is present as an innovation that can replace routine work, improve the accuracy of analysis, and strengthen the accuracy of financial reporting (Abdullah & Almaqtari, 2024). This AI capability is developing rapidly thanks to advances in the fields of machine learning, deep learning, and natural language processing, which enable systems to learn and adapt automatically to changes in data (Kokina et al., 2025).

The expansion of AI use in the business world has created a new need to ensure that AI systems operate in accordance with legal principles, technical robustness, and ethical use of technology (Li & Goel, 2025). Auditing AI systems is crucial to ensure transparency, accountability, and reliability of the results generated by these artificial intelligence algorithms (Li & Goel, 2025). This development also shows that AI is no longer merely a tool, but has become a separate audit subject that requires an auditability framework (*AI auditability framework*) to be monitored professionally and ethically (Li & Goel, 2025).

The integration of AI with technology has strengthened modern audit systems by providing reliable, transparent, and verifiable transaction data in real time (Han et al., 2023). The combination of these two technologies enables continuous auditing *and* increases the efficiency of the financial data verification process (Han et al., 2023). The positive impact of AI is also evident in improving the quality of corporate audits, where the application of this technology has been shown to improve internal control systems and corporate transparency (Tan et al., 2025).

Audit 4.0

The development of the Industrial Revolution 4.0 has brought significant changes in audit practices, marked by the increasing use of advanced technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), Big Data Analytics, and Cyber Physical Systems (CPS). According to Dai and Vasarhelyi (2016) in Rustam (2024), Audit 4.0 is defined as an era of high-level technology use in the audit process, where intelligent systems and internet-based services are used to collect and verify operational and financial

data. This transformation shifts the role of auditors from implementing manual procedures to managing automated systems that expand audit scope, minimize audit time, and improve the quality of audit results (Rustam, 2024).

Auditors increasingly rely on technology integration to enhance professional judgment (auditor judgment). Digital technology is considered capable of strengthening auditors' capabilities in risk analysis, data validation, and evidence-based decision-making (Samiolo et al., 2024). However, audit automation does not completely replace human judgment, but rather *augments* auditors' professional capabilities to be more efficient and accurate in dealing with the complexities of digital business transactions. Thus, Audit 4.0 represents a synergy between technology and auditor professionalism in achieving audit reliability in the digital era (Samiolo, Spence & Toh, 2023).

The implementation of AI and Industry 4.0 readiness directly impacts the improvement of audit practices, efficiency, and the quality of financial reporting. Using the *Technology Acceptance Model (TAM) approach*, the study shows that perceived ease of use and usefulness of technology are key factors driving the adoption of AI-based audit systems (Abdullah & Almaqtari, 2024). The use of *machine learning*, *data mining*, and *cloud computing* enables auditors to analyze large amounts of data, detect patterns and anomalies, and improve the accuracy of audit decisions. However, the success of Audit 4.0 also requires the readiness of human resources, digital infrastructure, and regulations that support the ethical and responsible application of technology (Abdullah & Almaqtari, 2024).

Audit Opinion Determining Factors

An audit opinion is an auditor's professional statement regarding the fairness of an entity's financial statements based on generally accepted accounting standards. This opinion serves as the primary benchmark in assessing the quality of financial reporting and the reliability of information presented to the public. Auditors are responsible for assessing whether the financial statements are free from material misstatement, whether caused by error or fraud. According to X. Zhang et al. (2022), audit opinions are strongly influenced by the auditor's independence, professional experience, and the effectiveness of regulations governing audit practices. In the context of research in China, they found that violations of the auditor rotation policy (*rotation violations*) can reduce audit quality because they prolong the economic relationship between the auditor and the client. This condition has the potential to create collusion, where auditors provide more favorable opinions in exchange for additional compensation (*fee premiums*). These findings confirm that compliance with the auditor rotation policy is a crucial element in maintaining the objectivity and integrity of the audit process, as rotation plays a role in minimizing conflicts of interest and increasing the credibility of the opinions issued (X. Zhang et al., 2022).

One important factor influencing audit opinions is the effectiveness of communication between auditors and the audit committee as part of corporate governance mechanisms. According to (Kim et al. 2025), good communication between external auditors and the audit committee can strengthen the oversight function of the audit process and reduce the potential for *opinion shopping* by the company. *Opinion shopping* itself is an action by management to find an auditor who is willing to provide an unqualified opinion even though the financial statements do not fully meet standards. The study explained that targeted communication helps auditors gain a better understanding of the risks and material issues in the financial statements, thereby improving the quality of the audit performed. Thus, effective communication is one of the determining factors of audit

opinions, because it can create a transparent audit environment, increase accountability, and reduce management pressure on auditors (Kim et al., 2025).

In addition to communication factors, the auditor's professional relationship and independence are also key determinants in forming an audit opinion. In a pre-print version of their research, Kim, Jo, and Cho (2025) emphasized that while intense communication can strengthen coordination between the auditor and the audit committee, an overly close relationship poses a threat to auditor independence. This condition is known as *familiarity threat*, which occurs when the auditor becomes too familiar with the client and loses objectivity in making judgments. Therefore, maintaining a balance between open communication and professional distance is crucial for the auditor to maintain their skepticism and objectivity. With this balance, the resulting audit opinion will reflect unbiased professional judgment, thus gaining the trust of stakeholders and serving as a basis for sound economic decision-making.

METHODOLOGY

This study applies a *systematic literature review approach* to comprehensively examine the determinants and implications of audit opinion determination. This method was chosen based on its ability to identify, assess, and synthesize various previous research findings in a structured and objective manner, resulting in a deep, evidence-based understanding of the topic under study.

The literature search process was conducted through several databases, including Scopus, ScienceDirect, Publish or Perish, and Google Scholar. The literature used was limited to publications between 2018 and 2025 to maintain research relevance. The article selection process was carried out systematically, starting from initial identification, reviewing titles and abstracts, and reading the full text to ensure topic suitability. Inclusion criteria included articles that specifically discussed the application of ABC and its relationship to managerial decision-making. Meanwhile, articles that were irrelevant or did not meet the criteria were excluded, resulting in 38 articles most suitable for analysis.

RESULTS AND DISCUSSION

Determining Factors for the Implementation of Audit 4.0

The implementation of Audit 4.0 improves audit efficiency and accuracy through the integration of artificial intelligence, big data, and cloud technology (Halim, Tan & Rahel, 2025). The perception of ease of use and usefulness of digital technology are key factors in the acceptance of audit software in the digital era. Audit 4.0 technology, which includes big data *analytics and AI, enables real-time* audits and increases the accuracy of ESG reporting, thereby reducing the risk of *greenwashing* and emphasizing the importance of collaboration between auditors and technology to ensure transparency and reliability of reports. The use of big data and *cloud computing* contributes to *real-time reporting of CSR trends* that can be used as audit evidence and support the creation of accurate ESG metrics (Halim, Tan & Rahel, 2025). In addition, it provides a foundation for the importance of ESG reporting as a modern business instrument that integrates social and environmental responsibility with financial goals.

Advanced artificial intelligence (AI) technologies such as *Machine Learning* and *Natural Language Processing* give auditors the ability to analyze unstructured data such as contracts and emails (Kokina et al. (2025)). However, this technology also requires auditors

to have the ability to critically assess the results of AI analysis to avoid algorithmic bias (Li & Goel, 2025). Auditor IT literacy strengthens their adaptability in dealing with complex digital systems, improving audit performance and quality, as found by Matta and Chamoun (2025). Organizational readiness in adopting technology is also an important factor. Razali et al. (2025) highlight the importance of external auditors' proficiency in digital technology as a key factor in carrying out their supervisory role effectively. In the context of detection, traditional methods are less effective without adequate computer technology support. Increasing digital competence also has a positive impact on the quality of internal audits, in their study which confirmed that the use of AI is correlated with improved audit quality.

The determining factors for the implementation of Audit 4.0 include auditor digital competence, technological readiness, and organizational support as the three main pillars. Digital audits in the Industry 4.0 era rely heavily on artificial intelligence (AI), big data, and *Robotic Process Automation* (RPA) technologies to improve audit efficiency and precision. However, auditors face challenges such as limited digital competence and data security risks that must be addressed for this technology to be adopted effectively (Musytari, 2025) stated. In addition, technology acceptance by auditors is also influenced by perceived ease of use and perceived usefulness of audit *software*. The *Technology Acceptance Model* (TAM) approach found that these factors have a significant influence on auditor attitudes in accepting new audit technology (Hotman & Daniel, 2025).

Furthermore, big data analytics and AI technology in Audit 4.0 support *real-time audit implementation* and improve accuracy, especially in ESG (*Environmental, Social, Governance*) reporting. Halim, Tan, & Rahel (2025) emphasized that collaboration between auditors and technology is crucial to ensure transparency and reliability of reports. The use of big data and cloud computing enables real-time reporting of CSR dynamics, which not only improves audit quality but also helps in creating accurate and relevant ESG metrics for stakeholders (Halim, Tan & Rahel, 2025).

Organizational factors such as management support, regulations, and technological infrastructure readiness also play a crucial role in the implementation of Audit 4.0. With the integration of the latest technology, auditors can conduct continuous audits with greater efficiency and anomaly detection. However, to optimize the potential of this technology, continuous training and development of auditors' digital competencies are essential. The success of Audit 4.0 implementation is greatly influenced by the synergy between auditors' personal competencies, technological readiness, and overall organizational support (Musytari, 2025; Hotman & Daniel, 2025; Halim, Tan & Rahel, 2025).

Implications for Audit Opinion

The development of Audit 4.0, characterized by the application of *Big Data*, *Artificial Intelligence* (AI), and *digital transformation*, has had a significant impact on the risk assessment process and the formation of audit opinions. Based on research Isa & Subramanian (2024), the use of *Big Data* in auditing increases the accuracy of risk analysis and expands the sources of audit evidence that can be accessed in *real time*, so that auditors can provide more comprehensive opinions and reflect the actual condition of the company. In line with that, Zhang & Fu (2025) it shows that the integration of financial indicators and textual disclosures through *multi-view machine learning* strengthens the auditor's ability to predict the trend of future audit opinions. This approach not only increases objectivity but also minimizes human bias in professional judgment. Rapid digitalization can create new

complexities and prolong the audit process (*audit delay*), especially in entities that are not yet digitally ready, thus potentially affecting the efficiency and timeliness of the delivery of audit opinions (Leng & Zhang, 2024).

Although automation and advanced data analytics can improve the quality of evidence and reduce the risk of material misstatement, concerns remain regarding the potential decline in auditor *professional judgment* due to reliance on automated systems. AI in auditing has the potential to automate the process of data collection and analysis, leading to independent audit decision-making, thus creating ethical and professional challenges regarding the ultimate responsibility for the opinion issued (Zhou & Liu, 2024). The quality of the audit opinion fundamentally remains dependent on the sufficiency and appropriateness of the evidence obtained by the auditor through substantive procedures and professional testing (Zuca, 2015). Therefore, the role of the auditor in the Audit 4.0 era must shift from merely performing procedures to assessing the integrity of systems and algorithmic controllers, so that the resulting opinion continues to reflect a balance between technological speed and professional responsibility.

Audit 4.0, which encompasses the implementation of audit digitalization, artificial intelligence (AI), and *Big Data -based analytical systems* , has significant implications for issuing audit opinions. Key findings indicate that the use of digital technology and AI-based models, such as *collaborative LLM frameworks*, enables auditors to assess the risk of material misstatement more comprehensively and evidence-based (Lu et al., 2025). This enhances objectivity and accuracy in determining whether financial statements merit an unqualified opinion or require modification. *Digital governance* and audit digitalization demonstrate that data-driven systems strengthen internal controls and minimize control weaknesses, resulting in more reliable audit opinions that reflect the company's true condition (Shi & Zhang, 2025).

Automation with high reliance on automation, *sustainable audit digital innovation* and *auditor empowerment* Wiyantoro et al. (2025) found that the use of advanced technology does indeed accelerate the audit process and improve the quality of *e-audits* , but also has the potential to reduce the application of *due professional care* and professional judgment of auditors. When auditors rely too much on algorithms and predictive systems in decision-making, the risk of *automation bias* arises , namely the tendency to accept system results without professional skepticism. This condition reduces auditors' sensitivity to the business context and the potential for fraud that is not detected by the system. Therefore, although Audit 4.0 brings efficiency and objectivity, auditors must still maintain a balance between technology and human professional judgment (Wang & Liang, 2025). Audit 4.0, characterized by the integration of AI, *Big Data analytics* , and intelligent automation, has fundamentally changed the way auditors assess risk. The use of AI allows auditors to assess risk more accurately through *real-time data analysis* and faster anomaly detection. Research Zhou & Liu (2024) confirms that Audit 4.0 technology increases the effectiveness of collecting and interpreting audit evidence, reduces the possibility of material misstatements, and strengthens the objectivity of audit opinions. *Digital transformation and corporate audit risk* show that digitalization changes auditor behavior towards risk, where reliance on digital systems can improve the consistency of opinions, but also demands higher auditor competency in understanding technology-based systems (Huang & Liu, 2024; Zhou & Liu, 2024).

Excessive automation can reduce the space for *professional judgment* , which is the essence of the audit profession. Although digitalization increases efficiency, technological

complexity and the potential for algorithmic bias can impact the quality of audit opinions (Fang et al., 2025). When auditors rely on automated system results without in-depth verification, there is a risk of reducing the critical assessment of unstructured audit evidence. This is in line with Zhou & Liu (2024) those emphasizing the need for a combination of artificial intelligence and human professional intelligence to maintain the independence and accuracy of audit opinions. Thus, the implementation of Audit 4.0 has dual implications for audit opinions: increasing reliability, transparency, and efficiency, but also posing new challenges in maintaining professional skepticism and ensuring the auditor's ethical responsibility.

The Role of Digital Auditor Competence

Technical competence is a key pillar for auditors in the era of Audit 4.0. In an era characterized by the dominance of technology, digital competence has transformed from a mere additional asset to an absolute foundation for the survival of the accounting and auditing profession. Evidence shows that auditors' ability to effectively utilize this technology not only improves audit efficiency and effectiveness but also significantly impacts the quality of the resulting audit opinion (Vitali & Giuliani, 2024). The tangible impact of adopting this technology is reflected in increased productivity and significant cost savings. Research shows (Jacob, 2024) that implementing RPA can reduce testing time by 70% while accelerating audit process execution by over 60%. Even the Big Four report a reduction in labor costs of up to 40% after automating more than 50 audit activities. Artificial Intelligence (AI), especially its more advanced forms such as Machine Learning (ML) and Natural Language Processing (NLP), enables auditors to analyze leasing contracts, emails, and other unstructured documents. (Kokina et al., 2025).

Without digital competence, the risk of technology misuse, flawed decision-making, and loss of public trust increases significantly. In the context of audit 4.0, critical thinking goes beyond simply verifying numbers. When AI provides recommendations or flags anomalies, auditors must be able to assess whether the findings are logical, relevant, and free from algorithmic bias (Li & Goel, 2025). Auditors with high IT expertise and literacy demonstrate significantly greater adaptability, emphasizing the importance of digital skills in addition to traditional competencies. IT literacy strengthens auditors' ability to navigate complex digital systems, enhancing adaptability, while low IT literacy can limit adaptability and hinder performance (Matta & Chamoun, 2025). Therefore, external auditors' proficiency in digital technology is a critical factor in determining their ability to effectively perform their role as impartial assessors and monitors of the security and integrity of an organization's financial information (Razali et al., 2025).

In the audit 4.0 environment, identifying fraudulent transactions with traditional methods is difficult. Audit professionals must possess extensive accounting knowledge, as well as effective knowledge, particularly computer technology (Kılıç, 2020). This is supported by the findings of the study (Zamzam et al., 2024), which state that competence significantly influences audit quality in the digital era as a key indicator of internal auditor performance. The findings (Hady & Mudhaffar, 2025) also found that AI adoption has a significant positive impact on audit quality and performance expectations. Auditors who use AI-based tools more frequently tend to have higher performance expectations, and this belief directly contributes to improved audit quality.

Auditors' digital competence plays a crucial role in ensuring the accuracy and reliability of their audit opinions. Auditors with strong digital competence are able to

identify fraud risks arising from technological complexity and more accurately assess the effectiveness of internal controls. This is in line with research findings (Samiolo et al., 2024) that the technology of the Industrial Revolution 4.0 helps auditors identify risks and anomalies more quickly and accurately, while also reducing human bias in the audit process. However, research findings also indicate that increased automation does not automatically improve the quality of auditor judgment, as auditors still require in-depth understanding. This is further supported by (Zamzam et al., 2024) the need for professionalism in auditors to avoid bias in the audit process. When using technology-based information systems, auditors need to possess competent information technology skills so that audit results will reflect their professionalism and technological capabilities.

research has also (Otia & Bracci, 2022) found that AI has been shown to improve efficiency, accuracy, and analytical capabilities in financial data processing, while enabling real-time, information-based decision-making. However, the research also identified a number of challenges, such as data privacy and security concerns, algorithmic bias, a lack of regulatory clarity, and a digital competency gap among accounting professionals. Furthermore, (Matta & Chamoun, 2025) it found that digital skills can improve audit quality if emphasized in training programs. Therefore, digital transformation offers clear benefits that increase the demand for auditors to have digital competencies and the need for continuous development to mitigate risks.

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